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PROCEEDINGS

of the American Academy of Forensic Sciences

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Special Sessions

SS1 Multidisciplinary Symposium on the Uses of Forensic Science — Who's What and Who's Who: Credentials and the Things We Do

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It is not uncommon for forensic "experts" to consult, to offer opinions, or to provide testimony in court while lacking the credentials that are recognized by qualified professionals in the discipline. Erroneous or misinformed opinions can jeopardize investigations, justice, personal liberty, and society's well being. This symposium will feature qualified experts from the major forensic science disciplines who will describe the typical work duties, limitations, and challenging issues of each forensic specialty area. Information will also be provided about professional education, training, and certifications that are required, recommended, or available in each discipline so users of potential experts may better evaluate the experts' qualifications.

Expert Testimony, Credentials, Forensic Science

SS2 Young Forensic Scientists Forum - Establishing a Foundation for a Successful Career in Forensic Science

C. Ken Williams, MS*, Forensic Scientist, New Jersey State Police Department, South Regional Laboratory, 1101 S. Whitehorse Pike, Hammonton, NJ; Claire E. Shepard, BS MS*, Crime Scene Investigator, Crime Scene Unit, Crime Scene Unit, 3630 Camp Circle, Decatur, GA; Mary Fran Ernst, BLS*, Saint Louis University, Division of Forensic Pathology and Education, 6039 Helen Avenue, St. Louis, MO; Jay A. Siegel, PhD*, Michigan State University, School of Criminal Justice, 506 Baker Hall, East Lansing, MI; James M. Adcock, MPA*, Professor of Criminal Justice, University of New Haven, 2445 Park Avenue #46, Bridgeport, CT; Patricia A. Manzillilo, MSFS*, US Postal Inspection Service, 225 North Humphries Boulevard, Memphis, TN; John V. Goodpaster, PhD*, National Institute of Standards and Technology, Analytical Chemistry Division, 100 Bureau Drive, Stop 8392, Gaithersburg, MD;

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The Young Forensic Scientists Forum addresses the issues and concerns of individuals who are just beginning their involvement with the forensic sciences. This special session is developed to provide useful information for anyone preparing for a successful career in forensic science. Topics to be presented will include formal education programs, the importance of internships and field experience, how to approach the job market, curriculum vitae and resume writing, and the role of certification. Once again, a career in a specific discipline will be highlighted. Because forensic scientists have such a significant role in court proceedings, the workshop will conclude with an afternoon session detailing the responsibilities of the expert witness and demonstrating techniques for effective testimony.

The number of scientists interested in applying their specific expertise to criminal investigation has rapidly increased. Consequently, rigorous competition is now common for almost every training and employment position in the forensic sciences. To be competitive, forensic scientists need not only the proper training, but also the ability to convey the importance of scientific evidence to the jury in a concise, comprehensible, and irrefutable manner. This workshop is designed for students as well as individuals in the early stages of their forensic science career. The daylong workshop consists primarily of presentations covering a wide range of topics by experienced members of and emerging scientists in the field of forensic science. The objective of the session is to provide participants with fundamental information and guidance about educational and career opportunities, internships, professional involvement, certification, research, AAFS presentations, and expert testimony. The discussion of the forensic scientist's role as an expert witness will include landmark cases, admissibility of scientific evidence, weight of expert testimony, and legal and ethical responsibilities. The role of the forensic scientist as an expert witness will be further demonstrated through a mock trial consisting of a direct and cross-examination of the witness' testimony of a prepared case.

The session is divided into two distinct parts: "Expectations" in the morning and "Realities" in the afternoon.

Objectives of the morning session:

- to explain the need for certification and how to obtain it
- to discuss the importance of professional involvement
- to enable the audience to make informed decisions in the areas of educational programs and internships
- to discuss the requirements for various employment opportunities within the field

Objectives of the afternoon session:

- to provide an atmosphere for active dialogue between the participants and presenters
- to discuss research possibilities within the field
- to explain the process for making a presentation within the Academy and applying for awards such as the Emerging Young Forensic Scientist Award
- to discuss the landmark cases in forensic science
- to instruct on evidence admissibility, demeanor, and qualifications
- to demonstrate direct and cross-examination of the expert witness

Career Opportunities, Testimony, Certification

SS3 Forensic Scientific Investigations: Police-Related Deaths (Pursuit, Apprehension, Custody) and Racial/ Ethnic Profiling—Is There a Correlation? The Role of the Forensic Scientist

Cyril H. Wecht, MD, Coroner County of Allegheny, 542 Fourth Avenue, Pittsburgh, PA; Michael M. Baden, MD*, Director Forensic Science Unit, New York State Police, Building 22, State Campus, Albany, NY; Henry C. Lee, PhD*, Chief Emeritus, Division of Scientific Services, Dept. Public Safety, 278 Colony Street, Meriden, CT; Linda B. Kenney, JD*, The Galleria, 2 Bridge Avenue, Atrium Building #5, 2nd Floor, Red Bank, NJ*

This session is intended to educate forensic scientists by specific case examples and personal experiences of the presenters as to how to deal with complex and controversial police-related deaths. Increased sensitivity and knowledge of forensic pathologists, criminalists, toxicologists, psychiatrists, engineers, law enforcement officers, and attorneys regarding such deaths will enhance official governmental medical-legal investigation of these cases and will help to improve relationships within the respective communities, especially with regard to minority groups.

Congressional and state legislation, U.S. Supreme Court decisions, and the emergence of dynamic civil rights movements beginning in the 1960s and continuing to the present time have resulted in many dramatic changes in our society. One of the most fascinating and controversial sociopolitical upheavals has focused on the field of law enforcement, and more specifically, the manner in which police arrest people and how prisoners are treated when in custody. Methods and procedures that were accepted without question or formal legal challenge 35 years ago are completely unacceptable today to a great extent.

The Rodney King case in Los Angeles; the Johnny Gammage case in Pittsburgh; the Louima, Diallo, and Dorismund cases in New York City; the Faison case in Newark — these are only some of the more publicized instances in which allegations of excessive force by police have been charged and pursued through both civil and criminal lawsuits. The Waco (Branch Davidian) and Ruby Ridge shoot-outs involving the FBI and the ATF have demonstrated that not even the nation's most prestigious law enforcement agencies are immune from legal actions filed by the survivors of people killed in what initially may appear to be completely justified

efforts to make legitimate arrests. However, after further scrutiny and investigation by other agencies, news media, and private attorneys, such justified efforts prove to be much less clear and incontrovertible.

Several jurisdictions have publicly conceded that their police have engaged in racial or ethnic profiling, including tracking and stopping motor vehicular drivers; setting up situations in which someone may be enticed into selling or purchasing illicit drugs; and limiting observation of potential shoplifters by private security guards (usually off-duty local police officers) in large retail stores to specific minority groups. In many such situations the arrests that ensued resulted in violent confrontations with civilian deaths, usually by gunshot wounds and less frequently by some kind of positional asphyxiation. A very interesting example of alleged racial profiling involved the New Jersey State Police on the New Jersey Turnpike near Trenton a few years ago. Five African-American young adult males were stopped for highly questionable reasons, and in the resultant fray, three of them were shot. Reconstruction of the shooting by one of the authors demonstrated that a key witness' version was physically impossible. (The lawsuits filed in this case were subsequently settled by one of the authors for a total of \$13 million.)

When a police-related death occurs, the proper and necessary investigative procedures should unquestionably include a meticulous autopsy by an experienced forensic pathologist in the local coroner or medical examiner's office. The postmortem examination should include a complete toxicology screen, extensive photographs, X-rays, and the identification, collection, and preservation for appropriate testing of all physical evidence by competent criminalists. It is imperative that independent forensic scientists, functioning in an autonomous governmental agency that is not controlled or influenced in any way by law enforcement agencies, conduct all such examinations.

Optimally, open inquests should be undertaken in all police-related deaths. Such a forum provides a unique opportunity to have all the facts and findings of the case presented under oath in a public forum. That is the best way to minimize concerns and doubts within the community that the death is going to be "covered up" in order to protect the police officer(s) involved. (Specific examples of such open inquests conducted in police-related deaths by one of the authors will be presented.)

Attorneys must be aware of how forensic scientists can be utilized to present the facts and valid objective conclusions in all of these controversial cases in the courtroom.

Police Related Deaths, Racial Profiling, Forensic Science Investigations

Breakfast Seminars

BS1 The Life and Death of Edgar Allan Poe

*Richard C. Froede, MD**, 3930 North Placita de la Escarpa, Tucson, AZ; *David Roby**; *Rhonda K. Roby, MPH**, Applied Biosystems, 850 Lincoln Center Drive, MS 404-2, Foster City, CA

There are a number of theories concerning Edgar Allan Poe's life and his unexplained death. This program will present the most recent alleged theory as to the cause of this death. The presentation will also include an enjoyable recitation of his brilliant prose and poetry. Edgar Allan Poe will come, he will entertain, and then, he will come "nevermore." It is hoped that at least one of the attendees present will be able to see and hear Edgar Allan Poe!

Edgar Allen Poe, Unexplained Death, Cause of Death

BS2 What Does Depravity Mean to You? Toward a Definition of Evil

*Michael Welner, MD**, The Forensic Panel, 224 West 30th St. #806, New York, NY

At the conclusion of this program, the participant will be familiar with the courts' historical awkwardness in determining "heinous, atrocious, and cruel" efforts to standardize the definition of depravity in the courts and results of research to date.

Higher court decisions, including rulings and writings of the U.S. Supreme Court, reflect judges' awkwardness with terms regularly used in court to essentially designate the wickedness of a crime. Criminal codes in many states contain provisions for aggravating factors for crimes that the tier of fact may decide are, for example, heinous, atrocious, cruel, wanton, vile, or outrageous. As descriptive as these terms are, they have heretofore been arbitrarily defined. This has hampered juries, courts, and even prosecutors in carrying out the responsibility to narrow the class of death penalty-eligible defendants.

In this age of forensic science, so much useful information is available to the court that reflects on the motivations of the actor before and after the crime and on the actions of carrying out the crime. However, there is little pressure for utilizing pathology, crime scene analysis, and psychiatry in helping to resolve the questions of "depravity." This has important implications, for the different terms of wickedness are often utilized in capital cases. The author reviews important higher court decisions in recent years that illustrate the inconsistencies and dilemmas in better defining depravity.

In an effort to better quantify evil so as to bring specificity and the rigor of the scientific method to these designations, the author has developed The Depravity Scale. This device assesses the history of the defendant's actions before, during, and after the offense and incorporates his mental state and feelings as reflected by available history and evidence. The instrument therefore provides a measure to distinguish crimes qualitatively, independent of the background of the offender and other collateral issues that sometimes influence or bias juries. This talk reviews how case law shaped the development of The Depravity Scale and how research input has since modified it.

Research studies over the past year have aimed to establish a consensus of items that people and professionals, regardless of their orientation within the criminal justice system, may agree as representative of depravity. The studies have gathered input from over 2,000 respondents, and have controlled for a number of important variables that might affect how different people appraise depravity.

The findings of this research are also presented. These include the discovery that certain aspects of attitudes, actions, and motivations represent depravity to defense attorneys and prosecutors alike, as well as to forensic mental health professionals.

Sample notorious cases are presented for their concordance with and dissimilarity to these findings. Implications for the forensic scientists are discussed, from the role of the pathologist, to the psychiatric interview, to evidence gathering.

Those who attend this session will learn of the areas of the specific items that have achieved most consistent support for their being representative of depravity. Important variables that distinguished the response patterns of over 2,000 participants are reviewed as well. In addition, the problems, as well as the potential benefits, of presenting such data to the courts will be discussed.

The participant also will gain an understanding of the utility of defining depravity to areas of the law such as personal injury, employment law, and family law. The multidisciplinary efforts of forensic science in resolving these questions are presented for application to future casework.

Depravity, Forensic Science, Forensic Psychiatry

BS3 Let's Go to the Videotape: Movies and the Law

*Linda B. Kenney, JD**, Civil Rights/Trial Attorney, Law Office of Linda B. Kenney, The Galleria 2 Bridge Ave., Atrium Bldg #5, 2nd floor, Red Bank, NJ; *Haskell M. Pitluck, JD*, Illinois Supreme Court, none, Crystal Lake, IL; *James E. Starrs, LL.M.*, Professor of Law and Forensic Science, The George Washington University, Washington, DC

It is the objective of this seminar to provide an overview of significant movies that have teaching value to lawyers and expert witnesses in order to demonstrate what constitutes a successful presentation of an expert in the courtroom. How can we forget *My Cousin Vinny* which demonstrated the value of "lay expert" witnesses? However, many other movies have touched upon the value of forensics and the proper preparation and presentation by lawyers and witnesses in the courtroom of forensic-related issues. This video seminar will explore various movies ranging from Charlie Chan, who preceded Dr. Henry Lee as the first Chinese Sherlock Holmes.

In the early Charlie Chan movies, the famed Chinese detective discussed staged crime scenes, transfer of evidence, time of death, forensic science, wrongful convictions and even performed a blood spatter demonstration in *Charlie Chan at the Racetrack* (1936). Sherlock Holmes stated that he was "familiar with forty-two different impressions left by tires." How did these experts fare when it came time for examination in the courtroom? The seminar also will include other movies such as *Witness for the Prosecution*, where we learn about hearsay, bloodstains, and knife wounds from Charles Laughton, Tyrone Power, and Marlene Dietrich. *Primal Fear*, with Richard Gere, Edward Norton, and Frances McDormand, teaches us about psychologists, academicians, and dissociative disorders. *Presumed Innocent*, with Harrison Ford and the late Raoul Julia, demonstrates what it takes to really examine a witness in the courtroom. The participating attendees will learn from the actors what it really takes to be a successful courtroom presenter. That is, if breakfast doesn't get in the way! As Sherlock Holmes stated, "The faculties become refined when you starve them. Why, surely, as a doctor, my dear Watson, you must admit that what your digestion gains in the way of blood supply is so much lost to the brain. I am a brain, Watson. The rest of me is a mere appendix. Therefore, it is the brain I must consider."

Witnesses, Preparation, Movies

BS4 Fingerprint Evidence and the Nature of Forensic Science

Simon A. Cole, PhD*, Cornell University, Department of Science & Technology Studies, Ithaca, NY, USA

This paper proposes that the discipline of Science & Technology Studies (S&TS), an interdisciplinary field drawing on sociology, history, politics, and philosophy of science and technology, can be of utility in helping courts and scientists understand and articulate what is meant by the term "scientific evidence." While "science" is notoriously difficult to define, S&TS can help clarify the Supreme Court's guidelines for scientific and technical evidence explicated in the recent *Daubert* and *Kumho* decisions.

In the 1990s, the Supreme Court superseded the *Frye* "general acceptance" standard for scientific evidence with five *Daubert/Kumho* guidelines: testing, standards, peer review, error rate, and general acceptance. While *Daubert* was widely viewed as a more liberal standard, for some fields it was actually more stringent. Forensic fingerprint identification, with a long history of general acceptance and a paucity of testing, was just such a field. Indeed, it now seems likely that *Daubert*, which was framed in a civil, "toxic torts" case, may have a considerable - and probably unintended - impact in criminal litigation as it is applied to forensic science.

This paper uses forensic fingerprint identification as a case study to illustrate the potential impact of *Daubert/Kumho* on forensic science. A great deal of controversy has been generated recently as defense attorneys have used the Supreme Court's new standards for scientific and technical evidence to challenge one of the oldest and most revered forensic techniques, latent fingerprint identification. Defense attorneys have filed more than a dozen *Daubert* challenges to forensic fingerprint identification. The National Institute of Justice (NIJ) issued an "Assessment of Status and Needs" and a "Request for Proposals" calling for research into the validity and reliability of forensic fingerprint identification. These documents may or may not (depending on who you ask) have constituted an admission on the NIJ's part that such validation did not yet exist. A full-blown controversy has emerged over whether fingerprint identification has a scientific basis and, if so, what that basis is. The controversy has begun to receive attention in the national press and was featured prominently on the AAFS's website.

For convenience, the contours of the controversy may be outlined according to the *Daubert/Kumho* factors themselves:

- Testing: Does a century of adversarial litigation count as testing? Furthermore, what is the hypothesis to be tested? Is it, as fingerprint examiners contend, that all friction ridge arrangements are unique; or, is it, as critics insist, that fingerprint examiners can reliably match latent fingerprints with their source fingers?
- Standards: What is the standard for a forensic fingerprint match? Is it a certain number of matching ridge characteristics, as traditionally believed; or, is it, as is now being argued by many practitioners, the subjective judgment of the examiner? Is either of these a legitimate standard? More peripherally, what are the standards of training, certification, and competence for fingerprint examiners?
- Error rate: Has an error rate for forensic fingerprint identification been calculated? If so, is it unacceptably high? If not, is fingerprint examiners' claim that the error rate is zero a scientific claim?
- Peer review/General acceptance: What is the appropriate peer group to evaluate and scrutinize the claims of fingerprint examiners? Should it be restricted to fingerprint examiners themselves, or should it be extended to forensic scientists more broadly, or even scientists in general?

The seminar will discuss how fingerprint identification fares under all of these criteria and contrast it with other forensic sciences. The paper concludes that forensic fingerprint identification does not meet the *Daubert/Kumho* criteria and that *Daubert/Kumho* can serve as useful

mechanisms exposing the weaknesses and untested assumptions embedded in some forensic practices. The paper will seek to offer a clearer articulation of what science is and how this conceptual framework might be applied to the forensic sciences more broadly.

Fingerprint, *Daubert*, Validation

BS5 An Unexcited Criminal Leaves No Fingerprints: And Nine Other Fingerprint Canards

James E. Starrs, Professor*, The George Washington University, 720 20th Street, NW, Washington, DC

The objective of this seminar is to augment an awareness of the fallacy of relying on unproven assumptions in fingerprinting or elsewhere in the various disciplines of the forensic sciences in reaching conclusions upon which courtroom testimony is based.

Fingerprinting, for more than 100 years, has been the standard-bearer leading the way into court for numerous other forensic methods, such as DNA profiling and infrared spectroscopy. What has been rarely recognized is that fingerprinting is rife with assumptions, which have verged on becoming myths. These assumptions have been such regularized hand-me-downs that, until recently, no one has challenged them in a concerted, organized and determined way.

Whether attributable to the new admissibility standards of the United States Supreme Court's 1993 decision in *Daubert vs. Merrell Dow Pharmaceuticals Inc.*, the December 2000 revisions of the Federal Rules of Evidence or just a wake-up call to defense attorneys springing from the much publicized criminal trial of O.J. Simpson, the venerable and venerated status of fingerprinting is now under attack.

The question posed in this seminar is whether there is any justification for the current spate of pre-trial (motions ad limine) and trial assaults upon the admissibility of fingerprint identifications and/or the weight to be accorded to such identifications. That question will be analyzed through the statement and explication of a number of common "theorems" which abound in the field of fingerprint identifications. What follows is a selection and summary statement of a goodly (or badly?) number of such so-called self-evident truths of fingerprinting:

1. Fingerprint identifications are bottomed upon scientific principles and methods.
2. A non-numeric basis for fingerprint identifications is not unscientific.
3. Limiting fingerprint comparison's conclusions only to "idents" or "non-idents" or "unsuitable" is not unscientific.
4. Selecting only ridge characteristics, which frequently appear on fingers, does not render fingerprint comparisons unscientific.
5. Every latent fingerprint and every part of every latent print is unique to one person and only one person.
6. For more than 100 years no fingerprints from two different persons have been shown to be identical, proving the uniqueness of each person's fingerprints.
7. The error rate in fingerprinting being nil, fingerprinting is infallible.
8. Latent fingerprints at a crime scene result from the perpetrator's being highly excited during the commission of the crime.
9. The historic practice of comparing a full fingerprint to another full fingerprint is a solid precedent for validating latent to rolled (inked) fingerprint comparisons.
10. The accumulation of dust on a latent fingerprint can be a basis for determining the age of the latent fingerprint.

Fingerprint, *Daubert*, Error Rate

BS6 Method of Quality Assurance Using Digital Network Architecture

Flora Kan, MS, 362A Christopher Ave., Gaithersburg, MD*

The objective of this seminar is to present how a computer digital network architecture can monitor, trace, reproduce, prove, forecast laboratory process of Deoxyribonucleic Acid (DNA) samples for quality assurance. The outcome enables the forensic community to validate and verify laboratory processes electronically and to increase the courtroom admissibility of DNA scientific evidence.

The physical evidence, Deoxyribonucleic Acid (DNA), is a silent, definite witness. Heralded as the most powerful and discriminating method of identifying the source of biological evidence available to the criminal justice system, forensic DNA testing has evolved both in the technologies it uses and its principles and theories to promote the reliability and courtroom admissibility. To ensure the courtroom admissibility, DNA scientific evidence involves two general considerations: the acceptance of the science itself, called scientific validity, and the proficiency of expert witness. Furthermore, DNA scientific evidence must include the analysis fact, principles, theories and the underlying data. Scientific facts, principles, and theories are presented and explained to the jury through expert testimony. Expert witnesses testify according to the Rules of Civil Procedure. Judges determine the scientific validity of scientific facts, principles, and theories, and are the gatekeepers to eliminate expert witnesses whose work is not scientific, peer reviewed, published, tested, or subjected to normal scientific scrutiny.

Expert witnesses should not only understand the science that they wish to present, but also be able to apply it to the facts of the case, understand the needs and viewpoint of their audience, translate scientific facts and opinions accurately from professional scientific terminology so that the trier of fact will comprehend it, and recall the testimony at the time of the decision making. The underlying definition of the expert witness is provided in Sections 702 of the Federal Law of Evidence and in the corresponding definitions of the Law of Evidence in every State: (Revised) Rule 702. Testimony by Experts (Revised August 8, 1998, by the National Commission on Uniform State Laws, and submitted to the Federal Judicial Council) reads as follows: "If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact at issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise. When determining the reliability of a principle or methodology, the court shall consider all relevant additional factors, which may include testing, research methods, peer review, rate of error, experience of expert and acceptance in the field."

Thus, laboratory scientists must assure the quality of laboratory casework and the expert witness must understand the forensic DNA testing casework and its science. These cover sample management, chain of custody, protocols, forms, laboratory casework, test results, quality issues, data interpretation, proficiency of laboratory scientists, security, privacy, review, reporting and archival. Additionally, DNA scientific evidence shall be collected and preserved from contamination. Most importantly, it shall be preserved from the DNA of the known blood sample of the defendants taken from them while in custody. Errors having occurred in a laboratory casework include, but are not limited to, incomplete chain of custody, wrong tests, scheduled procedure not performed, no testing chronology, no details of supervisory oversight, no signature, wrong samples used to test, samples contaminated or damaged, improperly stored/handled, samples lost, test failure and lost/erased casework documents. Correctly, consistently, and repetitively validating and presenting DNA scientific evidence becomes difficult, time-consuming, and tedious. The degree of the courtroom admissibility of DNA scientific evidence becomes arbitrary assessment among the forensic community.

The method of quality assurance is based on the conception of Electronic Case Folder (ECF) - the organization of forensic DNA labo-

ratory data in a logical sequence. ECF allows for the storage and processing of data information - who, where, when, how, and what was performed on data addition or modification. This conception is realized in both database design and the application business rules that are generally implemented in a graphical user interface. ECF data is the initial package of forensic DNA samples, laboratory specimens, chain of custody, processing methods, Standard Operating Procedure (SOP), processing results, notes, reports, and peer reviews. SOP is a set of instructions with a text for laboratory scientists and directives and commands to issue to the computer. Major characteristics of the ECF are the access rules, the rules of data classification, the rules of numerating ECF contents, the rules of the content modification, and the rules of the data archiving/retrieving. ECF archival and retrieval complete the life cycle of electronic records and enable the reproduction of forensic DNA scientific evidence. Furthermore, the method of quality assurance shall allow selecting and generating the printed output of text, number, and images from the content of ECF for the courtroom testimony.

The method of quality assurance retains DNA scientific evidence to validate reliably and to perform repetitively and systematically the following tasks:

- identify the issues;
- provide relevant scientific information;
- identify the relevant facts for jury;
- provide opinions;
- explain the basis of the opinions;
- identify disagreements with the opposing opinions; and,
- build credibility.

The advantages of the method of quality assurance are that they:

- document the research methods in testing the principle and methodology;
- establish a standard for the quality assurance that validates the scientific work;
- define goals, objectives, rules and procedures involving testing and modeling;
- evaluate and determine the performance and outcome of the research methods, the standard, goals, objectives, rules, and procedures;
- enable the scientific work to abide by regulation;
- enable the repeatability of the scientific work; and,
- enable the design of the research methods, the standard, goals, objectives, rules and procedures to achieve the purposes of cost savings, risk management, safety, and quality.

Expert Witness, Quality Assurance, Courtroom Admissibility

BS7 Britain's Most Prolific Serial Killer

John D Rutherford, BSc, Forensic Pathologist, Manchester, United Kingdom, Ridgefield House, 14 John Dalton Street, Manchester, United Kingdom*

The objective of this seminar is to present the lessons learned from the investigation of Britain's most notorious serial killer, Dr. Harold Shipman, a trusted family physician, who murdered a large number of his patients over a period of many years. There have been major repercussions on the British medical system of certification and continuing accreditation as well as on the Coronial "death handling" system.

On January 31, 2000, Dr. Harold Shipman, a primary care physician in Greater Manchester, United Kingdom, was convicted of the murder of fifteen of his patients. This heinous crime came to light after the discovery of a forged will and led to the exhumation of 12 of his alleged victims and a detailed police investigation of the circumstances surrounding these and many other deaths. There were serious problems in carrying out the investigation, the police having to tread a delicate path between gathering evidence, whilst Dr. Shipman was still practicing, of sufficient value for a

conviction and not arousing suspicion such that tracks could be covered. The police were also aware that in his community Dr. Shipman was a trusted family physician; to raise alarm prior to the collection of convincing evidence may have created unjustifiable waves of panic amongst patients and their relatives.

About two years prior to this major investigation a suspicious clinical colleague had asked the police to carry out a discreet investigation, but at that time there was insufficient evidence to draw definite conclusions and justify taking the matter any further.

During the course of collection of evidence Dr. Shipman's personal background was investigated, and it was found that he had suffered professional difficulties many years previously when he had been treated for drug addiction whilst working in another part of the country. This was unknown to his patients in his current practice.

Most of his victims had been cremated, but it was possible to exhume 12 of 20 interred bodies and in nine of these there was sufficiently strong toxicological evidence to present a convincing prosecution case. Circumstantial evidence was sufficiently strong in a further six to permit prosecution of those also. The trial took place in late 1999 at Preston Crown Court in the North West of England and resulted in jury convictions in all 15 cases. Because the death penalty is not an option in the United Kingdom, Dr. Shipman was sentenced to life imprisonment.

As a result of public demand, further investigations, subsequent to Dr. Shipman's conviction, included those carried out by the Coroner locally as well as a public inquiry instigated by the government. The latter is still in progress and current indications are that the number of victims will probably exceed 400.

The overall impact of such a scandal has caused serious repercussions on the British medical accreditation system. Intense review of fitness to practice codes, that is, monitoring of individual performance and statistical comparisons of death rates in similar practices, is in progress. Serious review of the Coronial system is under way and the question is being asked: would all this have occurred had a medical examiner system been in place? This review and reconstruction process will still be in evolution at the time of the 2002 Academy meeting and major changes are likely to take years to implement.

Serial killers will probably always be with us in one form or another. Practicing physicians are in possession of powerful weapons to effect murder and are in a strong position to cover their own tracks. This bestows upon them power and responsibility beyond that endowed upon the average person in the street. This is a burden that nearly all respect and bear willingly, but it is one which, as illustrated by this case, is all too easy to abuse. Trust, sadly, is no longer enough. State and strict accreditation board "policing" is regrettably becoming ever more necessary.

Serial Killer, Forensic Toxicology, Family Physician

BS8 Tom Krauss Memorial Bite Mark Breakfast—Dealing With the Media in High Profile Bite Mark Case

James L. Vance, FBI Academy, LECU, Quantico, VA*

At the conclusion of this presentation, the attendee should have a clear understanding of how to deal with the media in a high profile bite mark case and know how to interact and control the media.

There have been many high profile media events that have heightened public awareness of the heretofore little publicized world of forensic scientists.

As a result, forensic odontologists will be sought out by an ever more aggressive news media for commentary on their work and its relevance, particularly in high profile bite mark cases. While rarely an easy undertaking, proactive media relations can pay big dividends, both in terms of clarifying confusing issues and in highlighting the forensic odontologist's important, and often misunderstood work. Failure to deal with the media, on the other hand, won't make them go away and usually makes a bad story worse.

For the field of forensic odontology in the 21st century, successful media relations are as much an imperative as any other responsibility odontologists have.

Media, Forensic Odontologists, Interact

Academy-Wide Luncheons

L1 **A Deadly Mix of Hairspray and Acetaminophen**

Alden K. Henderson, PhD, MPH, Centers for Disease Control and Prevention, Atlanta, GA*

Dr. Henderson will present an investigation conducted in December 1992 in North Dakota. In September 1992, four adult Native Americans died from hepatic and renal failure within five weeks of their admission to a hospital in North Dakota. The decedents initially complained of abdominal pain, nausea, vomiting, fatigue, or loss of appetite that began one to two weeks before hospitalization. Their physical examination revealed hepatomegaly, ascites and jaundice. Laboratory findings included a profound hyperbilirubinemia and leukocytosis; serologic screens for viral hepatitis and bacterial cultures were negative. Each decedent had had a history of chronic alcohol abuse and had gone on an alcoholic binge just prior to their illness. Autopsies were not performed. The North Dakota Health Department invited the Centers for Disease Control and Prevention to assist in the investigation. Dr. Henderson will describe the investigation to determine the cause of their deaths.

Acetaminophen, Hairspray, Cause of Death

L2 **The Aftermath of *Gone With the Wind* — Anthropological Investigation of Civil War Burials**

Douglas W. Oswley, PhD, Department of Anthropology, National Museum of Natural History, Room 343, Smithsonian Institution, Washington, DC*

Confederate and Union military burials are still being discovered 136 years after the Civil War. Remains have been found at some of America's most important battlefields including Antietam, Gettysburg, New Market, Port Hudson, Glorieta Pass, and Brandy Station. This program will illustrate how archaeological, forensic anthropological, and historical research can identify remains and associated artifacts as to military unit, individual identity, and cause of death. Some of these discoveries are accidental, but others have resulted from planned investigations designed to answer specific questions or honor last requests. The discovery of the lost Confederate dead from the siege of Port Hudson, for example, resolved a contentious local controversy, through the identification of the men of the Washington Artillery killed in crossfire during the Battle of the Rappahannock which helped save a battlefield from development, and, the inventorying of bones interred with the tomb of the unknown soldier at Gettysburg which separated "the fallen" from the "dearly departed."

Attention will also be directed to current investigation of the Confederate submarine, the *H.L. Hunley*, which, after sinking the *U.S.S. Housatonic*, disappeared into the depths of Charleston Harbor on February 17, 1864. The *Hunley* was successfully raised in August 2000, and is the subject of an intensive study and conservation effort, including comprehensive forensic analysis of the remains of the crew. Although seemingly only a fascinating application of the forensic anthropologist's expertise, investigations of Civil War burials have led to dramatic advances in understanding the postmortem taphonomic processes and in determining the length of the postmortem interval.

Civil War, Burials, Anthropology

Workshops

W1 GHB: Old Substance, New Problem

Adam Negrusz, PhD, Assistant Professor of Forensic Sciences, University of Illinois at Chicago, College of Pharmacy, 833 South Wood Street, Chicago, IL; Fiona J. Cooper, PhD*, Senior Fellow, Post Doctoral Fellow, Washington State Toxicology Laboratory, 2203 Airport Way South, Suite 360, Seattle, WA; Marc A. LeBeau, MS*, Unit Chief, Federal Bureau of Investigation, FBI, US Department of Justice, 935 Pennsylvania Avenue, NW, Washington, DC; Laureen J. Marinetti, MS*, PhD Student at Wayne State University, Wayne State University, Department of Pharmaceutical Sciences, Detroit, MI; Lowell A. Borgen, PhD*, Senior Director of New Medicine Development, Orphan Medical, Inc., 13911 Ridgedale Drive, Minnetonka, MN; Deborah L. Zvosek, PhD*, Research Associate/Investigator, Department of Emergency, Hennepin County Medical Center, 4653 Colfax Avenue South, Minneapolis, MN; Stephen W. Smith, MD*, Assistant Professor, Faculty Emergency Physician, University of Minnesota School of Medicine, Minneapolis, MN*

Upon completion of this workshop, the participant should be able to understand the physiological significance and mechanism of action of gamma hydroxybutyrate (GHB), therapeutic use, mechanism of dependence, analytical methods used in toxicological investigations, see the scale and extent of GHB abuse, clandestine synthesis, realize how difficult the interpretation of analytical data in the investigation of death or drug-facilitated sexual assault can be, understand the complexity of acute poisoning with GHB, principles of treatment, withdrawal, role of the Internet, and be familiar with the most current research in the field of GHB and related compounds.

This workshop will address many aspects of use and abuse of gamma hydroxybutyrate (GHB) and related compounds. This includes therapeutic use of GHB, acute poisoning with the compound, driving under the influence, rave parties, and drug facilitated sexual assault. Analytical methodologies as well as interpretation of urine and tissue levels will also be presented. The workshop will present the most current research on GHB using experimental animal and clinical studies in humans.

The workshop will focus on major toxicological issues associated with use and abuse of GHB and related compounds such as gamma butyrolactone (G13L) and 1,4 butanediol (1,4 BD). GHB is an endogenous substance, a metabolite of GABA. GHB has been used as an anesthetic but also as a food supplement. Its use was reported in treatment of narcolepsy and alcohol withdrawal. During the last few years an alarming increase in GHB illicit use is observed. It is becoming a widely preferred abused drug of abuse in the United States, frequently reported as a substance used by perpetrators in drug-facilitated sexual assault to incapacitate their victims.

This workshop will review major milestones in GHB history from its discovery and synthesis in the early 1960s. Many interesting details regarding controlled clinical studies in humans will be revealed. In addition, a variability of endogenous concentrations of this compound in urine will be discussed. Several other important problems will be presented, such as advantages and limitations of commonly used analytical techniques, the interpretation of toxicological findings in an emergency room setting, drug-facilitated sexual assault scenarios and postmortem specimens. The most current research with animals, especially correlations between behavioral effects of GHB and its concentrations, will also be addressed. Finally, the clinical practitioners will share their research and observations on acute toxicity of GHB, use patterns, addiction and withdrawal.

Gamma Hydroxybutyrate, GHB Toxicology, Drug-Facilitated Sexual Assault

W2 Forensic Photography

David S. Goldman, BSEE, MSEE, PE, David Lee & Associates, Inc., Adams-Fay House, 20 Fruit Street, Hopkinton, MA; Mark I. Marpet, PhD, PE*, St. John's University, (H)14 Cowie Road, Chester, NJ; Robert J. Carruthers*, Nikon Forensic Services/Program Coordinator, Nikon USA, 1300 Walt Whitman Road, Melville, NY*

Upon completion of this workshop, the participant should be able to produce greatly improved evidentiary photographic materials for use in case preparation, deposition, and trial testimony. The participant should better understand photographic equipment and should also be able to better select the proper films and format to produce the evidentiary material.

The program will consist of the following: The anatomy of the camera, proper camera handling and maintenance, exposure selection (auto and manual), speed and aperture controls, lens and format with relation to proper selection for each assignment, evidence recording, film selection and film use (black and white, color, negative transparency, UV and IR), flash - close-up and full scene coverage (automatic and manual controls), close-up, micro, and macro photography used in evidence, general scene coverage and crime scene coverage.

The workshop will begin with a quick review of some of the basics of Forensic Photography. The heart of the program will be discussions on general scene coverage and crime scene coverage. The workshop will conclude with a discussion of digital camera, printer, and scanner equipment review that will cover the latest development in digital equipment technology.

Forensic Photography, Crime Scene Photography, Digital Photography

W3 International Forensic Automotive Paint Data Query (PDQ)

Don A. McDougall, FTIR/PDQ Royal Canadian Mounted Police, 1200 Vanier Parkway, Ottawa, Ontario, Canada; David B. Flohr, MS*, US Army Criminal Investigation Laboratory, 4553 North 2nd Street, Forest Park, GA*

Upon completion of this workshop, the participant should be able to utilize effectively the Paint Data Query (PDQ) program for three distinctly different purposes: generating potential manufacturer, make, model, assembly plant, and year information for questioned paints recovered from items collected from hit-and-run incidents; conducting a significance assessment for paints from K/Q comparisons that may then be used to lend weight to that evidence in court; and, maintaining and enhancing professional expertise and understanding of automotive paint systems as a result of having a searchable database that supports more than 12,000 paint systems and contains pigment/binder information and infrared spectra for over 43,000 individual paint layers.

This workshop is designed to be a hands-on training session in which the attendees will receive instruction in the organization of the database, will practice classifying paint systems, will enter queries into PDQ, and will gain the basic interpretive skills necessary for evaluating the results obtained from a search. Having an understanding of the program and confidence in the query parameters entered, the paint examiner will be able to provide an accurate assessment of dye possible sources for a questioned paint, utilize the database for making significant assessments for paints in K/Q comparative situations, and utilize the

database for maintaining their understanding of the structure and chemistry of modern automotive paints.

For more than twenty-five years, the Royal Canadian Mounted Police (RCMP) has been gathering chemical and color information on automotive paints. Beginning in the 1970s, systems for classifying, storing and retrieving that data for manufacturer, make, assembly plant, and year determination were developed by the Royal Canadian Mounted Police. PDQ is the most recent PC - Windows™ based version of the RCMP's automotive paint classification system for domestic and foreign (Japan and European) vehicle coatings. PDQ is not a population database but a representative database. As such, it is used as a tool to present the paint examiner with possible sources for a paint system based on a searchable text based query program. The number of samples, which an examiner would then have to compare in order to affect a manufacturer, make, model, assembly plant, and year determination, is reduced to those which most closely match the chemistry, color, and/or source information that were utilized for the query. The RCMP and/or the FBI maintain the original paint samples. As necessary, sample splits may be obtained for a side-by-side examination and comparison with a questioned paint.

This workshop is designed to be a hands-on training session in which the attendees will receive instruction in the history and organization of the database, will practice classifying paint systems for entry into PDQ, and will gain the basic, interpretive skills necessary for interpreting the results of a search. Prior training and practical experience in paint analysis and FTIR paint examinations and classifications are required. Upon completion of this workshop, the participant should be able to effectively utilize the Paint Data Query program for three distinctly different purposes: (1) generating potential manufacturer, make, assembly plant, and year information for questioned paints recovered from items collected from hit-and-run incidents; (2) conducting a significance assessment for paints from K/Q comparisons that may then be used to lend weight to that evidence in court; and (3) maintaining and enhancing professional expertise and understanding of automotive paint systems as a result of having a searchable database that supports more than 12,000 paint systems and which contains pigment/binder information and infrared spectra for over 43,000 individual paint layers. Attendees wishing to keep PDQ must be from a recognized police agency, sign a non-disclosure confidentiality agreement upon registration, and agree to annually contribute 60 original full layer automotive paint samples to the PDQ maintenance team for analysis and inclusion into the database. In addition, each attendee should bring a laptop computer with the following minimum requirements: Pentium/WIN95, CD-ROM, 16 MB RAM, and 50 MB free HD space. Finally, full utilization of PDQ requires Sadtler Searchmaster or Galactic Spectral ID software and dye glossy and matte Munsell Color books. These items are not provided with the workshop.

Paint Data Query (PDQ), Automotive Paint Database, Hit-and-Run Vehicle Identification

W4 Bloodstain Patterns: So You Know All About Them. . .or Not

Anita K.Y. Wonder, MA, Director, Wonder Institute, PO Box 1051, Carmichael, CA; G. Michael Yezzo*, Senior Forensic Scientist, Ohio BCI&I, PO Box 365, London, OH; Diane Scala-Barnett, MD*, Deputy Medical Examiner, Lucas County, Ohio, 2702 Stoneleigh Drive, Toledo, OH; Dennis Dolezal*, San Jose Police Department, San Jose, CA*

Upon completion of this workshop, participants will have information which qualifies the evidence as a science discipline, will have an appreciation of the broad range of applications to which the methodologies of bloodstain pattern analysis may be used, and will have expe-

rienced how objective techniques may be used in problem solving with bloodstain patterns.

The subject of bloodstain patterns has gained considerable recognition over the past few years, yet the science community remains ambivalent toward acceptance of it as an objective methodology. This workshop will provide science principles from biorheology, medical science, and fluid mechanical engineering beyond simple physics principles. Recent developments qualify the field as a full science discipline. Useful information will be presented for the benefit of investigators from all stages of application. The program emphasizes expanding evidence use for bloodstain pattern analysis as a means to justify budgets for training. Bloodstain patterns not only lend themselves well to team approaches but may require such in investigations. This class will provide the different exercises for practice in team problem solving with bloodstain patterns.

The instructors will provide at least four viewpoints of the material as it exists and as it is regarded in investigations: police, crime laboratory, pathology/medicine, and law/public opinion. Exercises will be included which provide hands on application of objective criteria. Special attention will be given to identifying blood sources and correlating with casework. The use of bloodstain patterns to rapidly resolve questions during major and minor traffic accident investigations will also be presented.

Bloodstain pattern evidence may be the most economical investigative tool available. Join the program participants to learn rapid, objective techniques to expand application and benefits from bloodstain pattern evidence.

Bloodstain Patterns, Crime Scene Investigation, Biorheology

W5 Forensic Mitochondrial DNA Analysis: A Community Forum

Alice R. Isenberg, PhD, Forensic Examiner, DNA Unit II, FBI Laboratory, 935 Pennsylvania Avenue, NW, Room 3505, Washington, DC; Constance L. Fisher, PhD*, Forensic Examiner, DNA Unit II, FBI Laboratory, 935 Pennsylvania Avenue, NW, Room 3505, Washington, DC; Catherine E. Theisen, PhD*, Forensic Examiner, DNA Unit II, FBI Laboratory, 935 Pennsylvania Avenue, NW, Room 3505, Washington, DC; Bruce Budowle, PhD*, FBI Laboratory, 935 Pennsylvania Avenue, NW, Room 3505, Washington, DC; Kevin W.P. Miller, PhD*, Forensic Examiner, DNA Unit II, FBI Laboratory, 935 Pennsylvania Avenue, NW, Room 3505, Washington, DC; Patricia Aagaard, BS*, Forensic Examiner, FBI Laboratory, FBI Academy, Quantico, VA; Robert P. Biancavilla, MPS, JD*, Nassau County Distract Attorney's Office, 262 Old County Road, Mineola, NY; Robert A. Bever, PhD*, The Bode Technology Group, 7364 Steel Mill Drive, Springfield, VA; William J. Watson, MS*, GreenScreen, 2600 Stemmons Freeway, Suite 133, Dallas, TX; Gina M. Pineda, BS*, ReliaGene Technologies, Inc., 5525 Mounes Street, Suite 101, New Orleans, LA; Christine A. Boyer, MSFS*, Armed Forces DNA Identification Laboratory, 1413 Research Boulevard, Building 101, Rockville, MD; Shawn M. Weiss, BS*, Laboratory Corporation of America, 1912 Alexander Drive, Research Triangle Park, NC; Terry Melton, PhD*, Mitotyping Technologies, LLC, 1981 Pine Hall Drive, State College, PA; Steve R. Fain, PhD*, US Fish and Wildlife Service, 1490 East Main Street, Ashland, OR; Jeffrey D. Wells, PhD*, University of Alabama at Birmingham, 901 South 15th Street, Birmingham, AL; Mark R. Wilson, MA*, FBI Laboratory, DNA Unit II, FBI Academy, Quantico, VA; Rebecca Reynolds, PhD*, Roche Molecular Systems, Inc., 1145 Atlantic Avenue, Alameda, CA; Tom J. Parsons, PhD*, Armed Forces DNA Identification Laboratory, 1413 Research Boulevard, Rockville, MD; Peter M. Vallone, PhD*, National Institute*

Upon completion of this workshop, the participant should understand the sequence interpretation guidelines and statistical analyses generally being used in the forensic mtDNA community, including the recommendations of the Scientific Working Group on DNA Analysis Methods (SWGAM); understand the data basing efforts taking place in the mtDNA community, including missing persons and population data; understand the legal issues faced by the forensic mtDNA community; hear the advice of case working labs from across the country regarding current issues with forensic mtDNA analysis; appreciate the application of mtDNA analysis in the areas of ancient mtDNA and non-human mtDNA, as well as phylogenetic studies of human mtDNA sequences; and, recognize the areas of research in forensic mtDNA analysis, including method development, technologically advanced analysis platforms, and single-nucleotide polymorphisms.

This workshop will feature presentations from many different segments of the forensic mitochondrial DNA analysis community. The morning presentations will focus on topics related to traditional forensic casework, starting with a brief overview of the major issues involved in mtDNA analysis, a review of the proposed Scientific Working Group on DNA Analysis Methods (SWGAM) guidelines for mtDNA analysis data interpretation, and a presentation on statistical interpretations of mtDNA data. Next, the Mitochondrial DNA Population database will be discussed in conjunction with CODISmt (the mitochondrial DNA component of the CODIS system) and the National Missing Persons DNA Database. The workshop will then focus on legal issues related to forensic mtDNA analysis, followed by a casework discussion from labs across the country.

The afternoon session will begin with presentations on alternative applications of mtDNA analysis in the forensic community. Ancient mtDNA analysis will be discussed as well as mtDNA analysis at the U.S. Fish and Wildlife Service and non-human mtDNA analysis. A presentation on phylogenetic analysis of human mtDNA will wrap up the discussion on alternate applications of mtDNA analysis.

The final segment of the workshop will focus on future directions in mtDNA analysis, including different analysis platforms and methods of analysis. This session will begin with a presentation on immobilized mtDNA sequence specific oligonucleotide probes followed by a presentation on the latest research being performed at the FBI Laboratory. Single nucleotide polymorphisms, microchips, and microspheres, as well as the platforms on which these systems are analyzed, will complete the research topics examined in the afternoon session. The workshop will conclude with a presentation on the FBI's proposal for federal funding of regional mtDNA case working laboratories. Both the morning and afternoon sessions of the workshop will close with panel discussions of the subjects covered.

Over the past decade, mitochondrial DNA (mtDNA) analysis has become more widely used in the forensic community. Mitochondrial DNA analyses are particularly important in cases where nuclear DNA analyses are not possible due to insufficient sample quantity and/or quality, or lack of appropriate reference samples. While mtDNA analyses do not provide the discrimination potential of some nuclear DNA tests, mtDNA sequence is often the only information which can be gathered from a piece of evidence.

The interpretation of mitochondrial DNA sequences can become complex due to the presence of heteroplasmy or mixtures of mtDNA. The SWGAM has been working on a document containing guidelines for the interpretation of mtDNA sequence data. After an overview of forensic mtDNA analysis, these proposed guidelines will be discussed. Once an mtDNA sequence has been obtained, a weight assessment of this data must be performed to convey meaning to the trier of fact. In order to perform this weight assessment, population databases must be

searched. Statistical analyses of mtDNA sequence data will be discussed along with the mtDNA population database maintained by the FBI Laboratory and associated with the Combined DNA Indexing System mtDNA component (CODISmt).

Missing persons cases demonstrate a valuable use of forensic mtDNA analysis. Remains can be associated with a maternal lineage through databases of mtDNA sequences from families of missing persons to provide some closure to those families. The National Missing Persons DNA Database program will be discussed along with its effort to facilitate the identification of missing persons' remains.

As mtDNA analyses are performed in more criminal cases in the United States, more of these cases are tried in court. The admissibility of mtDNA evidence in several cases will be examined and examples from private laboratories of other cases containing pivotal mtDNA evidence will be described.

While human forensic mtDNA analysis in criminal cases may be the most familiar to the traditional forensic scientist, other applications of mtDNA analysis are also of forensic interest. Much work is being done to attempt to amplify ancient human samples for mtDNA sequence analysis, as well as animal and insect mtDNA. Evolutionary biologists have been performing phylogenetic analyses on mtDNA data for many years, but the potential exists that a phylogenetic analysis could prove informative to the forensic scientist as well. All of these topics will be addressed in the afternoon session of the workshop.

Once the current issues of forensic mtDNA analysis have been addressed, the future directions of the field will be explored. Hot topics in the field include immobilized mtDNA sequence specific oligonucleotide probes, single nucleotide polymorphisms, microchips, and microspheres. The final topic of the workshop will interest laboratories looking to implement forensic mtDNA analysis at their own facilities. The FBI has proposed federal funding to aid in the establishment of regional mtDNA case working labs to aid laboratories that may not have the funding or constant need for mtDNA sequencing facilities. The terms of this proposal will be discussed.

Finally, panel discussions will allow attendees to address their specific questions and concerns to the speakers after both the morning and afternoon sessions.

Mitochondrial DNA, Missing Persons, CODIS^{mt} Database

W6 The Disaster Mortuary Operational Response Team (DMORT) Model for Managing Mass Fatality Incidents (MFIs)

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Upon completion of this workshop, coroner/medical examiner participants should be able to assess and manage response to mass fatality incidents (MFIs) within their jurisdictions and utilize available external resources as needed; forensic specialist participants should be able to organize and integrate their response as members of a multidisciplinary team; and, all participants should be able to recognize the increasing importance of forensic science in victim identification and other aspects of MFIs while planning for a future that may include incidents involving weapons of mass destruction (WMD).

During the past decade, the management of mass fatality incidents (MFIs) has undergone dramatic changes based in particular on the evolving roles of the forensic anthropologist, odontologist, pathologist, and other scientists in obtaining positive identification of the victims. In addition, some recent incidents and the potential for future terrorist activities have led to an increased focus on appropriate evidence collection and crime scene preservation. Fortunately, the U.S. Public Health Service Disaster Mortuary Operational Response Teams (DMORTs) provide trained and experienced teams of forensic and other specialists to assist local jurisdictions. The local coroners/medical examiners remain in charge of the victims' remains.

Forensic specialists and others who will share the knowledge gained from participating in the aftermath of air and train crashes, bombings, and natural disasters will exemplify this multidisciplinary model through presentations and discussions. Actual (or equivalent) specimens, radiographs, and other materials, including the most current DMORT computer programs, will be available for examination and/or demonstration.

Although this program is based primarily upon the DMORT model, it should provide participants with basic principles and information that will also be of use in planning and carrying out MFI management in general.

Public concern and expectations following recent mass fatality incidents (MFIs) whether due to accidents, natural disasters, or terrorist activity, have resulted in the increasing application of forensically based multidisciplinary approaches to managing victim identification and other aspects of the incident, including evidence recovery.

This is perhaps best seen in the composition and organization of the ten regional U.S. Public Health Service Disaster Mortuary Operational Response Teams (DMORTs). In addition to the morticians who first voiced concern about the proper care of victims and who remain today the backbone of DMORT, teams are composed of forensic anthropologists, odontologists, pathologists, fingerprint and computer specialists, and a variety of other support personnel. Team members are volunteers who become federal employees when activated during MFIs. The customary definition of an MFI is "one more fatality than local resources can handle," therefore the local coroner/medical examiner will make the decision to call in DMORT. Personnel deployed to each MFI will vary with the availability of local resources and the number of victims, but the basic approach is likely to be similar, starting with the use of the incident command system (ICS) for organization of personnel and activities including:

- The selection of a site for and establishment of a family assistance center (FAC) to aid in the acquisition of victim antemortem information while also providing progress reports for victim families and the media.

- The recognition, recovery and documentation of each unit of victim remains and associated evidence at the scene of the incident.
- The selection of a site for and establishment of an incident morgue for the processing and identification of recovered remains.
- The setting up and staffing of an information processing center to receive, process, and manage antemortem and postmortem victim data. Forensic specialists obtain the latter themselves from the remains at the morgue. (A recently developed DMORT computer program is used for data processing.)

The work at each of the above locations is facilitated with the aid of the DMORT Deployable Portable Morgue Unit (DPMU), which contains equipment ranging from section partitions to gurneys and computers that are palletized and ready for immediate deployment by air or overland to incident locations as well as with personnel to set up and take down the DPMU.

The roles and interactions of the various forensic specialists and others who staff these facilities are constantly evolving in response to lessons learned from each incident, as is the role of the federal government. For instance, in 1996, the National Transportation Safety Board (NTSB) was also tasked with coordinating federal and other resources to meet the needs of victims and their families in aviation and other transportation disasters, including reducing the potential for misidentification of victims through the appropriate use of forensic science. More recently, FBI Evidence Response Teams (ERTs) have begun to assist the NTSB in evidence recovery and documentation.

This workshop will provide a multidisciplinary overview and update on the role of the forensic sciences in MFI management for the coroners/medical examiners, forensic specialists, and others who must plan for the possibility of such incidents in their own jurisdictions.

Mass Fatality Incident, Forensic Identification Procedures, Multidisciplinary Teams

W7 The Medicolegal Investigations of Recreational Diving Fatalities

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Upon completion of this workshop, the participant should have a basic understanding of the special physiology and specialized equipment associated with self-contained underwater breathing apparatus (SCUBA) diving; appreciate the epidemiology of deaths associated with recreational diving, including geographic distribution, common causes of death, and contributing factors to these fatalities; investigate adequately and interpret the historical events and circumstantial evidence associated with diving fatalities; understand the recommended approach to the autopsy of persons who died while diving; and interpret the anatomical findings in the context of the historical events and have handout material and points of contact for future reference to competently investigate a diving related death.

This workshop is intended to provide a complete overview of diving physiology and pathophysiology so that investigators and pathologists leave the workshop armed with a general approach to investigating recreational diving fatalities. Using illustrative cases, the epidemiology and scenarios of fatal diving mishaps will be presented. Specific topics include gathering pertinent history, familiarization with dive equipment, modification of autopsy protocol with interpretation of the findings, and, from pertinent data gathered, determination of the most likely cause of death. A hands-on familiarization with diving equipment and resources for assistance in investigating these cases will be provided.

The popularity of recreational diving using scuba has increased dramatically over the past three decades. Present estimates place the number of active recreational divers in the United States at between 500,000 to one million. The number of fatalities involving U.S. citizens performing recreational dives averages 90-100 each year. These fatalities challenge the investigators and pathologists who must investigate and certify these deaths. Recreational diving fatalities are often litigated in civil court. This workshop is designed for the pathologist, criminalist, attorney, and General Section member who may become involved in the investigation of a scuba diving accident or fatality. The instruction level is intermediate.

The initial portion of the workshop will include a brief overview of diving physiology, including the effects on the body of breathing compressed air. The pathophysiology of barotrauma, nitrogen narcosis, oxygen toxicity, gas embolism, and decompression illness (caisson disease) will be reviewed. The pathophysiology of drowning will be reviewed since it is a frequent final outcome in a fatal diving mishap.

Following the discussion on physiology, the epidemiology and risk factors associated with recreational diving fatalities will be presented. A detailed presentation on the recommended investigation of a fatal diving mishap will be given using illustrative cases from south Florida and the Divers Alert Network (DAN). The importance of interviewing witnesses and gathering information on the diver's past medical history, diving experience, pre-dive status, and the circumstances surrounding the dive will be emphasized. The relevance of knowing the exact depth and bottom time of the dive, as well as when and where the diver began to run into difficulty, will be discussed. Additionally, the workshop will include a hands-on section where typical diving equipment will be available for examination and familiarization by attendees. This will be accompanied by a brief discussion on the evaluation of dive gear.

In the final portion of the workshop, we will review the autopsy protocol for scuba diving victims and emphasize those tests and observations that are helpful in determining the cause of death. The significance of finding intravascular bubbles will be discussed, as will the proper interpretation of the findings of the autopsy. Natural diseases likely to cause sudden incapacitation and death while scuba diving will be reviewed. Finally, related topics such as hazardous marine animals, zoophaga, and trauma leading to recreational diving fatalities will be presented.

Thorough handouts will be provided by the speakers, including checklists of important information to obtain regarding a diving mishap, a diving fatality reporting form, a suggested autopsy protocol for use with diving related fatality, and recommended resources for consultation and referral.

Cause of Death, Diving Fatalities, Medicolegal Investigation

W8 Practical Digital Photography

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Upon completion of this workshop, the participant should have a basic understanding of the technology behind digital photography, know the advantages and disadvantages of digital photography in forensic science, understand why digital images are easily manipulated and how to maintain their integrity, and understand how to capture and utilize digital photos.

This workshop will consist of a didactic discussion in which the participant will learn the basic technology behind digital photography and its advantages and disadvantages as it relates to forensic science. The notion that digital images are too easy to manipulate will be specifically addressed, as will methods of maintaining image integrity. Following the discussion, there will be a demonstration of the workflow of digital photography, including taking the picture, securely saving it in the computer, and using it for presentation.

Digital photography has become increasingly popular as the technology has improved and its cost has dramatically declined. Advantages of digital photography over traditional, film-based photography include improved convenience and reduced cost; its disadvantages are image quality and the possibility of hardware and/or software obsolescence. The use of digital photography for forensic applications has the additional obstacle of image integrity. Fortunately this is one of perception rather than reality as digital imaging technologies have created image integrity problems for all types of media. In this workshop, the technology of digital photography will be discussed, its advantages and disadvantages, and methods to maintain image integrity within the context of forensic science. In addition, other digital image technologies will be reviewed, including reflective and transparency scanner, printers, and film recorders. The lecture will be followed by a demonstration of the workflow of digital photography.

Digital Photography, Digital Imaging, Photography

W9 Basic Fingerprint Technology

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Upon completion of the workshop, the participant will be familiar with basic concepts of forensic fingerprinting. Pertinent points of fingerprint testimony with potential pitfalls will be discussed.

This workshop will provide a basic, yet comprehensive, review of conventional and newly developed techniques employed in contemporary fingerprint technology. The program aims to introduce a conceptual framework and practical applications of fingerprinting techniques for the medical examiner and the law enforcement investigator. The practical side of differential techniques relevant to fingerprinting (living and dead) will be highlighted through illustrative examples, case experience, and reviews of recently published studies. Discussion of comparison technology, using the Integrated Automated Fingerprint Identification System (IAFIS), will afford the participant a basic, up-to-date appreciation of its efficient applicability to current medicolegal death investigation within a framework of emerging new scientific standards. The faculty will emphasize current methodologies for lifting latent fingerprints. The presentation will close with consideration of potential pitfalls facing the forensic scientist who provides expert testimony on fingerprint evidence in court proceedings.

One of the many duties of the medicolegal death investigation team is to identify the deceased. Since the nineteenth century, fingerprints have been utilized for both presumptive and unequivocal identification. Moreover, fingerprint evaluations are crucial components of thorough crime scene investigation. Knowledge of print recovery and lifting techniques is important to the forensic pathologist and other forensic scientists. No two individuals share the same fingerprints, not even identical twins. The individual detail of fingerprints makes the comparison unique. In certain conditions, the recovery and evaluation of fingerprints might or could be technically difficult. The identification expert must be able to provide the best quality fingerprints for comparison. A survey of current procedures in autopsy fingerprinting will aid the medical examiner and the law enforcement official in collecting the appropriate specimens for evaluation. Latent print identification is a

branch of traditional fingerprint technology. The scientific basis for traditional fingerprinting and the current practice have recently been challenged. Pursuant to the Daubert guidelines, courts are re-examining the validity of criminal fingerprint comparisons. The faculty will emphasize standards of practice, including quality control, inter-analyst consistency and error rates in the comparison process - all in the context of ongoing judicial scrutiny. The participant of the workshop will receive a basic overview of these concepts emphasizing fundamental techniques of forensic fingerprinting with illustrative case examples.

Fingerprints, Latent Prints, Identification

W10 Planning and Designing a Forensic Laboratory: Perspectives on the Process From Laboratory Personnel, Architects, and Engineers

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Upon completion of this workshop, the participant will have an improved understanding of the contributions of the many different groups involved in planning and designing a forensic laboratory. The participant will gain insight into how laboratory associates, management, architects, and engineers interact and collaborate in the planning and design process and how they solve the unique collateral issues and problems that they encounter.

The United States Army Criminal Investigation Laboratory (USACIL) and its 90 employees are currently housed in a 54,000 square-foot World War II warehouse that was renovated into laboratory workspace in 1983. The pressures of changing technology and business processes, growing case volume and staff, increasing concerns about workplace safety, and evolving laboratory accreditation requirements have driven the need for a new laboratory to replace the current outmoded facility. Associates at many forensic laboratories find themselves facing similar situations. In order to meet increasing demands for service and satisfy the changing legal and regulatory requirements, the laboratory faces the prospect of new construction or renovation. New laboratory planning, programming, and design are expensive and time-consuming processes. The entire development may entail many years with the resulting facility intended to satisfy requirements for 25 years or more. Therefore, since there will only be one opportunity to get it right, it is imperative that the entire process be completed efficiently and effectively. As in forensic casework, success in this process requires that people with different backgrounds bring their varied expertise together in a common effort.

In order to provide perspective from all service units of the laboratory, USACIL formed a team of administrative personnel and laboratory examiners representing each of the divisions. This "New Lab Team" assisted architects and engineers in defining the requirements for the new facility and worked closely with them throughout the design process. The lead architect, lead lab planner, and architectural project managers from Hellmuth, Obata, and Kassabaum, Inc., engineers from R.G. Vanderweil Engineers, Inc., the USACIL project manager, and a laboratory division representative from the New Lab Team will discuss the planning and design processes from their individual perspectives. Their presentations will include needs assessment, budget estimation, and value engineering;

alignment of the laboratory design with work flow, technical, accreditation, and safety requirements; and interaction of the design team to define design concepts, clarify details, and resolve issues. The architectural design firm will bring the various presentations together with a "virtual fly-through" of the new United States Army Criminal Investigation Laboratory. The session will conclude with a panel discussion focusing on participant questions.

Laboratory Design, USACIL, Architecture

W11 Pediatric Death Investigation Including Subtle Forms of Fatal Abuse: From the Scene to the Courtroom

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Upon completion of this workshop, the participant will: be able to recognize the unique aspects of investigating deaths in childhood, be familiar with autopsy procedures and investigative techniques which may be employed in such cases, be aware of potential problems and possible solutions in pediatric toxicology, recognize subtle forms of fatal child abuse including neglect, understand that designation of manner of death as accident or undetermined does not exclude the possibility of prosecution of the alleged perpetrator, recognize the role of the forensic odontologist in identification and prosecution of certain cases, and be familiar with the psychological features of the perpetrators of filicide including possible motivating factors.

This workshop will begin with a discussion of the pediatric autopsy including aspects of the examination that are particularly important, and techniques which may aid in more complete and accurate assessment of possible injuries. In addition, problems in pediatric toxicology beginning with securing sufficient unaltered specimens will be addressed. A child death specialist will discuss her role in investigation of these cases from scene to interviews including case presentations. Through a series of case presentations, subtle forms of fatal child abuse including neglect will be discussed. These include cases of smothering, starvation, Munchausen Syndrome by Proxy, intoxications, and other situations in which neglect played a role in the child's death. Manner of death will be discussed including designation of such cases as accidents or undetermined as opposed to homicide, and the potential for prosecution in these cases in the absence of the designation of the manner as homicide. A forensic odontologist will discuss his role in the identification and prosecution of perpetrators in cases of child abuse in which bite marks are present. Finally, a forensic psychiatrist will present psychological features of perpetrators of filicide including possible motivating factors in the absence of insanity.

Investigation of sudden, unexpected deaths in childhood presents unique challenges to all involved in the process from the scene investigator to the forensic pathologist. In many cases, the cause of death is obvious as is the manner whether natural, accident, or homicide. In other cases, injuries identified at autopsy may obviously be the result of

non-accidental injury. However, identification of the perpetrator may be difficult. In still other cases, while classified as accidental or undetermined, the death may be the result of negligence on the part of the caretaker who may still be prosecuted. Thorough investigation, from the scene to the morgue, and cooperation between the various investigating agencies and representatives of the death investigation system ensure that cases of fatal child abuse are recognized and that the perpetrator is identified and prosecuted. This same cooperation may prevent innocent people from being wrongly accused and charged with such crimes. The training of people to investigate childhood deaths specifically has been initiated in some medical examiner systems. Though there really is no sub-sub-specialty of pediatric forensic pathology, many forensic pathologists, for varying reasons, become particularly interested in childhood deaths. The special interests of trained professionals can only be considered a positive step in childhood death investigation. In addition to those involved in the primary aspect of the investigation, other forensic specialists such as odontologists and psychiatrists may be involved in the investigation of these cases, specifically in the identification and prosecution of the perpetrators. This workshop emphasizes the role of each of these professionals in the successful investigation of childhood deaths through lectures and case presentations.

Child Abuse, Death Investigator, Pediatric Deaths

W12 Forensic Analysis of Trauma Due to Motor Vehicle Collisions

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Upon completion of this workshop, the participant should be able to understand that a multidisciplinary approach is necessary when addressing issues related to motor vehicle impacts, including the assessment of the significance of an injury, and to appreciate the mechanisms of certain common injuries arising from a motor vehicle collision.

Multidisciplinary staged analysis is necessary to understand how trauma is caused in motor vehicle collisions. Crash reconstruction based on the assessment of vehicle damage and predicted motion determines the forces exerted on the vehicle and its occupants. The application of biomechanical principles related to human tissue trauma assists in linking recorded injuries to the crash reconstruction and the predicted occupant kinematics. The major portion of the workshop deals with the response of various body tissues to impact forces, outlining the mechanisms of tissue compression and viscous tolerance associated with tissue deformation. The special susceptibilities of each body region and tissue are outlined in relation to static and dynamic loading and the potential for energy dissipation.

Head injuries are classified into three categories: skull fractures, focal brain injuries, and diffuse brain injuries. In these three categories there are various types and degrees of damage to bone and brain tissues with residual disabilities and fatal outcomes. Concepts of static and dynamic loading are fundamental to understanding these head injury mechanisms related to contact forces and acceleration strains. Neck

injuries, while constituting only 2% to 4% of serious trauma, can have severe debilitating if not life-threatening consequences. Various types of neck strain such as excessive axial compression, tension, bending, and torsion can result in fracture, dislocations, and cord injury. Chest injury in automotive crashes ranks second only to head injury in overall number of fatalities and serious injuries. The severity of injury to the thorax is proportional to the amount of specific energy the thorax must absorb. The impulsive loading and distortion of the chest cage and its contents leads to injury severity that is proportional to the degree of chest compression and the rate of deformation or viscous tolerance. The abdominal region contains vulnerable soft organs with only partial protection by the rib cage. Injuries from blunt impact can result from either direct soft tissue deformation or from relative internal motion with tensile, shear and torsion strains. Bone, similar to other biological materials, is visco-elastic and responds to limited loading forces by bending and torsion in a viscous fashion up to a given threshold prior to fracture.

Injury mechanisms are explained by reference to anatomical structure and vulnerability, with selected case examples to illustrate the insights from orderly collision investigation and reconstruction. The principles associated with occupant kinematics are reviewed with selected physics of bodies in motion. This workshop takes note of the developing features of vehicular design, driver training, and roadway design that contribute to diminishing the number of collisions and the severity of collision force transmitted to occupants, cyclists, and pedestrians. Special attention is directed to the role of restraint systems in occupant protection. Individual case review should also direct the investigator to question possible motives as well as mechanisms involved in motor vehicle crash injury. Some of these events can occur under circumstances other than the usual "road traffic accident."

Biomechanics of Motor Vehicle, Collision Reconstruction, Vehicle Dynamics and Kinematics

W13 Interpretation of the Electrocardiogram (EKG) in Cardiac Arrhythmias and Cardio-Toxicity and the Clinical Impact of Atrial Fibrillation and Ventricular Arrhythmias

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Upon completion of this presentation, the participants should be able to distinguish between normal and abnormal EKG findings in various cardiac disorders, to measure the heart rate, P-wave, PR-interval, QRS complex, T-wave and QT-interval, to differentiate between life threatening arrhythmias and different kinds of heart blocks, and to interpret the EKG strips to evaluate the toxicity of some cardiac drugs. The attendees will understand the relevant facts on cardiac disorders in the evaluation of lethal cardiac arrhythmias. An understanding of the clinical aspect and controlling side effects and toxicity of drugs that are often used to treat atrial fibrillation and ventricular arrhythmias may be achieved.

This workshop, presented in part at the 2000 AAFS Annual Meeting in Reno, NV, has been expanded to cover the aspect of some abused drugs as well as the clinical impact of life threatening arrhythmias (atrial fibrillation and ventricular arrhythmias). The workshop is intended primarily for toxicologists but contains

information pertinent to pathologists, emergency physicians, clinicians, and investigative criminalists. The workshop will begin with a brief overview of the anatomy of the heart, coronary arteries, and electrical conduction system of the heart. It will be followed by the presentation of methods of measuring the heart rate and P, Q, R, S, and T cardiac cycle parameters. Afterwards, participants will hear lectures on reading EKG strips of normal and abnormal cardiac rhythms. Upon learning the basic information, participants will have an opportunity to examine various EKG strips for evaluation. Discussions on the toxicology of some cardiac drugs will follow. EKG findings of drugs including drugs of abuse will be shown. Cardiac drugs often used to treat atrial fibrillation and ventricular arrhythmias have side effects ranging from abnormal arrhythmias, organ damage, to toxicities. The clinical aspects and electro-chemical pathology associated with these drugs will be assessed.

The discussion will focus on the examination and evaluation of EKG strips in cases of cardiac disorders. For forensic toxicologists and pathologists, there is a scarcity of information concerning electrocardiographic findings in assessing the cause of toxicity or fatality. Following the introduction to electrophysiology of the heart, EKG aspects will be presented. An EKG strip is necessary to evaluate the electrical stimulation of the heart. After electrical stimulation, the mechanical cardiac function responds by contracting. P, Q, R, S, and T represent a single cardiac cycle. The heart rate (HR) in normal sinus rhythm is between 60 to 100 beats per minute (BPM). The heart produces atrial and ventricular arrhythmias. The values of P-wave, PR-interval, QRS complex, T-wave, and QT-interval will provide participants an opportunity to recognize and identify the various kinds of atrial and ventricular arrhythmias. A dying heart shows no electrical activity. It is called asystole. The life threatening arrhythmias are atrial flutter (AF), atrial fibrillation (A-Fib), supraventricular tachycardia (SVT), ventricular tachycardia (VT), ventricular flutter (VF), ventricular fibrillation (F-Fib), and asystole (Asy). There are four types of heart block (HB): 1° HB, 2° HB (Wenckebach), 2° HB (Classical), and 3° HB. A complete heart block (CHB) is 3° HB. Knowledge of basic information will enable participants to differentiate between life threatening arrhythmias and different types of heart blocks. The atrial and ventricular arrhythmias mentioned above are seen in individuals who are suffering from cardiac disorders or who are exposed to particular drugs. EKG abnormalities due to overdose of abused drugs will be presented and cardio toxicity of these drugs will be discussed. The EKG findings in addition to drug levels in biological specimens will give another parameter to assess the degree of toxicity or fatality. EKG strips will be provided for the participants for practice and evaluation. Toxicology of some drugs commonly used for the treatment of cardiac disorders will be presented. EKG findings of drugs will be shown.

The goal of treating atrial fibrillation is to control ventricular response, convert to sinus rhythm when possible, and prevent strokes. One accomplishes this goal with chemical and electrical methods. The chemical methods involve the use of drugs that have extensive side effects and toxicity. Digoxin, b-adrenergic blockers, calcium channel blockers, adenosine and clonidine have all been used to control ventricular response. Antiarrhythmic drug therapy is often used to convert and/or prevent recurrence. Some of these drugs include amiodarone, propafenone, flecainide, sotalol, and disopyramide. Ventricular tachycardia and ventricular fibrillation are also life-threatening arrhythmias. Procainamide, lidocaine, and others are often used to treat these arrhythmias. All of these drugs have side effects ranging from arrhythmias that can be life threatening to organ damage to toxicities. The specific arrhythmias seen with each drug will be discussed and the electrochemical pathology associated with each method will be assessed.

Interpretation of EKG, Abnormal Arrhythmias and Cardio-Toxicity, Forensic Toxicology

W14 The Prevention of Child Molestation

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After completing this workshop, attendees should be able to place the reported occurrence of child molestations within the context of all paraphiliac behavior, to list three theories regarding the development of child molestation behavior, to outline and describe current cognitive-behavioral treatments for offenders, and to understand how to accomplish prevention of child molestation by early intervention.

The results from the assessment of over 16,000 individuals accused of sex offenses is reviewed with specific details regarding the characteristics of those accused of child molestation, the age of onset of sexual behavior with children, numbers of sex crimes reported, and victim characteristics. The theories of etiology of child molestation are reviewed. The treatments for child molesters are described with special reference to how chronic sexual interest in children is decreased with cognitive-behavioral therapy and/or medication. Finally, the data supporting the need for early identification of adolescent child molesters and methods of primary, secondary, and tertiary prevention are discussed.

An estimated 39 million adults and 3 million children have been victims of child molestation in the United States. The occurrence of child molestation and other paraphilias from 16,000 assessments of accused sex offenders are reviewed with specific details about those who molest children, their ages and genders, the age of onset of their child molestation behavior, numbers of victims, degree of aggression, and targets of their molestation are explained. Means of assessing possible child molesters are outlined, including visual reaction time, plethysmography, and polygraph. An outline of all available treatments for child molesters will be given with a focus on treatments to decrease deviant sexual interest and why this should be a major focus of treatment. Cognitive-behavioral treatment and medication intervention will both be discussed. Finally, primary, secondary, and tertiary prevention concepts are discussed, with an emphasis on how current treatment programs fail to focus on early intervention with juveniles who are at greatest risk to become chronic child molesters. A blueprint for how to prevent child molestation is given.

Child Molestation, Cognitive-Behavioral Treatment, Prevention

W15 The Clandestine Laboratory—A Recipe for Disaster

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Upon completion of this workshop, the participants should be able to understand the complexity of clandestine laboratory phenomenon, including knowledge of precursor chemicals and their availability, methods of synthesis, chemical hazards, evidence analysis, and to interpret clinical and forensic reports of the influence of methamphetamine production on human body. Investigative techniques will be explored.

For more than two decades the U.S. has experienced a dramatic increase in clandestine drug laboratory activity. The number of illicit drug manufacturing laboratories seized by law enforcement agencies during the last several years has reached epidemic proportions. The diversity of laboratory types and manufacturing methods is daunting, but the current overwhelming trend in the U.S. is the illicit production of methamphetamine which is approximately 95% of all law enforcement seizures. In addition to the criminal aspects and responder safety problems associated with clandestine activities, there are also environmental health hazard issues.

The workshop will present a series of brief presentations on the investigation, chemistry, toxicology, and pathology related to clandestine laboratories. The attendee will leave this workshop with up-to-date information on methods of investigation, physical, chemical, and toxicological hazards, methods of synthesis, and analytical aspects of processing clandestine laboratories.

The workshop is addressed to all AAFS members, drug law enforcement, and forensic specialists. Methods of investigation based on geographical methamphetamine findings will be discussed.

A summary of the common routes of synthesis currently observed in the U.S. for the illicit manufacturing of methamphetamine will be provided.

Analytes specified for analysis and selected based on individual association with specific clandestine laboratory manufacturing processes will be discussed.

Various hazards aspects presented by virtue of the physical and chemical properties of reagent and precursor substances will be addressed.

Beyond the chemical property hazards, the myriad toxicological hazards presented by chemicals used in controlled substance production are serious and significant. Of particular concern is the cumulative effect of chemical substances entering the body via respiratory and/or skin absorption.

Clandestine Laboratory, Methamphetamine, Hazard

W16 Psychological Autopsies in the Department of Defense— An Interdisciplinary Approach

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To learn the background of psychological autopsies in the military; to define current military policy; to understand the difference between a psychosocial investigation of a suicide and an investigation of an equivocal death; to outline training requirements for those mental health providers involved in doing psychological autopsies; to learn about the Office of the Medical Examiner, its jurisdiction, and interaction with worldwide medicolegal authorities; and to present examples where psychological autopsies have been useful to the criminal investigators.

To discuss the psychological autopsy, or forensic investigation, into the equivocal manner of death from the viewpoint of policy, mental health, criminal investigation, and the medical examination.

The Army has a 17-year history of programs that attempt to both reduce suicides and understand completed suicides. Psychological autopsies (PAs) were supposed to be performed on all suicides to gather psychosocial data, aggregate information about the reason for the suicide, and generate lessons learned for command. Local mental health practitioners interviewed unit and family members and forwarded their results to the Criminal Investigative Department.

The other Services (Navy, Air Force) performed psychological autopsies only on equivocal manners of death and selected high-profile cases. Working closely with the forensic scientists and investigators, a handful of psychologists on the staff of the criminal investigative organizations performed all the psychological autopsies.

The Army's methodology provided valuable information about the demographics and motivations of those who completed suicide; however, the quality of the PAs was uneven. Information from different sources was not always available to be synthesized by the mental health worker. Records were accessible to the media under the Freedom of Information Act (FOIA). Finally, lessons learned were not always provided to command or integrated into suicide prevention programs.

The term psychological autopsy has been used in association with two processes: 1) to understand the psychosocial factors that have contributed to the suicide; and, 2) to assist in the forensic determination of the manner of death classification (suicide, homicide, accident, natural causes, undetermined). Confusion sometimes arises because of the different uses of the term.

In 1996 the Inspector General (IG) suggested that the Services request and perform psychological autopsies in a uniform manner. A working group from all the Services and many disciplines worked to standardize and codify psychological autopsies.

The consequent policy governing psychological autopsies was issued in the summer of 2001. It mandates that the primary purpose of a psychological autopsy be used as a forensic investigative tool to assist in ascertaining the manner of death. It is to be requested by and to be provided to the medical examiner.

A review of the literature on psychological autopsies provides scant guidance as to how to train mental health professionals to conduct a forensic psychological autopsy in order to determine the manner of death. These mental health professionals may have excellent interviewing skills, but may know little about blood spatter analysis, ballistics, toxicology, etc. A model curriculum for mental health professionals, which emphasizes an interdisciplinary approach, will be presented.

Other situations where the forensic psychological autopsy model is applicable are special conditions such as autoerotic asphyxia, drowning, shootings, poisoning, motor vehicle accidents, and hangings. All of these have behavioral aspects that can assist a forensic pathologist in determining the manner of death. Case examples will be used to highlight these issues. These techniques have also proven useful in missing persons cases and conducting victimology studies in homicides.

Privacy of the information collected is essential. Since the victim is dead, many medical privacy rules do not apply. The ramifications of these issues deserve discussion.

The Office of the Armed Forces Medical Examiner (OAFME) will have an increasing role in requesting, standardizing, and reviewing psychological autopsies. The goals of this presentation will be: 1) to learn the background and mission of the Armed Forces Medical Examiner System (AFMES); 2) to learn about the jurisdiction of the AFME and its relationship to federal, state and county medical examiners/coroners, local authorities, and foreign countries; 3) to learn the role of the OAFME in medicolegal investigations of military and civilian deaths; 4) to learn the difference between self-inflicted deaths without suicidal intent and suicide; 5) to learn of some of the difficult cases reviewed by the OAFME, and 6) to learn the role of the AFME in requesting PAs.

Finally, psychological autopsies from a criminal investigator's viewpoint will be discussed. There are cases where investigative

information leads to two or more possible conclusions as to the manner of death, or equivocal deaths. The most common scenario involves cases where some information leads the investigator towards a theory of suicide and some information leads to a homicide theory. In these challenging cases, a multidisciplinary approach using a psychological autopsy is pivotal towards successful case resolution.

The PA is based on investigative information obtained by field investigators during the conduct of the investigation. Information is derived from a variety of sources to include evidence obtained, evidence analysis, records checks, interviews, etc. The focus for the field investigator is to obtain as much information as possible on any physical evidence, life circumstances and events, known history, behavior, and personality of the decedent. This information is provided to a trained forensic psychologist or psychiatrist who can provide insight into the thought processes most likely to be employed by the decedent.

The psychological autopsy allows the criminal investigator to evaluate and provide a more realistic rank order to potential scenarios and gain insight into what realistically happened to end the life.

Psychological Autopsies, Equivocal Death Investigation, Suicide

W17 Developing a Sexual Assault Response Team (SART) in Your Community

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Upon completion of this workshop, the participant will be able to discuss the concept of utilizing a coordinated multidisciplinary team approach to improve services provided to victims of sexual assault, list the various members of the Sexual Assault Response Team, and describe their roles and responsibilities, understand the various models used to successfully implement SARTs around the country, and recognize potential barriers to successful implementation and operation of SARTs.

This 4-hour workshop will explore the rationale for establishing a coordinated multidisciplinary team approach to providing care and services to victims of sexual assault. Speakers will define the SART, and primary and secondary members of the team will be identified and their roles described. Information regarding the development and function of the team will be provided. Special attention will be given to potential barriers to initial implementation and to problems affecting ongoing operations. Several successful models will be presented and discussed.

According to the U.S. Department of Justice National Crime Victim Surveys over the past decade, more than 300,000 sexual assaults are estimated to occur in the U.S. each year. These crimes take a huge physical, emotional, and financial toll on victims and on the community. A sexual assault is often a life-altering event for the victim, family, and friends. These cases require a tremendous amount of time and effort on the part of healthcare providers, law enforcement officers, victim advocates, crime lab personnel, and prosecutors.

In recent years, many communities have recognized the impact of sexual assault and have actively sought better ways to deal with these cases. Agencies and institutions throughout the country have utilized a variety of methods to coordinate resources in an effort to improve services and case outcomes. In the past decade, there has been a significant increase in the use of specialized teams of highly trained individuals to respond when these types of crimes occur. Depending on community resources, these Sexual Assault Response Teams, or SARTs, can be developed in several different ways. The focus of this workshop will be to define the Sexual Assault Response Team and its components, to identify potential roadblocks to program development, to discuss the benefits of the SART approach for both the crime lab and the legal system, and to present various successful models of SART implementation.

SART, Sexual Assaults, Victims

W18 Recovery, Examination, and Evidence of Decomposed and Skeletonized Bodies—An Anthropological and Entomological Approach

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Upon completion of this workshop, the participant should be able to recognize bioenvironmental evidence, to properly collect and preserve such evidence, and to record supplementary data needed for later analyses of bioenvironmental evidence.

This program will present techniques from the disciplines of anthropology, entomology, and pathology, which can be employed in the processing of crime scenes. This interdisciplinary approach will maximize the information obtained from bioenvironmental evidence gathered from a scene. Techniques will be discussed to assure the proper collection and preservation of these types of evidence for later analyses.

One of the most challenging cases faced by any forensic scientist or investigator is that of the badly decomposed or skeletonized body. It is a common misconception that such remains, in particular those discovered outdoors in a field or wooded area, provide little useful information concerning the circumstances of the death. However, through applications of techniques from the fields of anthropology and entomology, significant data may be obtained. The outdoor death scene is quite unique, since the remains and associated evidence can be viewed as temporary alterations to the ecology of the immediate area. Methods and techniques for recognition and interpretation of this "bioenvironmental evidence" will be presented during the workshop. The workshop is designed to be at an intermediate level, with an overview of anthropological and entomological techniques followed by considerations of recent advances in these areas of research. Decompositional processes will be covered along with the varied applications of entomological evidence, including entomotoxicology, preservation and processing of entomological evidence, and applications of entomological evidence in cases involving the living as well as the dead. Representatives of the various species discussed will be displayed for the participants. Each participant will receive a manual covering the materials presented.

Entomology, Anthropology, Postmortem Interval

W19 Tour of Scientific Games, Security Printing Company That Produces Lottery Tickets & Games

*Betty C. Gayton, BS**, Georgia Bureau of Investigation, PO Box 370808, Decatur, GA; *Jim Lee, MS**, Florida Lottery Division of Security, Capitol Complex, Tallahassee, FL

Scientific Games International (SGI) is the leading supplier of technologically advanced computerized wagering systems and related equipment to the pari-mutuel wagering industry, and a fast-growing provider of on-line systems and retailer terminals to the lottery industry worldwide. SGI is now the only fully integrated lottery service provider in the world.

SGI provides the full range of premium-quality lottery products, integrated systems, and support services to legally licensed lotteries.

Products include:

- On-line gaming systems
- Computerized retailer point-of-sale terminals for selling and cashing tickets
- Instant game management systems
- Validation processing systems
- Instant scratch-off and probability game tickets
- Instant-win promotional games and prepaid phone cards

The participants will travel from the Atlanta Marriott Marquis to Scientific Games International's main offices and primary production facility in Alpharetta, GA, north of Atlanta.

Security Printing, Questioned Documents, Lottery Tickets

W20 Central Nervous System Toxins: Biochemical Mechanisms and Physiological Consequences

*Robert H. Powers, PhD**, Chief Toxicologist, Hamilton County Coroner's Office, 3159 Eden Avenue, Cincinnati, OH; *Gary H. Wimbish, PhD**, Forensic Toxicology Consultant, 609 Cosby Road, Milford, TX; *Floyd R. Sallee, MD, PhD**, Director, Pharmacology Research Center and Psychiatry, Children's Hospital Medical Center, 3333 Burnet Avenue, Cincinnati, OH; *John F. Wyman**, Chief Toxicologist, Montgomery County Coroner's Office, 361 West 3rd Street, Dayton, OH; *Dorothy E. Dean, MD**, Deputy Coroner, Franklin County Coroner's Office, 520 King Avenue, Columbus, OH

Participants will gain an enhanced knowledge of the structure and function of the Central Nervous System (CNS), both in a general mechanistic sense, and as it specifically relates to the toxicological mechanisms in order to understand specific poisoning events. Presenters will express, in depth, the biochemical mechanism of the actions of several types of toxins acting primarily on the CNS and express the physiological consequences, and pathologic observations reflecting the consequences resulting from the actions of specific types of CNS toxins.

This workshop will consist of an in-depth review of the structure and function of the Central Nervous System (CNS) with an emphasis on identification of biochemical control points and mechanisms (i.e., activation, inhibition), followed by a series of mechanistic evaluations of specific toxins, as representatives of particular toxin types. Finally, the physiological consequences of the toxic action for each type presented will be explored, focusing on the mechanisms and consequences leading to death.

This three-part workshop will first provide an in-depth review of the structure and function of the Central Nervous System (CNS) with an emphasis on the biochemistry underlying the neurotransmission process, and the mechanisms of inhibition and activation. The site of action and

consequences to the CNS, as a system, for several well-known poisons will be considered. The target points for these poisons will include pre- and post-synaptic inhibitory neurotransmission and the biogenic amine neurotransmitters. Secondly, the biochemical mechanisms by which these poisons operate will be discussed in depth. Physical structure, location and function of receptors/enzymes, and the biochemical activity associated with normal function, and the toxic mechanism, on a cellular and molecular level will be presented. The third section will translate the toxic response from the molecular level to that of the whole organism. The overall physiologic consequences and mechanisms by which such responses can lead to a fatality, and the characteristic pathology that may be observed in a postmortem examination, will be presented and discussed.

Central Nervous System, Toxins, Poisoning

W21 Teaching Forensics Abroad

*Richard L. Tanton, MBA**, Senior Program Advisor, Kosovo Forensic Program, ICITAP, Perandori Dioklecin 14, Pristina, Kosovo; *Daniel D. Garner, PhD**, Chief of Forensic Services Section, ICITAP, Criminal Division, US Department of Justice, 1331 F Street, NW, Washington, DC; *Carmine J. Artone** and *Robert D. Brooke, BS**, Forensic Coordinator, ICITAP, 1331 F Street, NW, Washington, DC; *Kevin L. Lohridge, MS**, Deputy Director of Strategic Development, National Forensic Science Technology Center, PO Box 2710, Largo, FL; *Wayne Baird**, Vice President, Sales and Marketing, Forensic Technology Inc., 3300 Cavendish Boulevard, Suite 670, Montreal, Quebec, Canada

Upon completion of this workshop, the participant should be able to work effectively with interpreters in providing forensic training, should be able to function effectively as an assessor of forensic potential in foreign venues, and should be familiar with the special needs involved in teaching forensics abroad.

This program will familiarize prospective forensic trainers with the techniques used in bringing forensic training and expertise to other countries. It will rely heavily upon the extensive experience of the International Criminal Investigation Training Assistance Program (ICITAP). After an introduction to the global ICITAP Forensic Program, there will be presentations describing existing programs in South America and Eastern Europe. Instructions as to the use of interpreters and general guidelines for instructors working abroad will be provided. There will be presentations by National Forensic Science Technology Center describing distance learning programs, and by Forensic Technologies, Inc., addressing private vs. public sector issues in foreign forensic training.

Providing instructional aid to other countries has been an important part of U.S. foreign policy for decades. However, with the end of the "Cold War Era," and the beginning of what might be called the "Hot Warlette Era," the need for this aid has increased dramatically. The International Criminal Investigation Assistance Program (ICITAP) has been helping police and forensic scientists in foreign countries establish and maintain democratic criminal justice systems for over 10 years. ICITAP will soon have programs in over 70 countries and the demand for its services is rapidly increasing. To meet these demands in the forensic area, ICITAP will need to tap the vast forensic knowledge and experience of the AAFS membership.

The purpose of this workshop is to familiarize and train interested AAFS members how to share their forensic expertise efficiently and effectively in an international environment. To bring forensic training abroad requires great expense, coordination, and flexibility. A highly qualified forensic scientist can easily end up providing only a marginally effective course if he or she is unaware of the special language, cultural, and logistic realities of training in foreign countries.

The traditional method of providing foreign instruction is to bring the instructor to the country in question to teach. This is certainly the most exciting for the instructor, but it is very expensive and has inherent limitations when, as is the case for much of forensics, the subject matter requires long-term coaching to become truly effective. With the astounding advances in electronic communication, other alternatives are becoming available.

Distance Learning, Training Abroad, Forensics Overseas

W22 Theodore Robert Bundy: Why He is the Real Hannibal Lecter

Robert D. Keppel, PhD, Director, Crime Analysis Solutions, 800 Fifth Avenue, Suite 4100, Seattle, WA; Dayle L. Hinman, BS*, Special Agent, Florida Department of Law Enforcement, 2331 Phillips Road, Tallahassee, FL; Richard R. Souviron, DDS*, Associate Medical Examiner, Miami-Dade County Medical Examiner's Office, 336 Alhambra Circle, Coral Gables, FL*

Upon completion of this workshop, the participant should be able to understand the first use of computer applications in a complex serial murder investigation; should better understand the methods used in interviewing serial killers; should be able to process outdoor crime scenes more effectively; should be aware of the actual details of Ted Bundy's murders in Washington, Oregon, Utah, Colorado, and Florida; should understand the most appropriate methods for serial murder investigations; should understand the procedures necessary for documenting and analyzing bite mark evidence; and, be better prepared to deal with the devil.

From Criminalistics to Odontology to Pathology to Psychiatry & Behavioral Science to Jurisprudence to Physical Anthropology to General, these sections within the American Academy of Forensic Sciences have referenced the murders of Theodore Robert Bundy in various papers, workshops, and presentations throughout the years. At no time has anyone ever attempted to bring together in one workshop the various stages of the investigation of Ted Bundy's cross-country murders.

This workshop will focus on the multidisciplinary nature of the investigation into the murders committed by Ted Bundy. The role of various disciplines that played a part in Bundy's investigation will be explained in the workshop. The disciplines from which information is to be gained are Criminalistics (crime laboratory results), Physical Anthropology (six victims, nothing left but bones), General (crime scene and outdoor crime scene procedures utilized), Odontology (identification of the victims and the linking of Ted Bundy to the Chi Omega scene through the use of bite mark comparisons), Pathology (the information gleaned from postmortem examinations of the victims), and Psychiatry & Behavioral Science (the criminal personality profile of Ted Bundy and methods for interviewing the high profile serial killer). The workshop will highlight follow-up activities and will inform attendees of the implications of those activities on future serial murder investigations.

The workshop begins much like Bundy's cases began in September of 1974. At that time, the skeletal remains of the first two murder victims attributed to Ted Bundy were discovered near Seattle, WA, on a wooded hillside. What law enforcement officers didn't realize was that the killer had murdered six other coeds from Washington and Oregon whose bodies had not been found by that time. The workshop will present information from his murders in the Pacific Northwest to his travels to Utah and Colorado to attend law school at the University of Utah. Then, the workshop will cover his escape from Colorado to Florida. In each area, the presentation will include focusing on information that was known at the time, the significance of which would not be known until his final confessions.

The workshop presenters will highlight the landmark use of bite mark evidence in the Chi Omega murders. The presentation covers the eyewitness identification in Murray, UT, and Tallahassee, FL.

In dramatic fashion, the attendees will hear Bundy's effort to act as the consulting expert in the Green River Murders. This consultation was long before the idea in *Silence of the Lambs* was ever conceived. His tape-recorded conversations will reveal the true personification of evil and his experienced understanding of the concept of serial murder. For the first time, Bundy's profile of the Green River Killer will be expressed in his own words to the audience.

The confessions tape-recorded during Bundy's last days will be played for the audience. Attendees will hear Bundy confess in detail to the kidnapping and murder of Georgann Hawkins in Seattle. He will also give the final plea of his life to live and have his execution delayed.

The workshop will conclude with the events surrounding Bundy's execution. The session will end with post-Bundy suggestions about dealing with killers like him.

In most books or journal articles about serial killers, Theodore Robert Bundy is invariably mentioned. His life of murder has intrigued scientists, police officers, and the public alike. At least six books have been written glorifying his life. But what is the real story from the perspective of those who worked on his investigations? For the first time, three members of the American Academy of Forensic Sciences will present his cases in a way never before seen. The presentation will focus on the extensive crime scene processing that took place (the forerunner of today's principles of outdoor crime scene processing), the details of his murders in Washington, Oregon, Idaho, Utah, Colorado, and Florida, an analysis of bite mark evidence, his prosecutions in Florida, his attempt to be Hannibal Lecter consulting with King County authorities about the Green River murders, and finally, his ultimate confessions. The participants will hear original tape recordings of his opinions about the Green River Killer and his own confessions. The workshop has a multidisciplinary approach, presenting information of interest to members of the Odontology, Criminalistics, Pathology, Psychiatry & Behavioral Science, Jurisprudence, Physical Anthropology, and General Sections.

Serial Murder, Ted Bundy, Homicide Investigation

W23 Y-Chromosome Analysis and Its Application to Forensic Casework

Sudhir K. Sinha, PhD, ReliaGene Technologies, Inc., 5525 Mounes Street, Suite 101, New Orleans, LA; Manfred Kayser, PhD*, Max Planck Institute for Evolutionary Anthropology, Inselstrasse 22, Leipzig, Germany; John M. Butler, PhD*, NIST, Biotechnology Division, 100 Bureau Drive, Mail Stop 8311, Gaithersburg, MD; Lutz Roewer, PhD*, Institute of Legal Medicine, Hannoversche Strabe 6, Berlin, Germany; Bruce Budowle, PhD*, Laboratory Division, Federal Bureau of Investigation, 935 Pennsylvania Avenue, Washington, DC; Rudiger Lessig, MD*, Institut fur Rechtsmedizin, Universitat Leipzig, Leipzig, Germany; Jose A. Lorente, MD, PhD*, Director, Laboratory of Genetic Identification, President, AICEF-GITAD, Avenue Madrid 11, Grenada, Spain; Mechthild Prinz, PhD*, Assistant Director, Office of the Chief Medical Examiner, Department of Forensic Biology, 520 First Avenue, New York, NY; Jaiprakash G. Shewale, PhD*, Senior Scientist, RelaiGene Technologies, Inc., 5525 Mounes Street, Suite 101, New Orleans, LA; Toshimichi Yamamoto, PhD*, Associate Professor, Nagoya University, 65 Tsuruma?cho, Showa?ku, Nagoya, Japan*

Upon completion of this workshop, the participants should be able to understand the structure, evolution, and polymorphic markers on the Y-chromosome, the characteristics of Y-STR, and population genetics. The participants will also become familiar with multiplexed Y-STR systems and their usefulness and limitations in forensic casework.

The workshop will target individuals who are currently performing casework using autosomal STR analysis or who are in the process of validating/implementing Y-STR analysis for casework.

The program's morning session will focus on the general introduction of Y-chromosome including structure, evolution, and polymorphic markers on the Y-chromosome. Development of new Y-STR, Y-SNP markers and establishment of new multiplex systems will be discussed.

The afternoon session will focus on forensic validation, population genetics, and casework experience of multiplexed Y-STR systems currently in use in forensic casework.

The workshop will have the privilege of the participation of international scientists who pioneered the development and establishment of Y-STR analysis systems for human identity as well as human evolution studies.

Human Y-chromosome STR markers have gained popularity due to their ability to establish paternal relationship and analysis of male specific DNA in forensic casework.

The workshop will focus on all aspects of application of Y-chromosome specific DNA analysis in forensic casework. The program will have three major objectives. The first objective is to educate the attendees about the basic structure, evolution, and polymorphic markers on Y-chromosome. The characteristic of the Y-STR and its application to human evolution, anthropological studies, and population migration will be discussed. An up-to-date account of the status of scientific research in the field of Y-STR and Y-SNP, including various multiplex systems, will be reviewed. The characteristics of the markers that are suitable for human identity applications and criteria for selecting suitable loci will be outlined.

The second objective of the workshop will be presentation and evaluation of Y-STR database from Europe, Japan, Latin America, and the U.S. With the exception of mutational events, all male relatives of paternal lineage share the same haplotype. This imposes the restriction that statistical significance of an Y-STR DNA match cannot be assessed by the product rule. The estimation of haplotype frequency is limited by the size of the haplotype database. The discussion of haplotype frequency and genetic diversity will educate the attendees about the methods to be used in presenting the Y-STR DNA statistics in the courtroom.

The third objective of the workshop is to focus on the application of Y-STR analysis in forensic casework. The participants will have an opportunity to learn the protocol and procedures used in implementing Y-STR analysis for forensic casework. The presentations will detail the steps involved in validating various Y-STR multiplexes for forensic casework. The case examples presented will illustrate different scenarios where Y-STR testing has been useful.

STR, DNA, Y-Chromosome

W24 Understanding the Patterns and Motives of Violent Sexual Offenders

Robert K. Ressler, MS, Forensic Behavioral Services International, PO Box 187, Spotsylvania, PA; Richard D. Walter, MA*, Omega Crime Assessment Group, 78 Church Street, Montrose, PA; Thomas P. Muller, PhD*, Criminal Psychology Service, Federal Ministry of Interior, Austria, PO Box 100, Vienna, Austria; Michael Osterheider, MD*, Westphalia Center for Forensic Psychiatry, Eichilbornstrasse 21, Lippstadt, Germany*

Upon completion of this workshop, the participant should be able to understand the rationale for more in-depth research of violent sexual offenders; to understand and identify the difference between organized and disorganized sexual offenses and offenders; to recognize and identify the importance of violent sexual fantasies that develop in sexual offenders before, during, and after adolescence which lead to future violent sexual crimes; to use the information gained to better classify and evaluate sexual offenders in a law enforcement, mental health, or penal setting to better

recommend retention or release; and, to conduct improved interviews of violent sexual offenders which get at their true motivation as compared to traditional self report methods.

This workshop program will focus on the early efforts of the FBI to research and study the patterns and motives of violent and repetitive serial and sexual offenders. The FBI's Behavioral Science Unit initiated the research. The workshop will primarily focus on the deviant sexual fantasy development of violent sexual offenders, many of whom commit serial crimes. The notion of fantasy as a motivator will be illuminated through in-depth examination of pertinent case examples which vividly demonstrate that early deviant fantasy becomes the eventual road map to future violent and repetitive sex crimes. The concept of organized and disorganized criminal behavior will be explored and demonstrated by viewing actual crime scenes and viewing video interviews with those who committed such crimes. Further, the workshop participants will demonstrate interview techniques in an on-stage role playing scenario, designed to demonstrate how to draw important and necessary information from inmates in a law enforcement interview situation or in a prison setting, to better serve the needs of mental health professionals working in a penitentiary. Finally, workshop attendees will be oriented to a pilot study conducted in 2001, at the Westphalia Center for Forensic Psychiatry, located in Lippstadt, Germany. The study in Lippstadt focused on the difference between the traditional interview method of self-report as opposed to a new approach utilizing law enforcement investigative reports and actual crime scene photographs as a basis for interviews.

The workshop will focus on the early efforts of the FBI to study violent sexual offenders and offenses. A motivational model for sexual homicide will be presented. The FBI's Behavioral Science Unit, where 36 serial and sexual killers were studied, developed this model as part of a long-term study. The research was funded by the U.S. Department of Justice, the University of Pennsylvania, Boston University, and Boston City Hospital who were participants in the study. Other more recent models will also be offered to demonstrate the direction necessary to accomplish a more organized, efficient, and unified approach to this critical task. Past and present problems surrounding the difficulty of obtaining research subjects, pertinent demographic data, information of the specifics of the crimes, law enforcement information, and other related variables necessary to conduct sound empirical inquiry into this ever growing phenomenon will be highlighted. The presenters will offer their own experiences in this field and will attempt to suggest possible solutions to these problems by examining pertinent case studies, conceptual models, and offender topologies.

Since the inception of research into the patterns and motives of violent sexual offenders, deviant sexual fantasy has long been recognized as a foundation which precipitates and predisposes offenders toward violent sexual crimes. The original FBI model will be presented to demonstrate the conceptual framework for understanding the fantasy structure that motivates the serial and sexual killer. The notion of fantasy as a motivator will also be illuminated through in-depth examination of pertinent case examples to include such violent sexual offenders as Jeffrey Dahmer, Ted Bundy, John Wayne Gacy, Leonard Lake, Edmund Kemper, Gerard Schaefer, John Joubert, and others. The audience will examine actual crime scene photographs, video taped interviews, and other pertinent data to understand better the role of fantasy as a catalyst to progressively violent and repetitive sexual crimes.

Workshop attendees will be oriented to a pilot study conducted in 2001 at the Westphalia Center for Forensic Psychiatry, located in Lippstadt, Germany, whereby the workshop participants interviewed violent sexual offenders using the traditional method of self-reporting. This method was then compared with an alternative style of first reviewing actual law enforcement investigative reports and vivid crime scene photographs, which provided the interviewers additional insights into criminal motivation and ultimately produced dramatic results in the second interview.

The new method can produce a more accurate and valuable insight into the fantasy structure of a violent sexual offender. The new methodology may provide to the mental health professional a better insight into the inmate so that better evaluation, classification, and finally retention or release of the offender for parole hearings may occur.

Finally, this workshop is intended to be an interactive academic exploration of violent serial and sexual crimes and will provide an opportunity for the attendees to analyze actual cases by video and slide presentation. Further, attendees will be encouraged to utilize the information gained through their own practical experience along with the newly gained knowledge obtained through active participation in this workshop.

Violent Sexual Offenses, Sexual Fantasy, Serial Sexual Offenders

W25 Paper Science Related to Questioned Documents

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This workshop will provide an overview of paper products, the raw materials employed, the papermaking and converting processes involved, and paper issues related to forensic science and questioned document examination, and will include non-destructive and destructive testing techniques. This will be followed by an overview of the papermaking process from the forest to the final product. The nature of paper as a unique material together with its converting and end use performance will be examined in terms of its properties (composition, fiber properties, inter-fiber bonding, and structure). Finally, paper issues related to forensic science and questioned document examination, including chemical and physical non-destructive testing techniques, will be considered.

Paper, Questioned Documents, Forensic Science

W26 The Limbo: What an Expert Witness Can Expect From Cross-Examination—Ethics vs. Professionalism

Haskell M. Pitluck, JD, Retired Judge, Illinois Circuit Court, 573 Lake Avenue, Crystal Lake, IL; Andre Moenssens, JD, LL.M., Douglas Stripp Professor of Law, University of Missouri at Kansas City, 5100 Rockhill Road, Kansas City, MO; Linda B. Kenney, JD*, Civil Rights/Trial Attorney, Law Offices of Linda B. Kenney, 2 Bridge Avenue, The Galleria, Atrium Building 5, Red Bank, NJ; Christopher Plourd, JD*, Criminal Trial Attorney, Law Offices of Christopher J. Plourd, 1168 Union Street, Suite 303, San Diego, CA; Cyril H. Wecht, MD, JD*, Coroner, Allegheny County, 14 Wood Street, Pittsburgh, PA*

Upon completion of this workshop, the participant should be able to successfully prepare for and/or survive cross-examination, should have an understanding of the discovery documents necessary for a successful cross-examination in a courtroom, be able to determine whether certain areas and questions in cross-examination of an expert are proper or unethical, and will practice responding to lawyers treated as specialists brought into a trial to cross-examine specific experts.

Despite the fact that experts prepare many reports and attend depositions, and because most cases settle before trial or resolve by way of plea bargain, many have not survived the rigorous cross-examination that

occurs in the courtroom. Cross-examination differs from deposition testimony, where an attorney is trying to learn about the expert, since the goal is to destroy the expert's credibility in front of the jury. The hands-on presentation will demonstrate how to cross-examine a witness and survive cross-examination by simulating actual expert testimony based on actual reports. The demonstration will be peppered with lecture and commentary.

In this workshop, all participants are invited to submit an expert report and curriculum vitae to the presenters. The presenters will conduct a mock cross-examination of the participant or of one of the experts based on the expert report; in addition, the participants will be supplied with various strategies of what documents to obtain in advance of trial in order to successfully cross-examine an expert or survive cross-examination. Lawyers will understand when the expert is vulnerable. Experts will understand the difference between a direct attack on their opinions and qualifications and a collateral attack by attorneys. The question and amount of information relating to an expert's personal life and the depth of explanation of his/her credentials as stated in the expert's curriculum vitae will be explored at length. An expert's credibility is one of the most important facets to the expert's testimony. The expert is usually denigrated by the opposing counsel and perceived as biased. Bias has been espoused in literature for many years. For instance, the Pulitzer Prize winning author, Wallace Stegner, in *Angle of Repose*, wrote, "I called the jury's attention to the way in which speculation has become suspicion, supposition certainty, and certainty accusation. It's a lesson in the workings of the expert mind, which can go from a hunch to an affidavit, and from an affidavit to a fee, within minutes. To which with great authority the expert says what is not necessarily so." Recent court decisions in various states have expanded the area in which experts can testify. Expert testimony is allowed in cross-racial identification and other areas that were not accepted by the courts in the past. With the burgeoning of the expert area of testimony, so too comes both an expansion in some areas of cross-examination and a limitation in others. The participant will learn about the various court decisions that have allowed the financial records of experts to be obtained in discovery. A review of other court decisions, which limit the ability of an opposing counsel to attack the expert fees, will also be explored. At the end of this workshop, Ten Commandments for the lawyer and the expert will be set down in stone.

Expert Cross-Examination, Collateral Attack, Ethics

W27 Is This Driver Impaired by Drugs? Can Blood Drug Concentrations and a DRE Evaluation Answer this Question?

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Upon completion of this workshop, the participant should be able to have a greater knowledge of the scientific literature detailing performance impairment by drugs, have a greater understanding of the role of a DRE officer in a DUI case, and have a greater understanding of the interpretative value of a quantitative blood drug result in a DUI case.

Blood drug toxicology data and Drug Recognition Evaluation reports from multiple state programs will be evaluated for frequency of drug use. For cases where only a single drug is detected, data will be compared to the scientific literature on performance impairment to determine if the DRE parameters observed and the blood concentrations measured in real world impaired driving cases are consistent with the literature.

Forensic toxicologists are often asked to relate blood drug concentrations to impairment. Consideration of all the facts in a case is the best approach. The toxicologist can review the scientific literature and examine the police reports documenting the observed impairment. The body of scientific literature has grown due to the interest in the drug impaired driver over the last 20 years. Since the late 1980s many law enforcement officers have completed additional training in identifying and apprehending the drug impaired driver through the Drug Evaluation and Classification Program. A Drug Recognition Expert (DRE) is often called upon to evaluate a subject whose impairment is not consistent with the alcohol test result. The DRE obtains additional physiological and psychomotor performance data. Some researchers have presented and published data from individual programs. This workshop will examine the quantitative blood drug data and DRE evaluations from multiple state programs, and will evaluate the driving behavior, physiological parameters, psychomotor performance data, and toxicology results, with the goal of comparing these data with the scientific literature on performance impairment. Are the blood concentrations consistent with those in clinical performance studies? Are they consistent with published therapeutic or toxic levels? Would these subjects have been deemed "under the influence" or "impaired to the slightest degree" when compared to statutes in the U.S. or impaired driving laws of other countries? The driving behavior in these subjects will be examined and compared to epidemiological studies, simulator studies, or actual driving studies. The most common parameters identified by the DRE will be discussed and the relative significance of these parameters for each drug/drug class will be delineated. By reviewing data from a number of states, thereby increasing the number of single drug positive cases, a better picture of the drug-impaired driver can be established.

Drugs and Driving, Blood Drug Concentrations, DRE Evaluation

W28 Courtroom Communications: Recognizing and Responding to Trick Questions

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After attending this program, forensic scientists will be able to listen more attentively to questions, will recognize compound, vague, ambiguous, and unclear questions, and ask for clarification, will demonstrate an understanding of the "form of a question," will practice responding to typical questions asked at deposition or in cross-examination, and will function more effectively as a forensic expert.

This program will provide advanced instruction on "Actively Listening" to questions, and training in formulating acceptable responses to "trick questions." Attendees will learn to analyze the "form" of a question and to recognize common question predicates like, "Isn't it a fact that . . .?, Isn't it fair to say . . .?, Wouldn't you agree that . . .?, and Isn't it possible that . . .?" Emphasis will be placed on practical questions and scenarios frequently encountered in court. The workbook and slides

will include excerpts of actual testimony specifically selected to illustrate a trick question, improper question, or lawyerly techniques like subterfuge and misquoting the expert.

You are a forensic scientist and you are eminently qualified to present the results of your investigation to a jury. However, standing between you and the jury is the opposing counsel, a professional dedicated to protecting the rights of his/her client. In order to make your contribution to the justice system, you have to present the information you have acquired in a question and answer format. Unfortunately, while you may be more skilled in science than the opposing counsel, you are not as skilled with the spoken word or in resisting persuasion as your opponent is. In fact, while you have been studying your discipline, opposing counsel has been learning how to phrase questions in such a way as to get you to give up the desired response. Very simply, the purpose of this workshop is to help level the playing field.

In order to testify effectively, you must be able to withstand vigorous cross-examination and emerge unscathed from your battle of wits with a wily opponent. To do this, you must learn to **actively listen** to every question and be certain you understand exactly what is being asked. Some experts believe that they must answer every question, even poor ones, or risk being considered uninformed or unresponsive by the court and jury. You should answer every question you understand truthfully, but how do you handle a question that is vague, confusing, ambiguous, or contains a scientifically incorrect assertion? When instructed to "Answer yes or no," do you have to, even if it will be misleading? Handling difficult questions coolly and calmly, with aplomb and dignity, is the mark of a competent professional. Register for this workshop and learn all of this, and empower yourself as you improve your skills in **courtroom communication**.

Recognizing Trick Questions, Communicating Effectively, Active Listening Skills

W29 Digital Forensic Photography

David S. Goldman, BSEE, MSEE, PE, David Lee & Associates, Inc., Adams-Fay House, 20 Fruit Street, Hopkinton, MA; Mark I. Marpet, PhD, PE*, St. John's University, (H)14 Cowie Road, Chester, NJ; Richard McEvoy, Jr.*, Forensic Imaging, Inc., Technical Representative for Fuji-Film and Equipment, PO Box 597, Victor, NY*

Upon completion of this workshop, the participant should be able to produce greatly improved evidentiary photographic materials for use in case preparation, deposition, and trial testimony. The participant should better understand his/her photographic equipment and should also be able to better select the proper formats, storage media, and software archive methods used to produce digital evidentiary materials.

The workshop will begin with a quick review of traditional silver photography and a discussion of digital photography that will cover the structure of silver-based films and the design of CCDs. This will be followed by a discussion of signal processing to include JPEG, TIFF and RAW formats. Storage media such as compact flash memory and microdrives will be covered. A detailed review of software (Photoshop®, Fotostation™, ACDsee™, and Extensive Portfolio) will be undertaken. Finally, workflow from shooting to downloading to enhancement to output (printing, e-mail, and film) to archiving (CD, jukeboxes, and Merlin) will be discussed.

Digital Forensic Photography, Crime Scene Photography, Digital Photography

W30 Acquiring, Processing, and Protecting Imaging Evidence—Guidelines for Managers, Crime Scene Personnel, and Laboratory Experts

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At the conclusion of this workshop, participants will be better able to make informed decisions regarding the imaging technologies they should be utilizing in their agencies and laboratories. This will include a better understanding of the current limitations of digital imaging technologies so that participants will know when it is appropriate to utilize this technology and when it is not. Participants will be better prepared to develop standard operating procedures for the imaging activities they perform and to ensure that their images will be accepted in court.

Participants will learn about guidelines and recommendations for the acquisition, storage, and processing of images utilized in forensic applications. These guidelines and recommendations apply to all types of imaging evidence including film, digital, and video evidence. In a lecture-style format, members of the Scientific Working Group on Imaging Technologies (SWGIT) will describe the different types of imaging evidence, as well as the pros and cons of various imaging technologies in different settings. Strategies for the long term storage (archiving) of image evidence will be discussed, including a discussion of the technologies best suited for this purpose and steps to ensure a valid chain of custody. Having covered the acquisition and protection of images, the subject of digital image processing will be addressed, with an emphasis upon identifying those techniques that have proven most useful in the past. Since the images that result from such processing may be challenged in court, the proper means of documenting these steps will be reviewed, including the distribution of a sample standard operating procedure (SOP). The session will conclude with considerations for managers regarding issues that they should address when reviewing their

imaging programs, including the associated training. In addition to the workshop notes, participants will receive copies of the documents published by the SWGIT in which workshop topics are more thoroughly discussed.

Although digital imaging technologies have been used in a variety of scientific fields for decades, their application in the criminal justice system has been relatively recent. Consequently, there has been a need to gather and disseminate accurate information regarding the proper application of this and other imaging technologies (including silver-based film and video) in the criminal justice system. The Scientific Working Group on Imaging Technologies (SWGIT) was created in 1997 to fulfill that function.

This workshop is intended to review guidelines and definitions for the use of imaging technologies in law enforcement applications that have been developed by the SWGIT. Attendees will learn about recommended procedures for acquiring, processing, and protecting imaging evidence in their forensic environment, whether that evidence is in the form of film, video, or digital imagery. Among the major questions to be addressed include the following:

- (a) What are the pros and cons of the various imaging technologies (film, video, digital) for applications such as crime scene photography and latent impression photography (to include fingerprint, footwear, or tire tread evidence)?
- (b) When using a digital camera to acquire forensic images, what steps should one take to archive those images and preserve their chain of custody?
- (c) What image processing activities are appropriate in a forensic environment and how should one document those activities?
- (d) What questions should managers ask themselves (and answer!) before making any decisions regarding changing the way in which they collect and/or process their imaging evidence?

Additional topics to be addressed in this workshop include: basic imaging technology terms and definitions, proper documentation of imaging activities, proper handling of imaging evidence, image compression, guidelines for preparation of standard operating procedures relating to imaging, and training guidelines.

Forensic Photography, Digital Imaging, Image Processing

B1 Turner's Syndrome and Amelogenin/Autosomal PCR Products Peak Height Ratios

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The goal of this research project is to present data of a sex chromosome abnormality detected using a commercial forensic STR DNA analysis kit.

The aim of this study was to investigate some theoretical properties of the AmpF/STR Profiler Plus™ PCR amplification kit. This was achieved by comparing the two autosomal loci D3S1358 and D8S1179 and the Amelogenin locus from individuals with and without the sex chromosome abnormality known as Turner's Syndrome. For both groups the peak height(s) of the female sex chromosome derived PCR product was compared to the peak height(s) observed due to the PCR products derived from autosomal DNA template(s). Utilizing both the qualitative and quantitative properties of the PCR amplification kit, the comparison of the peak height ratio of the "X" peak to the autosomal peaks should differ in males (single copy X per nucleus), females (double copy X per nucleus) and Turner's Syndrome individuals (nominally single copy X per nucleus – see below). With only one X chromosome per nucleus Turner's individuals should exhibit peak height ratios typical of males (whilst being phenotypically female).

Turner's Syndrome (also known as Monosomy X, Bonnevie-Ulrich Syndrome) is a rare (1:2500), inherited, chromosomal disorder of females first described in 1938. In approximately 57% of sufferers one entire X chromosome is deleted (45,X). Of the remaining 43% of Turner's Syndrome individuals about half exhibit some form of X chromosome structural abnormality (e.g., partial deletion, ring chromosome, etc.) whilst the rest are mosaics (having mixed karyotypes such as 45,X/46,XX; 45X,46XY etc.).

Using standard laboratory techniques, DNA was extracted from blood or tissue samples from diagnosed Turner's Syndrome individuals and from blood standards acquired as part of our population database. The DNA was then quantified using the Quantiblot™ human DNA quantification kit and amplified using the AmpF/STR Profiler Plus™ PCR amplification kit. The DNA profile was produced using an ABI Prism 310™ genetic analyzer and analyzed using Genescan™ and Genotyper™ software. DNA profiles were obtained from eight Turner's syndrome individuals and compared to the DNA profiles from twenty-five genetically "normal" males and nineteen genetically "normal" females.

The DNA profile comparison consisted of comparing the peak height of the Amelogenin "X" peak to the peak(s) observed at the D3S1358 ("first blue") and the D8S1179 ("first green") loci. These comparisons resulted in the computation of a peak height ratio. These two loci were chosen because the PCR products derived from these templates are closest in size to the PCR product derived from the female sex chromosome. In order to account for both single and dual peaks at a given autosomal locus, the peak height(s) were summed and the result divided by two. This value was then used to determine the peak height ratio.

The peak height ratios were pooled for the various groups (males, females, Turner's individuals) and loci (D3S1358 and D8S1179) and subjected to simple statistical analysis with the means, standard deviations and 95% confidence limits being determined for each and were as follows:

Group	Locus	Mean	Std. Dev. 95% Confidence Limits
Male	D3S1358 1.105	0.144	0.663-1.547
	D8S1179 1.253	0.145	0.811-1.695

Group	Locus	Mean	Std. Dev. 95% Confidence Limits
Female	D3S1358 2.256	0.417	1.678-2.834
	D8S1179 2.482	0.286	1.934-3.030
Turner's	D3S1358 1.410	0.291	0.471-2.349
	D8S1179 1.655	0.178	0.756-2.554

The results in the above table show that (as expected) the peak height ratios for the Amelogenin "X" peak when compared to the two autosomal loci are significantly different ($p < 0.05$) in genetically "normal" males and females. It can be seen when comparing the mean values that the Turner's Syndrome group more closely correlate with the male group than the female group, although they did not differ significantly from either group. This result could be due to several factors including small sample size and the possible presence of 45,X/46,XX mosaics. Further work to incorporate more Turner's Syndrome samples (with defined karyotypes) should resolve these issues.

Turner's Syndrome, X-Peak, Profiler Plus

B2 Application of Lysis Buffer in DNA Isolation From Bone for Forensic Typing

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The goal of this research project is to introduce a new method for isolating DNA from bone for forensic DNA typing. The advantage of this method over conventional methods is in applying the lysis buffer and abolishing the step of grounding, thus reducing the risk of cross-contamination among the samples.

Strategies such as grounding have been previously employed to treat bone tissue prior to DNA extraction. However, to avoid cross-contamination between samples, cleaning of the grounding equipment is needed, which is laborious and time consuming. To address this issue, we have developed a method that using a lysis buffer prior to DNA extraction. A small piece of swine bone (~1 cm³) was dissected and was treated with lysis buffer containing proteinase K (1mg/ml) at 56 C for 1 day. The mixture was extracted with phenol-chloroform followed by ethanol precipitation. The DNA yield was measured using UV spectrometry and the DNA quality was evaluated using gel electrophoresis procedure. This extracted a sufficient amount of template DNA for a polymerase chain reaction. No or little DNA degradation was observed. This DNA isolation method was then systematically studied. The various amounts of the proteinase K concentration were tested and the optimum concentration was determined. The frequency of adding proteinase K during the incubation period was also studied and the optimum condition was determined. Based on these results, we are currently performing polymerase chain reaction using autosomal makers on the DNA template isolated from this method. Mitochondrial DNA analysis will also be performed. The advantage of this method over using conventional methods is in abolishing the step of grounding, thus reducing the risk of cross-contamination among the samples.

DNA Isolation, Bone, DNA Typing

B3 Detection of Sequence Variation in the HVI and HVII Regions of the Human Mitochondrial Genome in 889 Individuals and Casework Samples Using Immobilized Sequence-Specific Oligonucleotide Probes

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The goals of this research project are to gain knowledge of the frequencies of distinct SSO mitotypes and the level of discrimination of the current HVI/HVII SSO linear array and to gain appreciation of the usefulness of this technology as a screening tool for casework samples.

The immobilized SSO probe linear array technology has proven to be a rapid, sensitive method for detecting sequence polymorphism within the mtDNA genome and is a useful screening tool for various biological samples submitted as evidence material. Detection of sequence variation in the HVII region of the human mitochondrial genome in 689 individuals from four population groups using a panel of 17 sequence-specific oligonucleotide probes immobilized on a nylon membrane has been previously reported by Reynolds et al. (2000) in the *Journal of Forensic Sciences*. Since that report, the linear array assay has been expanded to include additional probes in 4 regions of the HVI region and for positions 16093 and 189. Also, several probes from the original HVII assay have been redesigned and the HVII E region ("C-stretch") probe has been removed. Currently, both the HVI and HVII regions are co-amplified simultaneously rather than separately. In order to evaluate the performance of the new array and to obtain population frequencies for a database, we typed the 689 unrelated individuals (200 US Caucasians, 200 African Americans, 200 US Hispanics, and 89 Japanese) with the current panel of 31 SSO probes spanning the HVI and HVII regions. As with the HVII linear array, one of four categories of probe signal within each probe binding region was observed for the HVI/HVII linear array: (1) a single probe is positive; (2) a single probe signal is visible but its intensity is weaker than a positive signal in other regions; (3) no probe signals are visible; or, (4) two probe signals are visible. To characterize these categories, DNA sequence analysis was performed when blanks or "0" signals and weak signals were observed. In addition, samples in which mixtures of two sequences were observed by SSO typing were sequenced and the second sequence was either attributed to heteroplasmy or contamination. Also, the genetic diversity value for each population was calculated from the frequency data and the frequencies of distinct mitotypes in each group were determined and compared to the published values and frequencies obtained with the original HVII linear array.

The current HVI/HVII linear array was also used to generate a regional database for Georgia at the Georgia Bureau of Investigation (GBI). For this database, blood samples randomly collected from 100 Caucasians and 100 African Americans from individuals who resided in Georgia, previously used to generate their regional STR and AmpliType PM databases, were typed with the SSO linear array. The HVI and HVII regions of each of the 200 samples were sequenced as well. The genetic diversity value for each population was calculated from the frequency data for both typing methods and are compared to each other as well as to the general US population database. We also estimated the frequency of heteroplasmy detected by both typing methods. In addition to the samples from the Georgia population database, samples from multiple cases submitted to the GBI also were typed using the SSO linear array and sequence analysis. Cases in which the suspect had been excluded by STR typing

were chosen for this study to allow us to assess the value of the linear array assay as a screening tool for the exclusion of individuals. In all but one case, linear array typing was sufficient to exclude the suspects who had been excluded by STR analysis. In this particular case, the suspect excluded by STR analysis had the same SSO mitotype as well as the same HVI and HVII sequence as the donor of the semen stain. Prior to mtDNA typing, it was thought that the suspect was a brother of the donor of the semen stain based on STR analysis. The mtDNA analysis was consistent with this conclusion. Several additional cases will be summarized, along with the mitotype frequencies of the individuals in these cases obtained from the Georgia database and the US database.

Since the current method for reporting mtDNA frequencies is the counting method, a large database is necessary to increase discrimination. Therefore, with this study, as well as through collaborations with several crime laboratories, we hope to increase the SSO population database substantially. Based on the population data collected from these 889 unrelated individuals and the casework samples, we conclude that the HVI/HVII immobilized SSO probe linear array typing system provides valuable, discriminating information and is an effective screening method prior to sequencing.

SSO Linear Array, mtDNA, Population Database

B4 Characterization of AmpF ℓ STR $\text{\textcircled{R}}$ Identifier TM PCR Amplification Kit for Use With ABI PRISM $\text{\textcircled{R}}$ 3100 Genetic Analyzer

Farideh Shadravan, PhD, Rhonda K. Roby, MPH, and Dennis J. Reeder, PhD, Applied Biosystems, 850 Lincoln Center Drive, Foster City, CA*

The goal of this research project is to test the different parameters associated with both the Identifier TM PCR Amplification Kit and the ABI PRISM $\text{\textcircled{R}}$ 3100 Genetic Analyzer to determine the optimal conditions for using these two new products together for human identification applications.

A new STR multiplex kit from Applied Biosystems, the AmpF ℓ STR $\text{\textcircled{R}}$ Identifier TM PCR Amplification Kit, using a 5-dye system, contains reagents necessary to amplify 15 tetranucleotide short tandem repeat loci and the gender identification locus Amelogenin in a single PCR reaction. The amplified loci include the 13 core CODIS loci (TH01, vWA, FGA, D3S1358, D13S317, D5S818, D8S1179, D7S820, D21S11, TPOX, D18S51, D16S539, and CSF1PO) as well as D2S1338 and D19S433, which are used mainly in Europe. The ABI PRISM $\text{\textcircled{R}}$ 3100 Genetic Analyzer is an automated, mid-to-high-throughput 16-capillary electrophoresis system that can separate, detect, and analyze the fluorescently labeled DNA contents of up to 16 capillaries in one run of 45-minute duration.

To evaluate the performance of the 3100 analyzer with the Identifier TM kit, various criteria such as sizing precision, peak resolution, sensitivity and color balance were extensively studied. First using three 3100 analyzers, several lots of two control DNA samples (9947A and 007 obtained from AmpF ℓ STR $\text{\textcircled{R}}$ kits) and the Identifier TM Allelic Ladder, a range of different run module parameters (injection voltage, injection time, run temperature) were tested, and it was shown that the default run module (3 kV injection voltage, 10 seconds injection time and 60°C run temperature) gave optimal performance with regard to sensitivity, color balance and one base resolution. Then varying amounts of different reagents used in this type of study were tested, and found that 3 μ L allelic ladder, 1 ng template DNA, 1 μ L PCR product input, 0.3 μ L GeneScan TM 500 LIZ TM Size Standard and 8.7 μ L Hi-Di TM formamide (Applied Biosystems, Foster City) gave satisfactory results.

Sizing precision was evaluated by testing four 36 cm 16-capillary arrays on one 3100 analyzer, while using the same lots of the two control

DNA samples and POP-4™ polymer. In this study, two full 96-well microplates (corresponding to 12 runs) were tested on each array. In addition to the two control DNA samples, for every run 3 µL allelic ladder was loaded into the well that corresponded to the capillary no. 16 of each array. After testing the arrays, the average fragment size (for 16 capillaries) and standard deviation (SD), as well as the minimum and maximum deviations from each mean allele size, were calculated for the 13 alleles common to the two control DNA samples (using the statistical features of Genotyper® software).

The results indicated a sizing precision of ≤ 0.15 nucleotide SD among the 16 capillaries for all 48 runs. But when the data was recalculated assuming that each whole plate was one run (consisting of 90 control DNA samples), in 2 out of 8 plates, SD values were > 0.15 for peaks with 330 and 340 bp fragment size. The same results were obtained for the 6 allelic ladder samples (one per run) when they were considered to be all in one run. These results indicated that with regard to sizing precision, run to run variation was occasionally higher than capillary to capillary variation. Variation in sensitivity from array to array was also evaluated in this study.

(ABI PRISM, AmpFℓSTR, Applied Biosystems, and Genotyper are registered trademarks and GeneScan, Hi-Di, POP-4, Identifiler, and LIZ are trademarks of Applied Biosystems Corporation or its subsidiaries in the US and certain other countries.)

Identifiler™ Kit, GeneScan™ 500 LIZ™ Size Standard, 16-Capillary Array

B5 Y-Chromosome Binary DNA Sequence Variation in Turkey and Its Relevance to Forensic Science

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The goal of this research project is to evaluate the possibility of using single nucleotide polymorphism of Y chromosome in forensic individualization.

DNA sequence variation associated with the non-recombining portion of the haploid Y chromosome can provide both unique and useful forensic information. Two main classes of loci exist: rapidly mutating YSTR loci and slow mutating, unique event binary polymorphisms (single nucleotide substitutions and small insertions or deletions). YSTRs are already being used in sexual assault cases where male and female tissues are mixed and in disputed paternity cases. Population based YSTR allele frequency data are already available.

Progress in the identification of hundreds of PCR compatible binary Y polymorphisms in diverse populations has created new opportunities for male specific DNA profiling. Such evolutionarily stable mutations accumulate throughout the lineal lifespan of the chromosome and can be used to define population specific haplotypes, indicative of genetic affinity, subsequent divergence and population substructure. Since single copy regions are developed as molecular reagents, only one or the other allele is expected. Panels of binary markers can be used as an initial filter to rapidly exclude male individuals in paternity and assault cases, to identify the presence of multiple unrelated male perpetrators via the appearance of apparent heterozygous signatures, and to provide clues to ethnic affiliation. Such polymorphisms are also useful in genealogical surveys and the diagnosis of genetic diseases associated with the Y chromosome such as male infertility.

A total of 50 binary Y markers informative in ethnic groups relevant to the Turkish population gene pool were genotyped using denaturing high performance liquid chromatography (DHPLC) methodology, in a collection of 450 unrelated males originating from different geographical areas of Turkey. Unpurified PCR were mixed at an equimolar ratio with a reference Y chromosome amplicon of known allelic state, denatured, reannealed and duplex status determined by DHPLC. Heteroduplex mismatches were detected by the appearance of two or more peaks in elution profiles versus a single peak for homoduplexes. Compound haplotypes were constructed and frequencies determined creating a portrait of the population sub-structure of Turkey.

Y Chromosome, SNP, DHPLC

B6 Relative Sensitivity Comparisons Between ABI Fluorescent Detection Instruments Using Data From Large Scale No-Suspect Casework

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The goals of this research project are to discuss forensic DNA casework examples demonstrating the existence of relative sensitivity differences between the ABI Prism 377 DNA Sequencer and ABI Prism 310 Genetic Analyzer. Discussion of the nature of these differences and the ability to detect such differences will be presented. Implications of instrument choice for DNA testing of evidence samples will be presented. The participants will also be informed of several corrective measures that may be taken in order to counteract potential losses of sensitivity.

In the course of performing STR testing on large numbers of no-suspect forensic cases, a large amount of data has been collected from the ABI Prism 310 Genetic Analyzer and ABI Prism 377 DNA Sequencer instruments. This data was compared to evaluate the relative sensitivities of each instrument and the implications instrument choice has on our ability to generate an interpretable profile from evidentiary samples. This is an important issue since many forensic samples contain very little DNA and retesting may not be possible. Thus, a poor instrument choice may negatively impact a laboratory's ability to interpret good data from that sample. Although it is widely known that the 310 instruments are "more" sensitive than 377 instruments, many labs choose to work with the less sensitive, higher throughput, gel-based ABI 377. Are these labs making the right instrument choice for their samples?

Data was collected to evaluate two main issues. The first issue is the practical difference in relative sensitivity between the two instruments and the second issue is the loss of any possible information of minor contributors specifically in cases of sexual assault. The first issue was evaluated by taking the same amplicon from samples and running these on both the 377 and the 310 instruments. This was done for both standards and mixtures. The average relative sensitivity of the 310 was compared with that of the 377 by observing and recording the relative fluorescent units of each sample. The AmpFℓSTR Profiler Plus™ and Cofiler™ PCR Amplification Kits were used following the manufacturer's recommended amplification protocol. Following the completion of amplification, 4µL of each sample were run on a product gel using GelStar® detection. Based on the product gel, each sample was prepared for loading/injection using the same volume and run on each instrument. The initial injection time for all samples was 5s and then increased or decreased to 10s and 2s, respectively, in some cases. The sample loading volume on the gel ranged from 0.5-1.0µL. The results of this study show a relative difference in sensitivity

between the two instruments, with the ABI 310 being the more sensitive of the two. For clarification, the term “relative” in this presentation is used to address our inability to quantitate the exact amount of DNA injected in a particular 310 run. This is in direct opposition to runs on the 377, where a measurable quantity of sample is loaded into a well in the gel, electrophoresed and analyzed.

The second part of our evaluation of casework data revolved around no-suspect sexual assault samples. These samples were extracted using a standard differential extraction procedure and a sperm count was recorded. The concentration of sperm was ranked from 0 to +4, with 0 indicating no sperm and +4 representing many sperm in many fields. The samples ranked as a +1 or less were amplified with a target of 0.75ng of DNA and run on an ABI 310, while the samples that ranked between +2 to +4 were amplified with a target of 1.25ng and run on the ABI 377. Preliminary findings indicate that the decision to run sperm cell fractions with high sperm counts on the ABI 377 was an appropriate course of action to take. Furthermore, additional data will be presented that may elucidate whether running +1 samples on the 377 as an initial screen may be an option with potential efficiency benefits.

Instrument choice may not be an option in some laboratories due to budgetary constraints or other factors such as throughput. In these cases, some flexibility may be gained by considering alternatives such as increasing amplification target amounts or increasing preparation volumes in order to assure the use of the most appropriate analytical techniques for a particular instrument. These alternatives will also be discussed.

ABI 310 and 377 Instruments, Sensitivity, No-Suspect Casework

B7 Population Data From Chile Using the PowerPlex™ 16

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The goal of this research project is to present the results and parameters of forensic interest (HWE, PD, PE) of the Chilean population for the 15 STR loci in the Power Plex™ 16 (Promega Corp).

The typing of STR loci is facilitated by the ability to amplify several loci simultaneously in a multiplex polymerase chain reaction (PCR). The 16 STR loci D3S1358, TH01, D21S11, D18S51, PentaE, D5S818, 13S317, D7S820, D16S539, CSF1PO, PentaD, vWA, D8S1179, TPOX, FGA, and the locus amelogenin can be amplified simultaneously using the the PowerPlex™ 16 kit (Promega Corp. Madison, WI, USA).

This paper presents allele distribution data in the general Chilean population. Extracted DNA samples (n=323) were amplified at the 16 loci using the PowerPlex™ 16 kit (Promega Corp. Madison, WI, USA). Samples were analyzed using the ABI Prism™ 310 Genetic Analyzer (PE Biosystems, Foster City, CA) according to the manufacturer’s recommended protocol.

All 15 loci are highly polymorphic in the Chilean sample population with the locus TPOX (67.3%) having the lowest observed heterozygosity, and the locus PentaE (92.9%) displaying the highest heterozygosity. The most discriminating loci were PentaE (PD=0.983) and FGA (PD=0.966). The combined probability of exclusion for the 15 STR loci is 0.99999961. There was little evidence for departures from Hardy-Weinberg expectations (HWE) in this sample population. Based on the exact test, the loci that departed significantly from HWE are D16S539 (p=0.002). After employing the Bonferroni correction for the number of loci analyzed, these observations are not likely to be significant. An inter-class correlation test analysis was performed to detect any correlations between alleles at any of the pair-wise comparisons of the 15 loci. A resume of the PD and PE is shown in the following table.

Locus	PD (Obs)	PD (Exp)	PE
1 D3S1358	0.88405873	0.88089494	0.49149762
2 TH01	0.89212828	0.90310794	0.53570855
3 D21S11	0.95387339	0.95629693	0.68708958
4 D18S51	0.96501458	0.96831543	0.73361811
5 PentaE	0.98328821	0.98654943	0.82803091
6 D5S818	0.89582466	0.90205337	0.53715336
7 D13S317	0.95340483	0.95562899	0.68325371
8 D7S820	0.90733028	0.90882529	0.55156953
9 D16S539	0.91795085	0.92152643	0.58126074
10 CSF1PO	0.86344232	0.86806648	0.46526042
11 PentaD	0.95168680	0.95664959	0.68774901
12 vWA	0.90207205	0.91023088	0.55517793
13 D8S1179	0.93419409	0.93968115	0.63224998
14 TPOX	0.83756768	0.83824361	0.42261732
15 FGA	0.96647230	0.96878723	0.73539573
Total	>0.99999999	>0.99999999	0.99999961

In conclusion, a Chile database has been established for the loci. All loci are highly polymorphic. The allelic frequencies of these PCR-based loci can be used to estimate the frequency of a multiple locus DNA profile in the Chilean population.

STR, PowerPlex™ 16, Chile

B8 Spanish Population Data for the 15 STRs Loci Included in the PowerPlex™ 16 Kit

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The goal of this research project is to present the results and parameters of forensic interest (HWE, PD, PE) of the Chilean population for the 15 STR loci included in the PowerPlex™ 16 (Promega Corp.).

The 16 STR loci D3S1358, TH01, D21S11, D18S51, PentaE, D5S818, D13S317, D7S820, D16S539, CSF1PO, PentaD, vWA, D8S1179, TPOX, FGA, and the locus amelogenin can be amplified simultaneously using the the PowerPlex™ 16 kit (Promega Corp. Madison, WI, USA).

This paper presents allele distribution data in the Spain population. Whole blood was obtained in EDTA vacutainer tubes by venipuncture from unrelated individuals (N=323) residing in Andalusia (Spain). Extracted DNA samples were amplified at the 16 loci using the the PowerPlex™ 16 kit (Promega corp. Madison, WI, USA). Samples were analyzed using the ABI Prism™ 310 Genetic Analyzer (PE Biosystems, Foster City, CA) according to the manufacturer’s recommended protocol.

All 15 loci are highly polymorphic in the Spanish sample population with the locus TPOX (66.8%) having the lowest observed heterozygosity, and the locus D18S51 (87.5%) displaying the highest heterozygosity. The most discriminating loci were D18S51 (PD=0.969) and PentaE (PD=0.968). The combined probability of exclusion for the 15 STR loci is 0.99999953. There was little evidence for departures from Hardy-Weinberg expectations (HWE) in this sample population. Based on the exact test, the locus that departed significantly from HWE are vWA (p=0.0488). After employing the Bonferroni correction for the number of loci analyzed, these observations are not likely to be significant. An inter-class correlation test analysis was performed to detect any correlations between alleles at any of the pair-wise comparisons of the 15 loci. A resume of the PD and PE is shown in the following table.

Locus	PD (Obs)	PD (Exp)	PE
1 D3S1358	0.92269737	0.92278200	0.58299702
2 TH01	0.91326177	0.92153232	0.57932276
3 D21S11	0.96156510	0.96393249	0.71562119
4 D18S51	0.96918283	0.97244149	0.75197184
5 PentaE	0.96892313	0.97153083	0.74728688
6 D5S818	0.87629848	0.87782049	0.48530485
7 D13S317	0.91784972	0.92716219	0.59710511
8 D7S820	0.92269737	0.93174389	0.60817361
9 D16S539	0.90226801	0.91172840	0.55780904
10 CSF1PO	0.83907548	0.86025565	0.45017867
11 PentaD	0.94650277	0.95237783	0.67224651
12 vWA	0.92944945	0.93221428	0.60962035
13 D8S1179	0.92529432	0.93586954	0.62118533
14 TPOX	0.81864612	0.82216391	0.40301804
15 FGA	0.96641274	0.96961134	0.73910229
Total	>0.99999999	>0.99999999	0.99999953

In conclusion, a Spain database has been established for the loci D3S1358, TH01, D21S11, D18S51, PentaE, D5S818, D13S317, D7S820, D16S539, CSF1PO, PentaD, vWA, D8S1179, TPOX, FGA. All loci are highly polymorphic. The application of the product rule is valid for estimating the rarity of a multiple loci profile for these 15 loci.

STR, PowerPlex™ 16, Spain

B9 Scientific Working Group for the Analysis of Forensic Drug Samples (SWGDRUG) — Update 2002

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The goal of this research project is to give the attendees the opportunity to learn about the objectives and accomplishments of the continuing SWGDRUG process.

The mission of SWGDRUG has been the formulation of recommendations for internationally accepted minimum standards for the forensic examination of seized drugs. This session will provide participants with a better understanding of the Scientific Working Group for the Analysis of Forensic Drug Samples (SWGDRUG) recommendations and the protocols for implementing these recommendations into their laboratory standard operating procedures. The SWGDRUG recommendations have been disseminated on the INTERNET and in Microgram. They are now available in an official publication which will be distributed at the 2002 AAFS meeting. The discussion will focus on the following SWGDRUG objectives and accomplishments:

- A. Promoting professional development in forensic drug analysis.
- B. Providing a means of information exchange within the forensic science community.
- C. Requiring the highest ethical standards of practitioners and trainees in all areas of forensic drug analysis.
- D. Providing guidelines for drug examination and reporting.
- E. Establishing quality assurance guidelines.
- F. Gaining international acceptance of SWGDRUG recommendations.

The SWGDRUG core committee will have met in January of 2002 to discuss the possible changes in core committee membership and in other areas where recommendations will benefit forensic science laboratories in

providing an optimized work product. This presentation will also include discussing the goals of SWGDRUG at future conferences. In addition, SWGDRUG core committee members attending this presentation will seek input from those in attendance. By affording forensic scientists the opportunity in an open forum to comment on the process of developing recommendations that will enhance the profession, SWGDRUG will remain an integral facet of forensic drug analysis on an international level.

Criminalistics, Drug Analysis, Drug Chemistry

B10 Forensic Science Laboratory Quality Management Meets Brady

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The goal of this research project is to alert forensic scientist practitioners of the legal requirements specified by the federal courts to provide information deemed to be material to the defendant.

Brady v. Maryland 373 U.S. 83 (1963) and a number of derivative cases place specific requirements on prosecutors to disclose favorable evidence to the defendant. Favorable evidence, or to use the legal terminology, "material evidence," may be defined as evidence which would be expected to affect the outcome of the case. The duty to disclose exists even in cases where prosecutors are unaware that a forensic science laboratory possesses material evidence. The difficulty with such situations is that public forensic science laboratories are often unaware of a legal duty and sometimes are uncertain which information constitutes material evidence.

We learned of this obligation to disclose first hand. The American Society of Crime Laboratory Directors – Laboratory Accreditation Board, ASCLD/LAB, requires external proficiency testing to be conducted by accredited laboratories. The Proficiency Review Committee (PRC) reviews the external proficiency test results and discrepancies are reported to ASCLD/LAB. When a discrepancy is determined by the PRC, the accredited laboratory is required to provide the PRC with a plan to correct the problem. Because of a lack of awareness, we neglected to turn over required information to the prosecutor's office after an examiner failed a declared proficiency test. The district attorney felt that the examiner's failure of a proficiency test was material information that should be turned over to the defense.

The remediation we decided included a review of a number of the examiner's cases. In two instances we found casework errors and communicated these to the prosecutors in those cases. One of the prosecutors advised his superiors of the examiner's proficiency test failure. We were advised by the district attorney about state and Federal case law requiring disclosure of material information to the defendant. We also learned that the prosecution has a duty to disclose material information to the defendant even in cases where the prosecution is unaware of its existence (see for example, *In re Brown*, 952 P.2d 715). In cases where the police or their agents possess material information unknown to the prosecution, the courts view this as if the prosecution has knowledge of that information. The government forensic science laboratory is viewed as an extension of the police investigative process.

The district attorney proceeded to send letters to defense attorneys in all cases examined by our employee over a two-year time period as a means to fulfill the prosecution's duty to disclose. We also conducted our own review of all the cases that the individual examined over a two-year time period. Some of the cases had been adjudicated and the evidence was destroyed. The prosecutor's office reviewed each of the cases to assess the significance of the forensic testing in each case.

We also worked closely with our civil attorneys to prepare for possible litigation resulting from this situation. The re-examination required many hundreds of hours of work and well over a year to complete the review.

ASCLD/LAB Proficiency Testing, Brady, Disclosure

B11 Need a Clue? Forensic Science Projects Help Piece Together the Crime Puzzle

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The goals of this research project are to provide a forum for the exchange of research project information between the project manager and the bench scientist. Federal funding supports a vast number of research projects annually with only a small portion of the technical information making its way to the beneficiaries of the research. This presentation will briefly touch upon forensic science projects under progress at the National Institute of Standards and Technology and will elicit comments and direction from those individuals that this research is trying to assist the forensic investigator.

The Office of Law Enforcement Standards (OLES) at the National Institute of Standards and Technology (NIST) has a mission to apply science and technology to the needs of the criminal justice community, including law enforcement, corrections, and forensic science as well as the fire service. OLES has published, mostly through the National Institute of Justice (NIJ), more than 200 standards, guides, and technical reports over its 30-year history. To assist the criminal justice agencies with the high-quality resources that they need to do their jobs, OLES develops methods for examining evidentiary materials, performance standards for equipment, users' guides, and standard reference materials. However, much of this information never makes it into the crime laboratory, much less into the hands of the forensic examiner or investigator. In an effort to familiarize the forensic science community with the latest research projects being conducted at NIST, a brief synopsis on those topics that affect the forensic examiner/investigator will be presented.

The primary disciplines that will be highlighted are computer crime, DNA, explosives, firearms, fire investigation, and hair analysis. Just as important as the briefing on the selected topics are the informational locators that can direct the scientist/investigator to the latest publications or test results. This information will also be provided.

Arson, DNA, GSR

B12 Quality Assurance and the Contamination Issue in Forensic Science

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The goal of this research project is to understand the contamination issues in forensic science and how to address them from a quality assurance perspective.

The scientific literature confirms that contamination is an issue of universal importance. From the lead contamination of Arctic plants to the dioxin contamination of breast milk, the issue of contamination presents real and challenging quandaries for society and science. The contamination and degradation of physical evidence in criminal cases presents analogous and ubiquitous challenges for the forensic scientist. From gunshot residue analysis to DNA samples, contamination imparts a real and present problem for forensic analysis and interpretation. How forensic scientists deal with the contamination issue is critical to their final report and opinion regarding the analysis of physical evidence.

Actual contamination, at least at the laboratory level, in forensic casework has been reported to be a relatively rare occurrence. For example, in DNA analysis, systematic studies of PCR contamination (Scherezingier *et al*, 1999) found that significant contamination occurred "only with gross deviations from basic preventative protocols," and PCR contamination using dot blot detection was less evident than generally would be expected. Another DNA study revealed that 11% (N = 117 test

swabs) of the test swabs taken from instruments used for autopsies had been contaminated (Rutty *et al*, 2000). In the case of explosives analysis, the risk of forensic sample contamination in the forensic laboratory was found to be extremely small (Crowson *et al*, 2001). It was also found, however, that a laboratory staff member introduced explosive material (RDX) contamination into the laboratory after handling the explosive RDX a week before, even though the employee conscientiously followed all precautionary decontamination procedures. The source of the RDX contamination proved to be the employee's wristwatch (contaminated with about 300 ng of RDX).

For the purposes of this discussion I would propose two types of contamination: primary and secondary. Primary contamination is inherent in the evidence sample and cannot be controlled for. An example is the mixtures of suspect and victim DNA in a rape kit swab from a victim. Very little can be done to eliminate or minimize primary contamination. Secondary contamination is introduced to the evidence sample through processing. An example is clothing fibers or hairs from police officers or crime scene personnel investigating a crime scene. Some things can be done to minimize secondary contamination; however, it should not be presumed that all secondary contamination could be minimized. Some secondary contamination must be expected as part of the evidence processing.

Quality assurance measures such as positive and negative controls, reagent blanks, and routine cleaning measures can be used to assess and limit the nature and extent of the contamination. Routine monitoring swabs taken in the laboratory environment may also help to detect the introduction of potential contaminants. Case-working guidelines from scientific and technical working groups generally address specific and appropriate quality assurance measures for many of the forensic disciplines.

Quality Assurance, Contamination, Forensic Science

B13 Undergraduate Education in Forensic Science

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The goals of this research project are to inform the members of the structure and content of current undergraduate programs in forensic science and the progress being made by the Council of Forensic Science Educators in developing an accreditation program. The members will be aware of the need for accreditation of educational programs and will contribute opinions and ideas to the COFSE.

Large numbers of Criminalists have formal education in science but received their introduction to forensic science on the job. Programs offering forensic science education have been available for over 30 years. The AAFS web site currently includes 25 undergraduate programs in the United States and 13 from outside of the U.S. There are 31 U.S. and 10 non-U.S. graduate programs not including Odontology listings. The undergraduate offerings cover a wide range including Associates Degrees and Certificates in Forensic Science, B.S. in Forensic Science, B.S. in Chemistry with an emphasis, concentration or minor in Forensic Science. There are also programs specializing in Forensic Nursing, Forensic Anthropology, and Toxicology. Four new undergraduate listings for 4-year programs appeared between October 2000 and July 2001. Unfortunately, there exists no formal evaluation or accreditation of these programs. In response to inquiries from ASCLD and AAFS, the Council of Forensic Science Educators has undertaken a survey of existing programs with a goal of determining what they have in common and how their offerings compare with published surveys of crime laboratory directors (Furton *et al.*, *J. Forensic Sci.*, 1999: 44: 128-132).

Fourteen responses from a variety of programs are presented. All of the programs offer a B.S. degree in either Forensic Science or in a Science with a minor or concentration in Forensic Science. The institutions provided copies of their program descriptions and requirements from

which it was determined how many course and semester hours are required within eight categories in order to receive a B.S. degree. The results of the survey are shown below:

Summary of Minimum Requirements of Undergraduate Programs

	Minimum	Maximum	Average
Chemistry Courses	5	12	8.0
Biology Course (s)	1	5	2.5
Physics Course (s)	1	3	1.9
For. Sci./Crim. Courses	1	10	3.2
Criminal Justice Courses	1	5	2.0
Calculus Course (s)	0	2	1.4
Statistics Course (s)	1	1	1.0
Internship Course (s)	1	2	1.1

In keeping with the Crime Laboratory Directors survey, most programs place a heavy emphasis on chemistry.

Certification and/or accreditation of Forensic Science Programs will have a number of positive effects on the Criminalistics profession:

- The community of educators and laboratory directors and criminalists will have the opportunity to work to form a consensus about what constitutes an education in Forensic Science and how it differs from an education that does not include Forensic Science.
- Laboratory directors will have a basis for evaluating the educational experience of applicants.
- Prospective students will have a basis for evaluating programs.
- A framework will exist for structuring new programs.
- Existing programs will have a structure within which they can evaluate and improve.

Accreditation involves much more than looking at the list of courses required by an institution. The COFSE is actively studying the components of an accreditation program and how the program might be administered. The following outline will be discussed as a possible working document for undergraduate programs.

Criteria for Program Evaluation

In order to be considered for accreditation, a program must be designed to give graduates a broad general education at the B.S. level and to enable them to function effectively as entry-level scientists in crime laboratories and/or as entry-level crime scene investigators. The criteria are divided into seven major categories:

1. Objectives and Assessments: The program has documented, measurable objectives, including expected outcomes for graduates. The program regularly assesses its progress against its objectives and uses the results of the assessments to identify program improvements and to modify the program's objectives.

2. Students: Students can complete the program in a reasonable amount of time. Students have ample opportunity to interact with their instructors. Students are offered timely guidance and advice about the program's requirements and their career alternatives. Students who graduate the program meet all program requirements.

3. Faculty: Faculty members are current and active in the discipline and have the necessary technical breadth and depth to support a modern forensic science program. There are enough faculty members to provide continuity and stability, to cover the curriculum, and to allow an appropriate mix of teaching and scholarly activity.

4. Curriculum: The curriculum is consistent with the program's documented objectives. It combines technical requirements with general education requirements and electives to prepare students for a professional career in the field, for further study in forensic science, and for functioning in modern society. The technical requirements include up-to-date coverage of basic and advanced topics in forensic science as well as an emphasis on science and mathematics.

5. Laboratories and Facilities: Laboratories and computing facilities are available, accessible, and adequately supported to enable students to complete their course work and to support faculty teaching needs and scholarly activities.

6. Institutional Support and Financial Resources: The institution's support for the program and the financial resources available to the program are sufficient to provide an environment in which the program can achieve its objectives. Support and resources are sufficient to provide assurance that the program will retain its strength throughout the period of accreditation.

7. Institutional Facilities: Institutional facilities including the library, other electronic information retrieval systems, computer networks, classrooms, and offices are adequate to support the objectives of the program.

Undergraduate Education, Accreditation, COFSE

B14 Reactions Involved in Fingerprint Development Using the Cyanoacrylate-Fuming Method

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The goal of this research project is to present the basic chemistry research findings to the forensic community regarding development of latent fingerprints using the cyanoacrylate fuming method.

Chemical processes involved in the development of latent fingerprints using the cyanoacrylate fuming method have been studied and will be presented. Two major types of latent prints have been investigated – clean (eccrine) and oily (sebaceous) prints. Scanning electron microscopy (SEM) was used as a tool for determining the morphology of the polymer developed separately on clean and oily prints after cyanoacrylate fuming. A correlation between the chemical composition of an aged latent fingerprint, prior to development, and the quality of a developed fingerprint was observed in the morphology. The moisture in the print prior to fuming was found to be a critical factor for the development of a useful latent print. In addition, the amount of time required to develop a high quality latent print was found to be minimal. The cyanoacrylate polymerization process is extremely rapid. When heat is used to accelerate the fuming process, typically a period of 2 minutes is required to develop the print. The optimum development time is dependent upon the concentration of cyanoacrylate vapors within the enclosure.

Research on the chemical processes involved in the development of latent fingerprints using the cyanoacrylate fuming method leads to the identification of specific water-soluble components of eccrine sweat as the initiators for the polymerization process. Scanning electron microscope (SEM) morphology results from thin films of individual initiator solutions, developed by cyanoacrylate fuming, indicated that small spheres and noodle-type structures are the two main polymer formations produced. These formations are consistent with the structures observed on cyanoacrylate-developed latent prints. Three different initiation/reaction mechanisms, dependent upon the initiator and/or pH, have been proposed. These mechanisms aid in explaining the polymer structures observed using SEM imaging on cyanoacrylate developed clean and oily latent fingerprints. FTIR and NMR analysis were employed to validate the proposed mechanisms.

Latent-print aging studies on clean and oily prints were carried out to determine the effectiveness of cyanoacrylate fuming on aged prints. Clean prints, older than 48 hours, were found to completely lose the ability to be visibly detected by cyanoacrylate fuming. Clean prints have been correlated with the latent prints of prepubescent children. Prior to the release of hormones (adrenal androgens) at the onset of puberty, sebum is not secreted in young children. Thus, latent fingerprints deposited by children tend to be eccrine in nature. In order to increase the superglue development efficiency of aged-clean latent prints deposited by children and adults, a means of regenerating the prints was evaluated. Attempts to regenerate clean prints using water vapor were not successful. However, regeneration of aged-clean prints using acetic acid was successful - even

after aging a print 6 months prior to regeneration and cyanoacrylate fuming. A standard method for regenerating clean prints has been developed. Chemical process suspected of being involved in the clean print regeneration process will be discussed.

Oily prints were successfully developed without regeneration after aging up to 22 months. Oily prints possess an inherent mechanism that allows a latent print to maintain (or rehydrate) a given amount of moisture within the print. After oily prints aged approximately 6 months, the degradation of ridge detail was noted. This degradation increased as the age of the print increased prior to fuming. The exposure of an oily print to acetic acid vapors produced by the clean-print regeneration standard method did not adversely affect the quality of a superglue developed oily print.

Latent-Print Regeneration, Acetic Acid, Chemical Reactions

B15 The Discrimination of Two-Dimensional Military Boot Impressions Based on Wear Patterns

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The goal of this research project is to shown attendees that a video/marker measurement system may afford a high level of discrimination when used to compare two-dimensional footwear impressions using a series of precise measurements based on wear patterns.

The idea for this study had its genesis with the observation that the lugs and stars present on the outsoles of some types of military combat boots have a truncated wedge shape. Because of this taper, the areas on outsoles making contact with a flat surface are at a minimum when the boots are new, but increase with wear. This pattern is also present on commercial footwear having Vibram® brand outsoles. Clearly, this feature (lugs and stars having a truncated wedge shape) would facilitate a higher level of discrimination based on the amount of time a questioned boot had been worn. However, might there be additional discrimination due to individual differences in weight, bone structure, and locomotion mechanics? To rigorously test this hypothesis, we wanted to eliminate all other variables. Ideally, when new, all of the boots in the study would be of the same brand, the same size and foot (we wanted only size 10 Regular, male, right boots), and all would have the same outsole patterns produced by the same mold. Additionally, all of the individuals involved in the study would wear the boots for the same length of time and all be engaged in the same activities. In an attempt to approach this ideal, we selected U.S. Marine Corps recruits, all at the end of their fifth week of training.

At the end of the fifth training week, to rapidly record the two-dimensional outsole impressions, we used a commercial footwear impression kit featuring a chemically infused pad and sensitized paper. Recorded at the same time were the size information present on the tongue of each right boot. Impressions of some new boots were also obtained as standards. It was not possible to obtain the impressions of the new boots before they were issued to the Marine recruits, or to insure that all outsoles had been produced by the same mold. An image analysis system was used to acquire the two-dimensional impressions as files. Certain outsole features were then selected, and measurements made using a commercial marker/measurement system. Measurements were recorded on spreadsheets (MS Excel 97) before being transferred into a database program (MS Access 97) for analysis.

To test the discrimination power of this series of measurements, all of the original footwear impression sheets whose selected feature measurements had been entered into the database were taken away. A number of these sheets were selected, their original identifying marks removed, and then added to these selected sheets were several footwear impression

sheets not yet entered into the data base. These were randomly lettered and then presented to the operator of the image analysis, marker/measurement system as “unknowns.” We wanted to eliminate accidental features (cuts, nicks, nail holes, etc.) as a discrimination factor in this study. Therefore, after the features of the “unknowns” were measured, they could only be searched against the database containing the previously entered feature measurements. Based on repeated measurements, a range of +/- 0.03 cm was found to be a normal variation. A matching criteria of +/- 0.10 cm gave results with the best combination of fewest false inclusions/false eliminations. With these criteria no false eliminations occurred. There was one false inclusion (all measurements fell within the +/- 0.10 cm range), but the measurements for the actual match had overall closer agreement.

Footwear Impressions, Wear Patterns, Discrimination

B16 Spectrochemical Analysis and Imaging of Latent Fingerprints

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The goal of this research project is to understand the chemical composition of latent prints so that new methods of producing visible print images could potentially be developed.

This paper describes work regarding spectroscopic chemical analysis of fingerprint material and methods investigated toward the potential of imaging fingerprints using spectral data obtained from spectrometers equipped with array detectors. The objectives of this study are to understand the chemical composition of latent prints so that new methods of producing visible print images could potentially be developed.

The forensic fingerprint community has recently developed a particular interest to study children's (prepubescent) prints. Cases have been reported stating that the recovery of children's prints at a crime scene is very difficult. Therefore, there is interest in the forensic community to improved understanding of the chemical character of children's prints so that current fingerprint techniques can be modified or new ones developed. A preliminary investigation of the application of IR and Raman analysis for chemical and imaging analysis of latent prints was conducted on adults' prints. The project demonstrated that it is possible to acquire IR and Raman spectra of sebaceous fingerprints on aluminum foil. The study also demonstrated that IR could be used to obtain spectra from prints produced from eccrine. The spectra provided information about the chemical composition of the material deposited in the print. Initial studies showed that there is reasonable repeatability in these experiments. Due to greater sensitivity by IR analysis, current work uses only IR to investigate the eccrine material secreted by children.

The initial approach was to evaluate what has been determined by previously published studies, most significantly, as determined by gas chromatography/mass spectrometry. This method requires an extraction process followed by a derivitization to produce the fatty acids volatile enough to chromatograph. The advantage of IR is that the prints can be analyzed directly from a reflective surface such as aluminum.

Additionally, prints have been successfully processed by imaging with an infrared microscope system. Due to the small field of view, this approach has yielded images of partial prints, but has served to affirm the potential of the method. A future system will be necessary to assess the ability to acquire images of whole prints.

To date, both approaches have been successful. Additional studies are required to fully determine the chemical composition variation within children and adults. More trials will be undertaken to determine the best methods for spectral imaging.

Forensic Analysis, Latent Fingerprints, Spectrochemical Analysis

B17 Comparison of DNA Data (FST) From Five Latin American Populations Using 15 STR Loci

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The goal of this research project is to show the Wright's FST statistic values after comparison of 15 STR loci from five different countries in Latin America showing an overall value of 0.0053 which is less than the 0.01 advocated by the second NCR report.

The short tandem repeat (STR) loci are highly polymorphic loci found in the human genome, are relatively small in size, and can be analyzed in a multiplex PCR fashion. Thus, for forensic purposes, analysis of STR loci are practical because minute samples can be analyzed and even substantially degraded samples may be typeable. In addition, the STR loci are highly informative for addressing the source of an evidence sample for direct comparisons or by family reconstruction cases. Because of the development of commercial multiplex kits, a large number of loci can be typed simultaneously in a relatively short time. Thus, population data can be generated for statistical purposes and to address certain population genetic questions. Some of the STR loci available for use in forensic analyses are CSF1PO, FGA, TH01, TPOX, VWA, D3S1358, D5S818, D7S820, D8S1179, D13S317, D16S539, D18S51, D21S11, Penta D and Penta E.

When a match occurs between the DNA profiles of the evidentiary sample and a reference sample from a suspect, or a reference sample and a victim (in some cases), an estimate of the rarity of the DNA profile is often made. The computation is based on using the product rule (the assumption of independence) with adjustments for population substructure. The National Research Council (NRC) II Report (1996) recommends Wright's FST statistic (or θ) to estimate the degree of relatedness in a population, which is used to correct for departures from Hardy-Weinberg expectations due to population substructure. The NRC II Report recommended conservative value for θ is 0.01 for most populations and for more isolated populations an estimate of 0.03 can be used.

The GITAD (Iberoamerican Working Group on DNA Analysis), the Forensic Genetic Section of the AICEF (Iberoamerican Academy of Criminalistics and Forensic Studies), is now conducting a large number of population studies in most of the Latin American countries in order to facilitate the use of their own databases and to offer to the international forensic community reliable data for forensic and anthropological use.

Therefore, STR population data now exist to estimate θ values across Latin America. Five populations (Argentina, Brazil, Chile, Costa Rica, and Uruguay) across a wide geographic area and with some different ethno-histories were analyzed. The DNA was typed using the multiplex kit PowerPlex™ 16 (kindly provided by the Promega Corporation, Madison, Wisconsin). The amplified DNA was typed using either an ABI Prism 310 capillary electrophoresis instrument or ABI 377 Genetic Analyzer (i.e., a polyacrylamide slab gel electrophoresis unit) (Applied Biosystems, Foster City, CA). The data show that all populations studied are highly polymorphic at all 15 STR loci. Moreover, the Penta E locus is one of the most polymorphic STR loci in the set of loci studied, which is an observation consistent with other population studies. The θ estimate over all 15 STR loci is 0.0053, which is less than the conservative estimate of 0.01 advocated by the second National Research Council Report.

Population data are now available for forensic, paternity, and genetic studies. The data support that there is not a substantial difference for practical forensic applications among these populations and for these STR loci and that a θ estimate of 0.01 is conservative for general population groups in Latin America. However, for more isolated groups the use of a θ value of 0.03 is still advocated.

STR, Latin America, FST

B18 PCR DNA Typing From Contact Lenses Submitted to Different Environmental Conditions: Strategies to Get a Better Yield

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The goals of this research project are to present the potentiality, versatility and feasibility of PCR DNA typing but at the same time to stress how it is necessary that the knowledge about the analytical process that we are performing and the different elements that can affect the result. We cannot leave the result in "hands of technique," and wait to see if it works or does not.

PCR DNA analysis offers a versatile instrument in locating and comparing questioned material left in a crime scene to known samples. Increasingly unusual sources of DNA yield excellent evidence as a profile can be processed with ever smaller amounts of samples. Although it doesn't mean that the typing can be obtained in a single case, there are still many factors that must be investigated to know which are the ones that take us to a negative result.

Contact lenses have already been used as a source of DNA in a criminal case (Wickenheiser and Jobin). Contact lenses are foreign bodies in the eyes which blink around 20,000 times a day. The lens moving up and down over the eye in the span of 24 hours is equivalent to three football fields in length. Under these circumstances, little corneal injuries may occur; but, in all cases, there are corneal cells on the surface of the lens. The amount of cells will depend on the mechanical friction from prolonged use of contact lenses, how well bacteria adhere to the surface of the lens, and also on how easily oxygen passes through the lens.

Today more than 14% of North Americans wear contact lenses. This percentage is increasing as the new material of contact lenses is making them more versatile. It means that the chance to get a contact lens as evidence in a criminal case or in a missing person case is higher every day.

To try to obtain a feasible procedure to analyze DNA from contact lenses, we have submitted them to different environmental conditions and to distinct cleaning solutions to see the effects on DNA recovery. PCR amplification and DNA typing Organic (PCIA introducing some changes to improve the yield of the extraction, especially 10 try to clean some proteins) and Inorganic extraction procedure, rehydration of the lens submitted to external dryness and to dehydration at room temperature and non-rehydration before to proceed to the extraction. ions Separation from the cleaning solution where the lens are kept has been performed and compared yielding different results. Microscopic photographs have also been taken to see how the conditions affect the structure of the lens and how the corneal cells behave under these different circumstances.

Results are presented in terms of DNA extraction (quantification has been performed with Quanty-Blot) and in terms of typing. We typed nuclear DNA using Powerplex™ 16 kit (Promega Corp.) from most of the lens with a positive result; although, in some of the loci, the typing was negative; in those with a larger length and mitochondrial DNA with a positive result in all of the lenses submitted to the study.

In conclusion, we present different procedures to follow to recover, extract, amplify, and type nuclear and mitochondrial DNA from contact lenses depending on the environmental conditions around the lenses and the circumstances of the cases. The strategy to proceed should be different to try to get a better yield.

DNA Typing, Contact Lenses, PCR DNA Analysis

B19 Analysis of Mitochondrial DNA Sequence Variation in Forensic Samples Using Linear Arrays of Immobilized Sequence Specific Oligonucleotide Probes and Sequencing

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The goal of this research project is to have participants learn about a rapid method for determining mtDNA types using immobilized sequence-specific oligonucleotide probes.

Typing mitochondrial DNA (mtDNA) using linear arrays of immobilized sequence-specific oligonucleotide (SSO) probes provides a rapid method for comparing hairs without the need to do an extensive microscopic comparison. Analysis of sequence variation in mtDNA using SSO probes also can be used to type other kinds of samples such as blood, bones, semen, and saliva. If needed, DNA sequence analysis may be performed when the information that is provided by SSO typing is not sufficient to exclude individuals as the source of a biological sample.

To investigate the value of the linear arrays as a screening tool, reference hairs and blood samples from victims and suspects were obtained from rape kits collected for sexual assault cases. These samples were assembled into eight mock cases such that each was comprised of three questioned pubic hairs, a bloodstain from one of the victims, and a reference bloodstain from one of the suspects, not necessarily from the same adjudicated case. It is important to note that the mitochondrial DNA sequences of the samples were not known prior to assembling the mock cases. Therefore, two laboratories extracted and analyzed the samples. The linear arrays used to type these samples contain 31 probes to detect polymorphisms at 18 positions within both hypervariable regions I and II in the mitochondrial genome. For this study, all samples were sequenced and all of the typing results between the two laboratories were compared.

In the majority of the cases, the SSO typing was sufficient for determining whether the suspect could be the source of the hairs. When the SSO type obtained from a suspect's reference sample was different from the type obtained from a questioned hair, the suspect could be excluded. When the same SSO types were obtained in both the suspect's reference and questioned hair samples, the suspect or a maternal relative could be the source. However, two unrelated individuals could also have the same SSO type. Therefore, when the same SSO types are observed between reference samples or between reference and hair or other samples, follow-up sequencing is recommended. It is important to note that two unrelated individuals could also have the same control region sequence. Of the eight mock cases in this study, there were three in which the suspect was excluded as the donor of all three hairs. There were five cases in which one or more of the hairs could have originated from the suspect. In one of these cases, the victim and suspect had the same SSO type. With this set of hairs and reference stains, sequence analysis was able to distinguish samples that originated from different individuals.

Typing of the samples with the SSO probe linear arrays provides a rapid screening method to eliminate or include a suspect as the possible source of hairs and other biological evidence, reducing the amount of sequencing required. The SSO probe linear arrays also provide a more rapid and definitive characterization of hairs than microscopy. With this technique up to 40 samples can be typed at one time. The use of duplex primers to amplify the hypervariable regions requires only one-half to one-quarter the amount of extract needed for current DNA sequencing

methods. In addition, when sequence analysis is required to obtain more discriminatory information, the same amplified product used for the SSO probe typing can be sequenced so that no additional aliquots of the extracted sample need to be consumed. The linear array assay is easy to perform and the results can be interpreted immediately after completing the assay. The signals can be read visually or scanned, and interpretation can be performed without extensive training or additional expensive equipment. Obtaining and interpreting sequencing data, on the other hand, is more difficult and requires significantly more time, training, equipment, and experience. Therefore, significant savings of extracted samples, time, and money may be obtained through the use of linear arrays as a screening tool when performing mtDNA typing. Also of great importance, casework turnaround time can be greatly reduced by implementing a screening method such as these linear arrays prior to DNA sequencing.

mtDNA, SSO Probes, Sequencing

B20 Inhibition Affecting Quantification and Amplification of Forensic DNA Samples

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The goal of this research project is to evaluate the possibility of inhibitors affecting quantification of extracted DNA from forensic casework samples.

Forensic DNA casework samples often contain inhibitors which can affect the amplification of extracted DNA. This is a potential concern when considering which crime samples to use for analysis. A new concern, which has been observed and noted at the Arizona Department of Public Safety Crime Laboratory, is the inhibition of the quantification process as well.

In five cases, with samples such as cigarette butts, envelope flaps, shirt collars, knit caps, ball caps and labels, inhibition of the quantification process has been observed. Quantiblot readings ranged from less than 0.0075 ng/uL to 0.03 ng/uL (ng/uL of DNA/TE Buffer) or inconclusive (faint band visible before color detection). Due to the quantiblot results, 20 uL of each extracted sample was used in the amplification process with 30 uL of Applied Biosystems amplification reagents, as per their protocol. All but one of the samples in question showed no evidence of amplified DNA based on the capillary electrophoresis results using the 310 Genetic Analyzer. The one sample that showed results on the 310 displayed peak heights greater than 8100 RFU in raw data. This sample was then re-amplified at 1/2X (10 uL of extract) and 1/4X (5 uL of extract). Both amplifications again produced results greater than 8100 RFU in raw data. The sample was then re-run at 0.25 uL of amplified product instead of the standard 1.5 uL of amplified product, and a full DNA profile was obtained.

The other samples that showed no signs of amplified DNA were re-amplified at 1/2X (10 uL of extract), 1/4X (5 uL of extract), 1/8X (2.5 uL of extract), 1/16X (1.25 uL of extract) and 1/32X (0.6 uL of extract). Partial DNA profiles (using a lower cutoff threshold of 150 RFU) and full DNA profiles were obtained after amplifying less of the extracts than originally thought possible from quantiblot results. A full DNA profile was obtained from one sample after amplifying 1/32X (0.6 uL of extract). Previous dilutions of this sample showed no evidence of amplified DNA except for 1/16X (1.2 uL of extract). At this amplification only amelogenin was obtained.

Inhibitors have been known to affect the amplification process, but it has been shown that the presence of inhibitors may also affect the quantification process. Results were obtained by diluting the extracted samples and amplifying them at levels, which, according to the quantiblot results, should not have resulted DNA profiles.

Inhibition, Quantitation, Quantiblot

B21 Modified PCR for STR Analysis and Mitochondrial Sequencing of Old Bones

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The goals of this research project are to present the use of a modified DNA extraction and STR amplification protocol and demonstrate how it can be used to resolve difficult forensic cases.

Between 1976 and 1983 Argentina was ruled by a military dictatorship that sponsored terrorism against its citizens in the form of abduction and torture. During this time more than 30,000 Argentines disappeared and about 220 children were either abducted with their parents or born in captivity by abducted women. The missing are referred to as *desaparecidos* or “disappeared ones” and in 1977 the Association of Abuelas (grandmothers) of Plaza de Mayo was founded by a group of women with the goal of finding their missing grandchildren.

The current case involves a woman, who at that time lived just outside the capital city of Buenos Aires and in 1984 gave birth to what appeared to be a healthy boy at a local hospital. The next day at discharge the mother was presented with a sickly child that died at 3 days postpartum. Having just emerged from a long period of repression with many still living in fear and suspicion, coupled with the frequent reports of baby theft for illegal national and international adoptions, the mother began to question the identity of her child, fearing that her healthy child might have been stolen. After 13 years of struggling with these doubts, the woman was able to convince local authorities to exhume the remains of her child for DNA testing to finally establish the identity of her child. Over the next 2 years several unsuccessful attempts were made to test the remains of the child. In 1999 our laboratory was contacted and sent 3 rib bones and 2 femur bones from the child, which was all that remained of the infant by that time.

Our laboratory processed a section of femur using a double extraction protocol and standard amplification protocol to obtain results at 5 STR loci (D3S1358, vWA, D8S1179, D21S11, and D5S818) plus amelogenin using the ABI Profiler Plus Amplification kit. In this DNA extraction procedure the digest supernatant (SDS and Proteinase K solution) containing any released DNA was discarded after an initial incubation. The remaining bone solids were then re-extracted with fresh SDS and Proteinase K. While the DNA yield is lower with a double extraction, the overall quality of the DNA is improved. A subsequent amplification using double extracted DNA and 2 additional PCR cycles allowed the bone sample to be typed at all 9 STR loci (D3S1358, vWA, D8S1179, D21S11, and D5S818, FGA, D18S51, D13S317, and D7S820) within Profiler Plus. Results of the second amplification were consistent with that of the first analysis at the overlap loci. Blood from the mother and her husband were processed by standard protocol.

The profiles of the mother and the infant and the alleged father and the infant were consistent with parent-child relationships. Gender determination by amelogenin typing was correct: XX for the mother and XY for the bone sample and the alleged father. Statistical analysis established that the infant was in fact the child of the mother with greater than 99.9% certainty (0.5 % prior probability). A similar analysis established paternity with greater than 99.9% certainty as well. Mitochondrial sequence analysis of the HV1 and HV2 regions of the mother and the bone sample confirmed the STR results. While the use of extra PCR cycles must be used judiciously, there are cases in which reliable results can be obtained to allow resolution of difficult forensic cases. The results of this testing brought a great deal of comfort and relief to the mother and her husband who, after 15 years, were finally able to bring closure to their ordeal with the assurance that their child was not among the *desaparecidos*.

STR, Bone, Mitochondria

B22 A Case Study of DNA Contamination From an Osteological Sample

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The goal of this research project is to inform analysts of DNA contamination of bone specimens prior to Mitochondrial DNA analysis and recommend procedures to process the specimen.

Mitochondrial DNA (mtDNA) analysis of osteological samples is a valuable forensic tool in the identification of missing or unidentified persons. Maternal inheritance and lack of recombination make the mtDNA molecule an informative marker for establishing family relationships even several generations removed from the individual in question. Because of the potential of contamination from exogenous DNA and the high sensitivity of detection afforded with mtDNA sequencing, one should consider the nature of the sample(s), the manner in which the sample(s) was collected, and the handling or manipulations that may have been undertaken with the sample from previous other examinations. Bone specimens may come into contact with exogenous DNA prior to collection by being in proximity with other remains, which should not be considered to be contamination due to manipulations. Without proper safeguards, the sample can also be contaminated with exogenous DNA during collection by handling. Also, if the cutting tools, used to excise pieces of bone for DNA analysis, are not adequately cleaned, contact with instruments may introduce DNA contamination. However, contamination from exogenous DNA is not problematic, because the surface of most bone specimens can be cleansed. A case study, involving the extraction of mtDNA from bone fragments, demonstrates that bone fragments can be contaminated prior to mtDNA analysis. The case involved a bone specimen that yielded a mtDNA result that was not interpretable. A typical protocol involves sanding the bone's outer surface to remove external contaminants and then a portion of the mid section of the bone is cut out and used for extraction. Often, only a cut piece may come to the laboratory ready for processing. One should not assume that the cut surface is contaminant free. The cleansing process should also be applied to cut surfaces (and in some cases to the inner surface of the bone). If evidence of contamination persists, where possible another sample should be considered for analysis. Procedures such as sanding the outer surface of a bone, sampling from the mid section of the bone, and subsequently sanding the cut surface of the bone are recommended prior to the extraction of mtDNA from bone fragments.

Mitochondrial DNA, Osteological Sample, Bone Fragment

B23 First Mitochondrial DNA Case at Harris County Medical Examiner Uncovers Novel Mutation

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The goal of this research project is to discuss mitochondrial DNA sequencing with respect to forensic casework from a medical examiner's office perspective and to address the issue of a unique mtDNA haplotype which includes a rare mutation in the HV2 region giving rise to C-stretch length heteroplasmy.

Mitochondrial DNA (mtDNA) has been used for forensic casework since 1996 and for remains identification since the early 1990s. MtDNA sequencing has recently been employed for use at the Harris County Medical Examiner's Office (HCMEO), the first medical examiner's office to have mtDNA sequencing capability in this country. MtDNA sequencing has extended the use of DNA technology for criminal casework to include samples that historically produced minimal or no results when using STR analysis of nuclear DNA. Problematic samples for nuclear DNA analysis such as hairs without roots, bones, teeth, degraded or old samples, or samples of small DNA quantity may now yield a mtDNA profile when obtaining a STR profile is not possible.

MtDNA sequencing is also useful in cases of remains identification when obtaining reference samples from close family members is not possible. To identify remains using STR analysis, reference samples from a parent or offspring are the most appropriate candidates because each of these individuals shares 50% of their nuclear DNA with the questioned individual. Siblings, grandparents, or grandchildren only have 25% of their nuclear DNA in common with an individual; therefore, using these family members as a reference makes statistical analysis of resulting profiles complicated and possibly less informative. Because mtDNA is maternally inherited, all maternal relatives should have the same mtDNA haplotype (neglecting the occurrence of mutation, which at most is calculated to occur at once in every 33 generational events). This aspect of mtDNA analysis makes comparison from less closely related individuals more straightforward because the two maternal relatives being compared should have the same mtDNA sequence. For this reason, the HCMEO adopted a policy to use the quicker and less expensive STR typing for parent and offspring reference samples and reserves mtDNA sequencing for other maternal relatives when parent and offspring samples are unavailable.

The first mtDNA body identification performed at the HCMEO involved the homicide of a Mexican national in Harris County. Neither fingerprints nor dental records were available for comparison to the unidentified remains and the only relative available for a DNA comparison was the alleged decedent's brother. A mtDNA sequence was obtained from the decedent's blood and the brother's saliva. These two sequences were the same, so the two individuals could not be excluded as being maternal relatives of one another.

In a search of the FBI Laboratory's Mitochondrial DNA Population Database to obtain the relative frequency of the mtDNA haplotype from the decedent and his brother, the mtDNA haplotype in question was found to be unique in the forensic database (0 observations in 4142) and was also not observed in the published database. The next most similar haplotypes all contained 2 differences from the questioned haplotype, and these haplotypes, unsurprisingly, were all of Hispanic descent. Furthermore, the questioned haplotype contained a novel 310 C mutation in the HVII region resulting in a homopolymeric C-stretch similar to the homopolymeric C-stretch that commonly occurs in the HV1 region when there is a T to C transition at 16189. In this case, however, the 310 T to C transition results in a C-stretch of 12 bases, with minor components of 11 and 13 C's. As is common with homopolymeric stretches, length heteroplasmy was observed in the C-stretch making it difficult to sequence downstream from the mutation.

MtDNA sequencing is a useful tool for the identification of remains at a medical examiner's office when dental records, fingerprints, and close relatives are not accessible. Although the cost and time requirements, along with the lower power of discrimination compared to STR typing do not make mtDNA sequencing the first choice of DNA analysis, it extends the capability of the DNA laboratory to aid in the identification of remains.

Mitochondrial DNA, Heteroplasmy, Body Identification

B24 A Validation Study of Y-PLEX™6, a Multiplexed Y-Chromosome STR System

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The goal of this research project is to demonstrate the results of a validation study of the Y-Plex™6, a multiplexed Y-chromosome STR system, established by ReliaGene Technologies, Inc.

Most of the forensic DNA typing for sexual assault cases involves the identification of male contributors to intimate swabs obtained from females. A percentage of these samples, even after differential extraction, have a large female to male DNA ratio that results in poor amplification of the male component of the mixture. A Y-chromosome STR system that selectively amplifies areas on the Y chromosome is a useful addition to the DNA analysis of casework samples.

ReliaGene Technologies, Inc. has introduced a multiplexed Y-chromosome STR system (Y-PLEX™6). This system provides the analysis of six Y-chromosome loci (DYS393, DYS19, DYS389, DYS390, DYS391 and DYS385) in a single multiplexed reaction. The DYS385 primer set amplifies two loci. A single peak is observed for some individuals at DYS385, while other individuals may have two peaks representing variable length repeats.

DNA from blood samples (CT Sex Offender Database) was extracted using the QIAmp Blood Kit (QIAGEN). The extracts were quantitated using the QuantiBlot Kit (Applied Biosystems, Inc.). Extracts were stored frozen until amplification (less than 2 years). The amplification mixture (total volume 25 ul) consisted of 1.0 ng of DNA, 5.0 ul of primer set mix (ReliaGene Technologies, Inc.) and 0.5 ul of AmpliTaq Gold (Applied Biosystems, Inc.). The amplification was performed in a thermocycler (Applied Biosystems, Inc., models 2400 and 9700). The amplified products were separated on a 377 DNA Sequencer (Applied Biosystems, Inc) and analyzed using Genescan and Genotyper software. A custom Genotyper macro is supplied with the Y-PLEX™6 kit.

The average peak height for each locus was determined: DYS393, 957 rfu (n=154); DYS19, 560 rfu (n=155); DYS389, 448 rfu (n=151); DYS390, 412 rfu (n=153); DYS391, 534 rfu (n=158); DYS385, 273 rfu (n*= 242); (n= number of observations with a peak > or = to 50 rfu, n*= number of observations with two peaks > or = to 50 rfu). The peak height balance was compared within the DYS385 locus, for those samples with two peaks such that the smaller allele was not in the stutter position of the larger allele. The smaller allele had an average peak height that was 6.9% larger than the average peak height of the larger allele (n=92).

The average percent stutter (stutter > 30 rfu) and the percent stutter range were determined for each locus amplified. The percent stutter was calculated as (height of the stutter peak/ height of the major allele) x 100.

	DYS393	DYS19	DYS389	DYS390	DYS391	DYS385
# of Observations	106	55	87	47	58	46
Average % Stutter	7.2	6.3	12.4	6.9	5.7	8.4
% Stutter Range	4.8-14.8	3.9-10.1	9.3-19.6	4.2-9.7	3.5-7.9	3.7-18.9

Allele frequencies at each locus for the three racial groups (Caucasian, African American and Hispanic) were compared.

	DYS393	DYS19	DYS389
Caucasian	Allele 13, 77.7%	Allele 14, 56.0%	Allele 29, 33.3%
African American	Allele 13, 46.5%	Allele 15, 32.6%	Allele 30, 37.2%
Hispanic	Allele 13, 77.3%	Allele 14, 48.9%	Allele 30, 38.1%

	DYS390	DYS391	DYS385
Caucasian	Allele 24, 45.5%	Allele 11, 55.2%	Allele Pair 11-14, 50.0%
African American	Allele 21, 67.4%	Allele 10, 79.5%	Allele Pair 15-16, 14.0%
Hispanic	Allele 24, 47.7%	Allele 10, 48.9%	Allele Pair 11-14, 20.5%

PCR “artifacts” were observed in the yellow electropherograms in all female DNA samples amplified under similar conditions, although the peak heights of these “artifacts” were variable. Small peaks of 92, 118, 154, 370 and 450 basepairs were observed in most samples. In addition, some samples had a peak of 257 basepairs in the yellow electropherogram. No “artifacts” were observed for the female samples in the blue electropherograms.

Additional validation studies in progress include: species specificity, other body fluids, the effects of environmental degradation, sample mixtures, precision, minimum quantity of template sample, and nonprobative casework samples.

Y STR, PCR, Validation

B25 Significance of Fiber Evidence

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The goal of this research project is to present findings on the significance of fiber evidence based on a random population study.

Significance of Fiber Evidence

Often times question fibers are identified in a case and the physical and chemical characteristics are determined to be the same as a known fiber. This study investigates the likelihood of fiber samples from a random population having the same microscopic and chemical properties. It gives an idea as to how significant the fiber evidence may be or how significant a specific fiber is.

The random population was collected by taking samples of approximately 450 garments from volunteers at Austin Bergstrom International Airport in Austin, TX. An international airport was chosen as the collection site to represent a random cross-section of the population. The random population included people of different age groups, professions, and origins, which resulted in a wide range of garments.

The samples were collected by having the participants roll their clothing with an adhesive lint roller. The adhesive paper was then attached to a plastic sheet to secure the fibers. Information from the volunteers was recorded, including age range, sex, and garment type for further classification.

The fibers were characterized according to their physical and chemical properties. The fibers were first generically classified according to type and color. Within the generic groups, the fibers were further analyzed and compared using polarized light microscopy, infrared spectroscopy, microspectrophotometer, and cross-sections to assess the degree of discrimination of the fibers. At this point the data was reviewed. Any fibers found to have the same physical and chemical characteristics at this point were further verified with the comparison microscope.

The data of this study was compiled into a database using Microsoft Access. Using this database, a query can be made with either very basic characteristics or with more specific parameters. Starting with the most general search, one can identify how common a fiber is by generic type alone (cotton, polyester, acrylic, etc.). By increasing the parameters, such as adding color, morphology, diameter, and cross-section, the search becomes more specific. The user can determine which parameters are to be included in the query depending on what they are trying to determine. The results of the queries will provide the user with a statistical value of the significance of the fiber.

Although an exact number cannot be assigned to the significance of fiber evidence, the results of this study can give a better idea of what finding a certain type of fiber evidence in a case does mean. As time goes by, this study can be repeated to add to this database and to follow what trends may be developing in the fiber world.

Fibers, Database, Trace Evidence

B26 A Defense of Fiber Evidence in the Wayne Williams’ Case

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The goals of this research project are to give participants a better understanding of the fiber evidence presented at the Williams’ trial; to make them more knowledgeable about factors that affect evidential value; and, to help them to be better prepared to respond to criticism and attacks made against valid fiber evidence.

It has been almost exactly 20 years since Wayne Williams was convicted of two homicides in the city of Atlanta. The Wayne Williams case involved the investigation of a large number of murdered black children and young men in the Metropolitan Atlanta, Georgia area between July 1979 and May 1981. Thirty murders, which were thought to be linked, were being investigated at the time of Williams arrest in June of 1981.

Associations based on textile fiber evidence were an essential part of the case developed against Williams and were the most compelling evidence of his involvement in the murders presented at his trial. The fiber evidence demonstrated an extremely strong and contemporary linkage between the Williams’ surroundings and the bodies of eleven murder victims. Prior to and during Williams’ trial there was much negative speculation about the value of fiber evidence. This speculation continues to this day. This is so, even though over the last twenty years many studies have shown that fibers can be important evidence of association in criminal cases.

Some have claimed that the Williams case was only a case about an uncommon green carpet fiber; others that it was simply another fiber case. It was much more than that. The fiber evidence in the Williams’ case involved over 28 specific fiber types many of which were uncommon. Hundreds of individual fibers associated Williams with the victims’ bodies. One victim had 12 fiber types and two head hairs linking the body to Williams and his environment.

It is difficult to appreciate particular evidence and its value without being an active informed participant in the case. However, a lack of knowledge about fiber evidence has not stopped critics of the guilty verdict. Over the past twenty years, attempts have been made to obtain a new trial for Williams. In addition to appeals that have been filed, there have been many who claim to believe in Williams’ innocence and criticize the investigation, the trial, and the evidence used to convict Williams. Victims’ mothers, a Georgia Supreme Court justice, authors, producers, actors, and a County Medical Examiner, to name just a few of the critics, believe that Williams deserves a new trial.

It would not be difficult to refute many of the criticisms, because little if any meaningful evidence has been produced to support the critics’ beliefs. It is important, however, to respond to criticisms against valid fiber evidence. If no response is made, criticism of fiber evidence will take on a life of its own and will be used to justify skepticism toward fiber evidence in future cases.

After a short review of the actual fiber evidence presented at trial and a discussion of the factors that affect the evidential value of fiber evidence, the technical and legal criticisms made against the fiber evidence in the Williams’ case will be examined and critiqued. Criticism of the fiber evidence began with defense expert testimony at the trial, continued during the appeal process, and has figured prominently in many publications and presentations about the Williams’ case that occur to this day. The paper will also briefly review the current status of forensic fiber evidence and consider what the trial would look like if held today.

Fiber Evidence, Textiles, Trace Evidence

B27 Fluorescence in Fibers and the Effects of Fabric Brighteners in Detergents

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The goal of this research project is to examine inherent fluorescence of fibers, and the fluorescence of fibers that have been exposed to fluorescent whitening agents (FWAs) found in detergents.

The question has been raised as to whether the fluorescence seen in a fiber is an inherent property introduced during the manufacturing and dyeing processes or is acquired through the laundering process using common household detergents. The purpose of this study was to examine the inherent fluorescence of fibers, and the fluorescence of fibers that have been exposed to fluorescent whitening agents (FWAs) found in detergents.

Fiber fluorescence is a property readily examined during the course of fiber examination. Fluorescent compounds are excited by relatively discrete wavelengths of radiation and reemit the energy as longer wavelength radiation. Often fluorescent whitening agents reemit radiation in the blue-violet region of the visible spectrum. Clothing can acquire fluorescent properties after washing with common household detergents. The ability to differentiate acquired fluorescence due to washing from fluorescence applied as a result of the dyeing processes may be essential in casework scenarios.

In general, the optical brighteners must be compatible with dye applications and chemical bleaches, should have stability over temperature and pH ranges, and should have substantial rates of migration and affinity for the fiber. In addition, there are several structural requirements for these compounds that include: a planar structure, conjugated bonds and electron donating groups.

A system has been developed in the laboratory for simulating the washing, rinsing and drying cycles of typical household washing machines. Fluorescence was measured using a S-E-E 2000 microspectrometer equipped with filter cubes, which allow for excitation wavelengths of 365nm, 405nm, 436nm and 546nm. The study began with a sampling of seventeen different household detergents. The detergents were used to wash non-inherently-fluorescing white cotton swatches. After washing, fluorescence was observed in each sample. In order to streamline subsequent experiments, three detergents were selected which represented high, medium and low degrees of fluorescent intensities.

White cotton fibers that had no inherent fluorescent properties acquired fluorescence after being exposed to laundry detergents via the washing cycle. The samples were irradiated using the four filter cubes. It was determined that the FWAs in detergents produce emission maxima in the blue-violet region of the visible spectrum when the 365nm filter is used. This suggests the possibility that the fluorescence associated with FWAs can be emitted in a consistent wavelength range.

Through everyday wear, the applied FWAs from detergents are attacked chemically and destroyed, and can be washed out or removed through abrasion. Fluorescent whitening agents have been the subject of many investigations. Several studies indicate that a light driven process may account for the chemical degradation of FWAs. If fibers acquired fluorescence from detergents, an evaluation of its persistence was necessary. Stressors such as time, light exposure, and soil were evaluated to determine how they affected the acquired fluorescence of fibers. Experiments were designed to simulate the rigor of everyday wear. Fluorescence was measured before and after exposure to the aforementioned stressors.

Every time fibers are washed they can absorb FWAs thus acquiring fluorescence. However, fluorescent whitening agents used in detergents may only show affinity for certain types of materials. Also, some textiles already have dyes with fluorescent properties such that no improvement

can be observed. To better understand how various synthetic fibers are affected by FWAs, several experiments were conducted. All the experiments involved examination on the S-E-E 2000 microspectrometer prior to washing, followed by washing of the fabric as listed above and then re-examination on the microspectrometer. The experiments were varied and included studies of the following: fibers that were colorless and displayed non-inherent fluorescent properties; colorless fibers that contained inherent fluorescent properties; and dyed fibers which fluoresced in regions different from that attributed to FWAs found in detergents.

As a result of this study, it has become apparent that some fibers appear to acquire fluorescence while others do not. This may be related to the chemical and morphological structure of the polymer, and possibly the use of certain dyestuffs. For example, fluorescent red acrylic fibers were brought into the laboratory as evidence. Comparisons were carried out and it was determined that the victim's sweater could not be excluded as a possible source of those fibers. The question was posed in the courtroom as to the source of the fluorescence seen in the acrylic fibers. From this study it appears that certain fibers such as acrylic do not show an affinity for the FWAs found in detergents; whereas, other fibers, such as cotton and nylon, do show an affinity and produce fluorescence at discrete wavelengths.

Fibers, Fluorescence, Optical Brighteners

B28 An Atlas of Biodeterioration Artifacts in Human Head Hair

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The goal of this research project is to present to the forensic science community an atlas of transmitted light photomicrographs of artifacts produced in human hair by fungal infestation and to present the various stages of fungal destruction of hair.

From time to time forensic hair examiners are called upon to examine hairs that have been exposed to environmental degradation. Hairs at a crime scene may have been exposed to the effects of sunlight, moisture and microbial contamination. Known hair exemplars may have been recovered from previously buried bodies and as a consequence may have been subjected to fungal attack. In such cases, the questioned or known hairs may have been altered in ways that significantly affect microscopic comparison and DNA profiling. Forensic hair should be able to recognize the effects of environmental degradation, in order to take them into account when they perform microscopic comparisons. Moreover, the quantity and quality of mitochondrial DNA recovered from hair may be related to the degree of degradation. This presentation will show photomicrographs of the six stages of fungal attack on human hair:

1. Attachment of fungal spores. During this phase of fungal attack, clusters of fungal spores attach themselves to the surface of the hair and begin to develop hyphae.

2. Growth of lateral fungal hyphae along the surface of the hairs with notching of cuticular scales. Once fungi begin to grow on the surface of the hair, hyphae extend away from the hair shaft (aerial hyphae) and along the surface of the hair generally parallel to the axis of the hair (lateral hyphae); as the growing lateral hyphae encounter the free edges of the cuticular scales, the scales are lifted and removed from the surface of the hair. The localized removal of one or two scales from a row of scales produces a "notching" effect.

3. Penetration of the hair cuticle and cortex by specialized penetrating organs. After a period in which the lateral fungal hyphae grow along the surface of the hair, the fungi begin to develop specialized penetrating organs which burrow through the hair cuticle into the cortex. The penetrating of hyphae into the shaft of the hair seems to involve both chemical attack and mechanical disruption. Two types of penetrating

tunnels have been observed: very fine tunnels which appear microscopically as fine dark lines extended into the hair cortex roughly perpendicular to the axis of the hair; and wide conical tunnels which appear dark if the mountant does not fill the tunnels or light if the mountant penetrates and fills the tunnels.

4. Growth of lateral hyphae within the medulla of the hair. Once the penetrating hyphae reach the medullas in the hairs, they begin to grow laterally through the medullas, eventually consuming the medullary cells and some of the surrounding cortical cells.

5. Reduction of the hair to a “soda straw” hair or a “swiss cheese” hair. Lateral growth of the hyphae within the medullas may completely hollow out significant segments of the hair shaft so that under the microscope the hair may resemble a drinking straw; when this hollowing out of the hair is associated with large penetrating tunnels the hair shaft has the appearance of a piece of swiss cheese.

6. Focal destruction of the entire hair shaft. Eventually the hair shaft is completely destroyed at specific points and breaks up into short segments.

The hair samples examined to prepare this atlas were obtained from a variety of sources, including laboratory research studies and actual case work such as a Honduran rape case, the Jesse James exhumation project, the St. Mary’s City lead coffin project, the Harewood Cemetery exhumation project, and the Boston Strangler Case.

The photomicrographs used in this presentation were made with two camera systems: a Leica CL 35-mm camera using Fuji ISO 800 professional color print film and an Olympus C-3000ZOOM 3.3 megapixel digital camera. The digital images were adjusted for brightness, contrast and color balance with the Olympus Camedia software (Version 5.0). All microscopic examinations were carried out with a Leitz Dialux microscope. Environmental conditions conducive to fungal attack on human hair will also be discussed.

Fungus, Hair, Microscopy

B29 Analysis of Dyes Extracted From Millimeter-Size Nylon Fibers by Micellar Electrokinetic Chromatography

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The goal of this research project is to present to the forensic community a potential qualitative/quantitative method for trace-fiber color comparisons using micellar electrokinetic chromatography (MEKC).

Developing a means of analyzing extracted dye constituents from millimeter-size nylon fiber samples was the objective of this research initiative. Aside from ascertaining fiber type, color evaluation and source comparison of trace-fiber evidence plays a critical role in forensic-fiber examinations. Literally thousands of dyes exist to-date, including both natural and synthetic compounds. Typically a three-color-dye combination is employed to effect a given color on fiber material. The result of this practice leads to a significant number of potential dye combinations capable of producing a similar color and shade. Since a typical forensic fiber sample is 2 mm or less in length, an ideal forensic dye analysis would qualitatively and quantitatively identify the extracted dye constituents from a sample size of 1 mm or smaller. The goal of this research was to develop an analytical method for comparing individual dye constituents from trace-fiber evidence with dyes extracted from a suspected source, while preserving as much of the original evidence as possible.

The method outlined herein was found to be capable of detecting acid dyes, extracted from dark- and light-colored nylon fibers using as little as 1-mm of material. Large-volume stacking and polarity switching in a micellar electrokinetic chromatography (MEKC) system were employed

to achieve the research goal. Anionic-acid dyes were extracted from individual nylon fibers using a 4:3 pyridine/water solvent. Trace amounts of pyridine proved detrimental to the separation, necessitating a solvent exchange with water. The optimized running-buffer system consisted of 50 mM SDS/10mM Borate/17% methanol at an approximate pH of 9.5. A sample volume of 500 nL was injected into a 75-micrometer column by pressure prior to applying a -25 kV reverse-polarity voltage. At this point, neutral and positively charged components were effectively backed-out of the column into a waste vial, while the anionic dyes were concentrated at the front of the column. Once the current reached -50 microamps, the voltage was changed to +25 kV for the anionic-dye separation. Using this injection technique, matrix interferences that affected reproducibility, such as water-soluble nylon monomers and low-molecular-weight polymers, were effectively removed and sample stacking was accomplished. When employing this method, acid-dye limits-of-detection were reduced from ~600 ppb (large-volume normal injection) to ~78 ppb. In addition, this injection technique resulted in a notable increase in separation efficiency and resolution.

Nylon-fiber samples and corresponding dye components were collected from manufacturers for validation purposes. Sample extracts were analyzed by the method described above using a capillary electrophoresis/diode array detection system. Extracted dyes were identified using both the dye-retention time and UV-Vis spectrum. The capability of evaluating the visible region, as well as UV, was crucial for distinguishing the dyes from other UV-absorbing components. An unexpected consequence of this on-column separation technique was the detection of other UV absorbing fiber-constituents, such as UV protectants, surfactants, binders, dye impurities, etc., that yield a potential fingerprint of the colored fiber material. Figure 1 illustrates an electropherogram obtained from the analysis of a 1-mm brown nylon fiber.

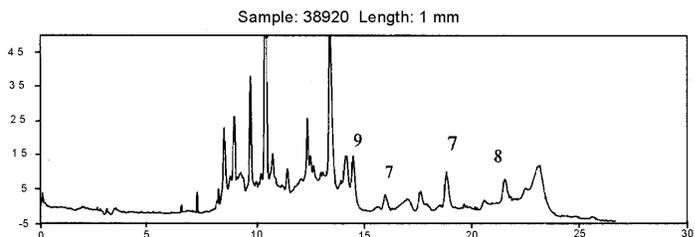


Figure 1. Electropherogram obtained from the extract of a single, 1-mm brown nylon fiber containing three dyes labeled 7, 8, and 9.

Peaks corresponding to known extracted dyes are labeled 7, 8, and 9. All other peaks were derived from extracted UV-absorbing constituents.

Nylon Fiber, Acid Dye, Capillary Electrophoresis

B30 Optical Cross Sectioning of Fibers Using Phi-Z Scanning on a Laser Scanning Confocal Microscope

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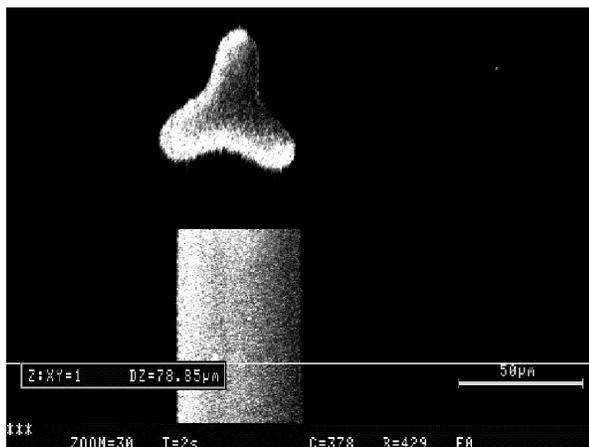
The goals of this research project are to help participant understand: 1) the theory of confocal microscopy, and 2) the use of PhiZ scanning of a confocal instrument to obtain an optical cross section of fiber with no physical manipulation of the fiber itself.

Determination of cross sectional shape of fibers is an integral part of any fiber examination. This determination is typically performed via optical cross-section on a light microscope using transmitted light. Lines present along the fiber’s length are interpreted by the examiner to be a particular cross-sectional shape. The disadvantage to this method is that the

actual cross section is usually not seen, increasing the chance of an error in interpretation. The lines designating cross sectional shape may also be poorly resolved from a top view, resulting in misinterpretation. Physical methods also have been employed. Fibers can be physically cross sectioned either through mounting in some media and microtoming the fiber or by the Joliff method. The cross section of fibers has also been examined via SEM by standing the fiber up at an angle. The disadvantage of these methods is significant sample preparation. It is advantageous for the examination to be performed in the same mounted slide as is used for polarized light examination. These physical methods require the fiber to be removed from the slide and prepared and mounted in some other fashion.

Laser scanning confocal microscopy differs in several respects to conventional light microscopy. The instrument uses a monochromatic laser as a light source and a X-Y scanning unit to scan a specimen in a faster pattern similar to scanning electron microscopy. The principal difference, however, is the fitment of a pinhole aperture in front of the detector which is in precise alignment with the condenser focal plane. This pinhole aperture allows only in focus light from the focal plane to reach the detector. It also results in an extremely small depth of field, the depth of which is determined by the selection of the objective. The advantage of confocal instruments is that optical sections at defined depth intervals can be imaged, saved on a computer, and then stacked upon each other to obtain an image which is in focus along its entire depth of field. Virtual 3-D imaging is also possible.

A variation of optical sectioning in a confocal microscope is Phi-Z scanning. In this method a linescan is defined across the field of view. The sample is scanned along this line at defined depth intervals and the linescans stacked in a Z-series. The linescan image is then rotated and viewed along the Z-axis.



Natural and synthetic fibers were examined via the Phi-Z method. The fibers were mounted on microscope slides in oil or Norland optical adhesive, requiring no special mounting or treatment. Real cross-sectional images were obtained in a period of less than one minute per sample.

Fiber Analysis, Laser Scanning Confocal Microscopy, Cross Sectioning

B31 Forensic Examination to Trace Evidence Using Raman, UV-Vis, and Fluorescence Chemical Imaging

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The goal of this research project is to show that chemical imaging rapidly provides high spatial/spectral resolution data, and both qualitative and quantitative chemical information of organic and inorganic species.

Chemical imaging combines molecular spectroscopy and digital imaging for the chemical analysis of materials. Raman chemical imaging, fluorescence chemical imaging, and visible-reflectance chemical imaging (color analysis) provide many benefits and increased capabilities to forensic scientists. Chemical imaging is a nondestructive technique, requiring little to no sample preparation, thus decreasing potential contamination and increasing the efficiency of sample analysis. For example, fiber samples can be examined without having to extract them from mounting media on microscope slides and samples such as fabric and tapes can be placed directly on the sample stage without any prior preparation. Chemical imaging methods have been applied to fibers, paint, tapes, questioned documents, and drugs, demonstrating the potential of this technology to assist forensic scientists in day-to-day casework. Chemical imaging rapidly provides high spatial/spectral resolution data, and both qualitative and quantitative chemical information of organic and inorganic species.

In addition to the multiple analytical methods, specially designed software may be used to process and interpret chemical imaging data, exceeding routine spectral interpretation. Statistical strategies coded in the software can be utilized to extract and summarize key discriminating information, providing a simple method to interpret graphical interface to these powerful spectroscopic analyses.

Visual information is critical in most cases for a forensic examiner to articulate scientific information to a lay juror. Chemical imaging allows the chemical information of materials to be displayed in images as well as spectra, making the results of technical information easier to understand.

Today, chemical imaging techniques have expanded to a multitude of techniques including Raman spectroscopy, fluorescence microscopy, visible reflectance spectroscopy and NIR spectroscopy. The benefit of chemical imaging holds untapped potential in forensic science, by enabling examiners the ability to visualize and identify chemical variability in trace evidence materials.

Chemical Imaging, Raman, Forensic Science, Microscopy

B32 Effects of Storage Temperature and Humidity Control on the Recovery of DNA From Aged-Bloodstains

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At the conclusion of this presentation, the attendees will understand the effects of storage conditions on the ability to type archived DNA.

Many DNA sample repositories or "DNA banks" exist primarily for the support of epidemiological and genetic research or to enable identification of forensic evidence on human remains. Whole blood, plasma, and buccal epithelium are convenient and minimally intrusive sources of DNA for current DNA analysis technologies. Given that "banking" tissue below ambient temperature is expensive (equipment, space, and energy) and problematic (assuring continuous operation), banking facilities are evaluating sample types and storage media for use with long-term ambient storage. To date, bloodstains on cotton fiber filter papers are most abundant and widely used.

The ultimate utility of any DNA banking effort depends upon the ability to successfully analyze the stored sample. Since artificial aging of samples may not be equivalent to natural aging, it is desirable to evaluate proposed sample and storage conditions using naturally aged materials. Over 300 anonymous aged bloodstains, field collected on un-treated Schleicher & Schuell 903 paper (903) and stored from 2 - 15 years at

ambient temperature and humidity, were made available for study. Fifty similarly collected samples stored -20°C for six years were available for direct comparison. Additionally, control samples were prepared in the mid-1990s from whole blood on several storage media for studies of the effects of time, temperature, and humidity control on the recovery of DNA.

All samples were characterized with short tandem repeat (STR) multiplexes, including the PowerPlex™ 16 System (Promega, Corp. Madison WI) and AmpFISTR® SGM Plus™ (Applied Biosystems, Foster City CA). These kits detect PCR amplification products ranging in size from 100 through 450 nucleotide base pairs (bp). Analysis of the PCR products was accomplished using an ABI Prism® 310 Genetic Analyzer (Applied Biosystems, Foster City CA). A number of DNA recovery methods (both Chelex and salting-out) and amplification protocols were evaluated. The quality of the recovered DNA (yield gel) and its typeability were determined for all samples.

All of the field collected samples yielded typeable DNA, although some loss of the larger STR loci occurred in the older and more degraded samples stored under ambient conditions. Yield gels show the DNA from these samples to be smears of DNA with sizes ranging from 12 kb down to approximately 100 bp while the DNA extracted from the six-year old samples stored at -20 °C is greater than 12 kb in size. No consistent differences in typeability as a function of extraction technique were observed.

The STR signal amplitude (peak height and peak area) of the extracted DNA as a function of storage temperature and time was studied using the following method: The 903 paper was first Chelex extracted then washed in 10mM Tris buffer to remove the chelex resin and allowed to air dry in a laminar flow hood. A 1.2 mm sub-sample punch was placed in a PCR reaction tube and amplified with PowerPlex™ 16 System. Comparison of the amplitude signals from this direct matrix amplification with that from the Chelex extracts suggests that DNA is retained more tightly by the paper the longer the samples are stored at ambient temperature. In contrast, little DNA remained on the paper with the samples stored at -20°C.

These results support observations from control samples prepared on 903 and other media and now stored at multiple temperatures (ambient, -20°C, -80°C, and -200°C) for up to seven years. The “release” of the DNA from these samples has been followed with yield gels and slot-blots as well as with peak heights and areas of STR multiplex loci.

DNA Database, STR Typing, Long-Term DNA Storage

B33 Automated Approach to DNA Purification, Quantification, and STR Analysis

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The goals of this research project are to gain an understanding about how the various steps in DNA analysis are being automated and integrated to increase throughput and generate more reproducible results.

DNA analysis in the forensic setting is a drawn-out process consisting of evidence acquisition, DNA purification, quantification, amplification, DNA fragment separation and data analysis. Cell type separation (differential extraction) must also be performed in many casework samples. These varied tasks are frequently performed by skilled individuals using a variety of manual techniques. As the demand for testing increases due to the powerful nature of this type of evidence and concomitant new laws, there is a growing necessity to provide a fully integrated and automated approach to DNA analysis. We will describe forensic and automation friendly techniques for several of these steps and will show some of these processes on a Beckman Biomek® 2000 platform.

DNA purification is typically performed by phenol/chloroform, Chelex® or silica based resin extractions. Each of these approaches has advantages and disadvantages and may or may not be amenable to automation. To address the specific needs of the forensic community we developed a new purification approach that is rapid, easy to use, amenable to a wide variety of sample types and efficient with very small samples. The DNA IQ™ System can also automatically quantify total DNA for database and paternity samples. The DNA IQ™ System provides a 45 minute extraction procedure that is compatible with most solid supports. DNA is purified in a 30 minute process using a proprietary magnetic particle. The combination of extraction and purification removes virtually all PCR amplification inhibitors including dyes found in blue or black denim, soil and black leather. A protease digestion replaces the extraction process when isolating DNA from bones and tissue. Both the sperm and epithelial fractions generated from rape kits can be input directly into the purification process with excellent results. For single source samples used for felon databasing, the limiting amount of resin used with the DNA IQ™ System yields the same amount of DNA regardless of sample size. The process works well for buccal swabs where the starting materials may contain over a ten-fold range of DNA. The resulting purified sample contains approximately 1ng/ul and does not require further quantification to obtain consistent amplification. To further simplify this process, the DNA IQ™ System has been adapted to work on the Beckman Biomek® 2000 robotic system in a completely walk-away format, requiring about 1 hour for 40 samples. The robotic system can handle different sample volumes from a variety of extracted material. Automation of the extraction and differential extraction process is currently being developed.

For database or paternity samples the purified DNA is ready to be amplified as the DNA is delivered at approximately 1ng/ul. However, human specific quantification is a requirement for casework samples. We developed a unique technique based on the polymerase catalyzed depolymerization (pyrophosphorylysis) of a probe hybridized to repeated human DNA sequences. The liberated dNTPs generated during depolymerization are used to generate ATP which is a substrate for Luciferase, generating a light signal that is proportionate to the amount of human DNA present in the solution. The AluQuant™ Human DNA Quantitation System has a dynamic range of 0.1 to 50ng of DNA and an excess of non-human DNA does not interfere with the quantification. The technique contains no gels and gives discrete numbers for the quantification. The process requires 2 hours including a one-hour incubation. Like the DNA IQ™ DNA purification system, the AluQuant™ System was adapted to work on the Beckman Biomek® 2000 robotic system.

STR analysis has become the mainstay of DNA analysis in the forensic community. This approach provides easily interpretable data that can be obtained in a relatively short period of time and with a minimum of sample DNA. Following the requirement by the Combined DNA Indexing System (CODIS) of a set of thirteen STR loci for national databasing, we developed PowerPlex™ 16. This is a single amplification system that includes the CORE loci, a sex determinant locus (amelogenin), and two low-stutter, highly polymorphic pentanucleotide repeat loci (Penta E and Penta D). Rapid analysis can now be performed with powers of discrimination of over 1 in 1017 for unrelated individuals and about 1 in 106 for siblings with as little as 0.2ng DNA template. This system is optimized for the ABI PRISM® 310 Genetic Analyzer and ABI PRISM® 377 DNA Sequencer. To increase the efficiency of the fragment separation process, a matrix was developed that allows PowerPlex™ 16 to be run on an ABI PRISM® 3100 Genetic Analyzer. Consistent with our modular approach, we will continue to automate the various steps in the analysis process and integrate them into the existing automated format.

Automation, DNA Purification, STR

B34 Evaluation of AluQuant™ for Forensic DNA Quantitations

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The goal of this research project is to present the results from an evaluation of an alternate method of DNA Quantitation and its application to forensic DNA analysis.

Human forensic DNA analysis involves the quantitation of extracted DNA prior to amplification. The current method of quantitation utilizes a higher-primate specific probe to estimate the amount of DNA in an extract. This slot blot procedure has been the predominant method used for pre-amplification DNA quantitation in forensic DNA analysis. An alternate DNA quantitation assay, the AluQuant™ Human DNA Quantitation System (Promega Corporation, Madison, WI) has been recently developed. An evaluation of the reproducibility, sensitivity, and specificity of AluQuant has been performed and will be presented. In addition, the presentation will include results from a comparison of the use of slot blot and AluQuant for DNA quantitation and subsequent nuclear DNA analysis of forensic samples.

Slot blot hybridization provides an estimate of the DNA contained within an extract based on a visual comparison of band intensities between DNA from the sample extracts and a series of DNA standards. However, there are some facets of quantification by slot blot that could be improved. First, visual evaluation of band intensities can be subjective. While the use of a digital imaging system to capture the image can address the subjectivity of a visual evaluation, the use of film still has a limited dynamic range. Second, slot blot hybridization is a labor-intensive process. Although the method can provide DNA quantification results within a half day, it demands the attention of the user throughout the protocol. An alternative DNA quantitation protocol that provides a wider dynamic range, with at least comparable performance to slot blot hybridization and minimal user intervention, would benefit the forensic community.

The AluQuant Human DNA Quantitation System is similar to the slot blot hybridization method of DNA quantitation in that it requires hybridization of a probe to the target DNA. However, AluQuant differs from slot blot hybridization in many respects. The slot blot procedure requires immobilization of the DNA sample to a solid support followed by hybridization, washing steps, film exposure and processing. In contrast, hybridization occurs in solution with the AluQuant system. This solution based hybridization assay does not require wash steps to remove unbound probe, resulting in potential time and labor savings. Another feature of the AluQuant system is that it provides an analytical output rather than a subjective visual determination with regard to DNA quantity. In addition, the AluQuant process is amenable to automation.

The mechanism of AluQuant has been described previously (Molecular Diagnostics 6:55-61). The AluQuant process consists of the following: The target DNA within the extract is denatured. The DNA is mixed with a reaction buffer containing a human specific probe, the READase polymerase and kinase enzymes, sodium pyrophosphate, and ADP. During an incubation step, the polymerase binds to double stranded DNA (i.e. the probe and the target DNA duplex). The high level of pyrophosphate in the reaction drives pyrophosphorolysis, resulting in the release of dNTPs. The terminal phosphate of the dNTP is transferred to ADP by the READase kinase to form ATP. The ATP and luciferin are utilized in a subsequent reaction involving the luciferase enzyme, resulting in the production of light at 562 nm, which is monitored using a luminometer. The intensity of light that is produced is proportional to the amount of DNA in the reaction. By comparing the intensity of light produced from a reaction containing an unknown sample to the amount

produced by reactions from a standard curve of known DNA concentrations, the amount of DNA in the sample can be estimated. Although this system utilizes a multi-step biochemical reaction, DNA quantitation by the AluQuant system is a relatively facile process.

This study has included the evaluation of reproducibility, sensitivity, and specificity of AluQuant. Initial studies have shown that AluQuant is a precise method of DNA quantitation. For example, studies thus far have shown that the coefficient of variation for 1 ng DNA is 0.07. In addition, when compared with the current method of DNA quantification, both slot blot hybridization and AluQuant routinely detect 100 pg DNA. The ability of AluQuant to specifically measure human DNA in the presence of DNA from microorganisms, such as bacteria or yeast, is important because forensic samples can contain non-human DNA. In this evaluation it has been shown that the addition of as much as a ten-fold excess of *E. coli* or *S. cerevisiae* DNA does not negatively impact on the ability of AluQuant to quantify human DNA. This study also includes a comparison of the use of slot blot hybridization and AluQuant for DNA quantitation of forensic specimens and the impact of the different methods on subsequent signal yield for STR typing.

The final phase of this study involves the use of AluQuant for quantification of mitochondrial DNA (mtDNA). The current slot blot technique measures the amount of nuclear DNA present in a sample and is not designed for quantitation of mtDNA. Preliminary studies suggest that direct quantitation of human mtDNA may be possible using human mtDNA specific probes and the AluQuant system.

DNA Analysis, Quantitation, Slot Blot

B35 Development of the AmpFISTR® Profiler Plus™ ID PCR Amplification Kit

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The goal of this research project is to provide developmental validation data and results for the new AmpFISTR® Profiler Plus™ ID PCR Amplification Kit, which contains a D8S1179 degenerate primer.

Since its introduction in 1997, in response to the growing need for a more highly discriminating DNA testing kit for forensic applications, the AmpFISTR® Profiler Plus™ PCR Amplification Kit has proven to be extremely useful in the field of human identification applications. The Profiler Plus™ kit co-amplifies the following nine short tandem repeat loci: D3S1358, vWA, FGA, D8S1179, D21S11, D18S51, D5S818, D13S317 and D7S820. The Profiler Plus™ kit, along with the AmpFISTR® Cofiler™ kit, enables amplification of the 13 core STR loci required by CODIS and has proved reliable and useful for casework, databasing and paternity applications. Previously, Budowle *et al* (Legal Med, 2000:2; 26-30) reported an excess of homozygosity at the D8S1179 locus in a population of Chamorro and Filipinos from Guam. A single G-A transition (point mutation) was observed in all null alleles at the primer-binding site. A degenerate unlabeled primer for the D8S1179 locus was included in the newly developed AmpFISTR® Identifier™ kit to address this mutation. For those laboratories that prefer to have a Profiler Plus™ kit containing the D8S1179 degenerate primer, the AmpFISTR® Profiler Plus™ ID (for Profiler Plus™/ Identifier™ Kit combination) has been developed. The new AmpFISTR® Profiler Plus™ ID kit contains the same primers and uses the same reaction conditions and thermal cycling parameters as the AmpFISTR® Profiler Plus™ kit with the addition of a degenerate D8S1179 primer.

Validation experiments were performed to investigate the performance of the Profiler Plus™ ID kit based on the guidelines from the DNA Advisory Board (DAB) Quality Assurance Standards for Forensic DNA testing laboratories (subsections 8.1.1. and 8.1.2) specifically relevant to

the addition of a degenerate primer only. These studies include primer titration, magnesium chloride titrations, annealing temperature, species specificity, population studies, mixture studies and analysis of forensic samples. After establishing the optimum concentration in a primer titration, the D8 degenerate primer was added to the Profiler Plus™ primer set to determine the effect on the balance of peak heights. Primer concentration for the degenerate D8S1179 was set such that the heterozygote peak height ratio for samples with and without the mutation was balanced. Varying MgCl₂ concentrations were tested to evaluate the performance of the kit. Several annealing temperatures (55-63°C) were tested with control (homozygous D8) and DNA containing one D8 mutant allele. The null allele is recovered at the lower temperatures range with no D8 degenerate primer. However, at 59°C and higher temperatures the null allele is recovered only after the addition of the D8 primer. Guam population samples exhibiting the D8 mutation were genotyped with the Profiler Plus™ ID kit and resulted in recovery of the null allele. A subset of samples from a database previously typed using the Profiler Plus™ kit was reanalyzed, genotyped and showed concordance with previous results. Additionally, DNA from primates and non-primates was amplified using the Profiler Plus™ ID kit. Testing on blood, oral swabs, and mixtures was also performed with the Profiler Plus™ ID kit. Based on the data obtained, the Profiler Plus™ ID kit performs similarly to the Profiler Plus™ kit.

AmpFISTR® Profiler Plus™ ID, Developmental Validation, Degenerate Unlabeled D8S1179 Primer

B36 Validation of Reduced Volume PCR Amplification Reactions Using the AmpFISTR® ProfilerPlus™ Kit

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The goal of this research project is to make attendees aware of an option for improving the sensitivity of PCR reactions by reducing the reaction volume.

Current forensic DNA typing methods almost exclusively use genetic typing systems based on the polymerase chain reaction (PCR). The PCR-based systems require very small sample quantities and offer the advantages of high sensitivity, complex multiplexing, and enhanced interpretation of forensic samples. The most commonly employed systems utilize short tandem repeat (STR) loci. PCR-based STR multiplex typing kits are now produced commercially, making DNA profiling more efficient yet costly. The commercial PCR amplification kits were developed and validated for a fixed volume reaction. PCR amplification kits produced by Applied Biosystems (ABI) were optimized for a 50 µL reaction. The amplification kits from Promega Corporation were optimized for a 25 µL reaction.

Laboratories are now seeking methods to further improve the efficiency of DNA analysis without increasing the cost. The Forensic Science Service has researched the possibility of increasing PCR sensitivity by increasing the number of amplification cycles. Alternatively, the North Louisiana Criminalistics Laboratory has explored the option of reducing the volume of the PCR amplification reaction. Reducing the reaction volume could potentially decrease the amount of samples consumed and increase the sensitivity of the reaction. A concern with this approach was that reducing the reaction volume could significantly alter the amplification kinetics thus affecting the quality and reliability of the resulting DNA profiles. To determine how a reduction in reaction volume would affect the kinetics, sensitivity, and interpretation, the following experiments were carried out:

1. The quantity of template DNA was reduced proportionally with the reaction volume.
2. The reaction volume was reduced while maintaining a constant quantity of template DNA.
3. The efficiency of the PCR reaction was evaluated at reduced reaction volumes.
4. The lower limit of detection of the PCR amplification was evaluated at reduced reaction volumes.
5. The ability to interpret mixtures was assessed by preparing and amplifying serial dilutions of known mixtures at reduced reaction volumes.

When the quantity of template DNA was reduced proportionally with the reaction volume there was no significant change in the signal intensity of the resulting electropherograms. The amplification reactions with 0.4 ng or less template DNA exhibited an increase in the peak ratio variance as a result of stochastic effects. When the quantity of template DNA was maintained at 2.0 ng, the total amount of PCR product was approximately equal for reaction volumes of 50 µL, 25 µL, and 15 µL. Little or no variance was observed in the peak ratios at the heterozygous loci. The kinetics of the PCR reaction appeared to be unaffected as the volume of the PCR reaction was decreased; however, the same concentration of PCR product could be achieved in fewer cycles in the lesser volume reactions. The lower limit of detection of the amplification reaction decreased with the reaction volume. This increase in sensitivity was observed for both single source DNA samples and for the major and minor components of the known mixture reactions. The reactions with less template DNA were observed to have an increased incidence of stochastic variance in the peak heights.

This series of experiments verified that it was feasible to decrease the volume of the PCR amplification reaction and still produce reliable DNA typing results. However, laboratories considering this as a cost effective option alone should be aware of the method's limitations and of when a reduction in reaction volume could affect the quality of the work generated by the laboratory.

PCR, Sensitivity, Reduced Volume

B37 Typing of Forensic Samples Using the AmpFSTR® Identifiler™ Kit

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This research was undertaken to determine if a new multiplex kit commercially available from Applied Biosystems could be used to simultaneously amplify and type 15 short tandem repeat (STR) loci from various forensic samples.

Highly polymorphic short tandem repeat (STR) loci, or microsatellites, offer great promise for forensic analysis, paternity and gene mapping. The commercially available AmpFISTR® Identifiler™ kit (Applied Biosystems, Foster City, CA) contain all the necessary reagents for simultaneous coamplification and typing of D3S1358, vWA, FGA, D8S1179, D21S11, D18S51, D5S818, D13S317, D7S820, D16S539, TH01, TPOX, CSF1PO, D2S1338, D19S433 and Amelogenin loci. This is a five-dye system for automated DNA fragment analysis which includes the 13 CODIS loci required for known-offender databasing in the United States and two additional loci, D2S1338 and D19S433, which allow the kit to be consistent with the AmpFISTR® SGM Plus™ PCR Amplification kit.

Deoxyribonucleic acid (DNA) was extracted from various samples commonly encountered in forensic casework. Amplification and the reactions for PCR were prepared according to the manufacturer's recommended protocol. Approximately 1.0ng of the extracted DNA from each sample was used for amplification with the primers. All 16 loci were

amplified simultaneously in a single reaction. Thermocycling was performed in a Applied Biosystems GeneAmp® PCR System 9700 thermal cycler according to the recommended protocol of the manufacturer of the kit.

Amplification products using the AmpFISTR® Identifier™ kit were analyzed by capillary electrophoresis on an ABI PRISM® 310 Genetic Analyzer instrument. 1.5 µl of the amplification product and AmpFISTR® Identifier™ Allelic Ladder was added in the corresponding tubes which contained a mixture of 24.5 µl of Hi-Di Formamide and 0.5 µl of GeneScan®-500 LIZ Size Standard. The mixture was denatured at 95° C for three minutes and snap-chilled on ice for three minutes.

PCR products were injected for five seconds and capillary electrophoresis was performed for 28 minutes at 15kV in POP 4™ using the 1mL syringe. Filter set G5 module file with the appropriate matrix file using the 6-FAM, VIC, NED, PET and LIZ matrix standards was used on all runs. ABI PRISM® 310 Collection Software was applied for data collection. The data were analyzed by GeneScan® Analysis Software. Genotyper® software was used for the automated genotyping of the STR loci.

Results indicated that AmpFISTR® Identifier™ kit can be used for amplification and subsequent typing of DNA extracted from various types of forensic samples. Samples which have been previously profiled with AmpFISTR® Profiler Plus™ and COfiler™ typing kits were concordant with the overlapping loci.

AmpFISTR®, Identifier™, Kit

B38 Variation Observed in Amplification Levels of Mixture Components Using Large STR Multiplex Systems

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The goal of this research project is to help participants better understand the variation which can occur in levels of amplification of different alleles at a single locus and across multiple loci.

DNA profiles using short tandem repeat (STR) loci provide quantitative data which can be extremely valuable. While this quantitative data may not be critical to the analysis of single source profiles, it should be considered in the analysis of profiles obtained from samples containing mixtures of DNA from two or more individuals. Data from validation samples from numerous laboratories have been analyzed for peak height ratios and percent stutter at each locus. This information can be used to assist in the analysis of a mixture. However, there are several other factors that can compound the problem of analysis of mixed samples. The ratio of the components in the mixture, the number of components in the mixture, the amount of DNA from each component and the state of degradation all impact the feasibility of interpreting data from a mixture.

We have used data from validation studies and no-suspect cases to explore additional methods that could facilitate the interpretation of samples having a two-component mixture. This approach was used with casework mixtures where there is not a clear primary component but the sample contains a sufficient amount of DNA that loss of an allele due to a stochastic effects is unlikely. STR validation studies using samples having fixed ratios of the two component DNAs with variations in the total amount of DNA amplified were also included in the data analysis. Using this protocol we could compare results from the amplification of 2 ng of a 1:10 ratio of components to amplification of 0.2 ng of the same components at a 1:10 ratio. We have coupled that information with data collected from the analysis of fifty no-suspect sexual assault cases where the profile

of the victim is known. Profiles chosen for this portion of the data set showed no obvious indications of consisting of a mixture of more than two persons. All profiles were analyzed on the ABI Prism 310 Genetic Analyzer or the ABI Prism 377 DNA Sequencer. All amplifications were done with the AmpFISTR Profiler Plus and COfiler PCR Amplification Kits. A threshold of 60 RFU (relative fluorescent units) was used for all analyses.

Both STR mixture validation samples and the no-suspect sexual assault samples were evaluated to identify loci where the RFU of both contributors could be definitively determined. This included loci with four alleles (two from each contributor) and loci with three alleles where the victim (considered and consistent with being a known contributor) was homozygous and the second contributor could be determined to be heterozygous. Any loci meeting these criteria were evaluated across the profile for both the Profiler Plus and COfiler systems. The consistency of the ratio of (RFU of contributor A) divided by (the sum of RFU of contributor A + RFU of contributor B) across the loci of the profile was examined for all loci that met the criteria described above. Information from the casework data has been analyzed and compared to the more idealized validation sample data. Additionally, data from samples containing relatively small amounts of starting template were compared to data from samples containing larger amounts of starting template. Results and interpretation of these comparisons will be discussed and the application to deduction of second component profiles will be presented.

STR Mixture Analysis, No-Suspect Casework, STR Multiplex Systems

B39 Comprehensive Multiplex Amplification of Available Y-STR Loci

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The goal of this research project is to inform the forensic community about the range and efficacy of Y-STR markers that exist in multiplex PCR formats.

It is possible, and in certain circumstances advantageous, to make use of the unique biology of the Y chromosome for forensic purposes. Firstly, Y-chromosome specific systems may prove invaluable for the identification of the genetic profile of the male component in mixed male/female specimens in those instances in which the female portion is present in overwhelming quantities relative to the male. This could be due to the deposition of semen by an azoospermic or oligospermic male, to cases of oral sodomy where only trace amounts of male buccal epithelial cells may be present, or due to the normal degradative and sample loss processes that occur with the passage of time. Additionally, Y systems could be used to determine the number of semen donors in cases of multiple perpetrator rape. A third reason for employing Y chromosome polymorphisms would be in criminal paternity analysis or disaster victim identification. The haplotype of a missing individual may be determined by typing a male relative such as a son, brother, father, nephew or uncle. Fourthly, the ability to specifically detect a male profile could obviate the need for the time-consuming and oft-times inefficient differential extraction procedure for the separation of sperm and non-sperm fractions. Finally, male specific systems may provide additional statistical discrimination for autosomal markers in mixture or relative cases.

Although more than thirty potentially useful STR loci have been described on the Y chromosome, a more limited number have been appropriately evaluated for forensic use. The aim of the present work was to improve the discriminatory potential, and hence the probative value, of Y-STR based testing by extending the set of Y chromosome STR loci available for operational use. In accord with the requirements of multiplex

systems developed for forensic use, we sought to maximize the number of loci to be co-amplified, ensuring appropriate assay sensitivity (1-3 ng of input genomic DNA), balancing inter-locus signals and minimizing background interference such that few confounding female DNA artifacts were obtained at a female:male DNA ratio of 100:1.

Two Y chromosome STR systems, multiplex I (MPI) and multiplex II (MPII), have been developed and subject to extensive optimization. These allow for the co-amplification of the 19 Y STRs - DYS19, DYS385, DYS388, DYS389, DYS390, DYS391, DYS392, DYS393, DYS425, DYS434, DYS437, DYS438, DYS439, Y-GATA-A7.1, Y-GATA-A7.2, Y-GATA-C4, Y-GATA-H4 - and their subsequent separation and detection using a standard capillary electrophoresis analytical platform. The two multiplex systems are robust over a wide range of primer, magnesium and DNA polymerase concentrations and perform well under a variety of cycling conditions. Complete male haplotypes can be obtained with as little as 100-250 pg of template DNA.

Additional markers have been developed which are somewhat less discriminating than the aforementioned loci. However, taken together with MPI and MPII, these allow for a comprehensive, and nearly complete, analysis of currently available Y chromosome markers. Included are: DYS426, DYS436, DYS288, DYS435, Y-GATA-A.10, Y-GATA-A4, YCAI, YCAII, YCAIII, G09411 and the YAP insertion. The analysis of the combination of the male specific loci will conceivably allow for the discrimination of a majority of unrelated males. Additionally, the ability to amplify specifically a male component in an overwhelming background of female DNA will often render it unnecessary to employ a differential extraction strategy to obtain a male haplotype (or haplotypes in the case of multiple male donors) in cases of sexual assault.

The establishment of a national Y-STR reference database is essential to facilitate the generation of reliable estimates of Y haplotype frequencies. Haplotype frequencies are required to provide a statistical estimate of the significance of a match. Details of our effort to compile data from a variety of US academic researchers and to perform population studies, with a view to developing a searchable US database of Y-STR haplotypes to be used by the US forensic community, will be presented.

Y Chromosome, Multiplex, Y-STRs

B40 Y-Chromosome Specific STRs Analysis Using Y-PLEX™ 6 Amplification Kit

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At the conclusion of this presentation, the attendees will understand that human Y chromosome is male specific and is present in normal males in single copy.

The human Y chromosome is male specific and is present in normal males in single copy. DNA polymorphism detected on the human Y chromosome is equivalent to its autosomal counterparts. The analysis of Y chromosome polymorphism is useful for paternity involving male offspring or missing male offspring, evolutionary studies and for human identification. It is particularly useful in sexual assault cases where mixtures of male and female body fluids are involved. In evidence samples where the body fluids of male and female donors are mixed, Y chromosome markers can yield specific information about the perpetrator. In seminal stains encountered in sexual assault cases where small amounts of male DNA fraction are mixed with a large amount of female DNA, it is possible to type the male DNA specifically. In sexual assault cases where there might be more than one male contributor, detection of Y-chromosomal STR alleles can be used to determine the number and the identity of all contributors.

DNA was isolated from blood, hair and body fluids such as semen from vasectomized men, stained semen smear slide, postcoital slides, toothbrush, paraffin embedded tissue, bones, nails, envelopes, bloodstains deposited on Isocode® card, and FTA® Micro Card etc. by organic extraction or by using Chelex extraction procedures. Bloodstains from various animals were also extracted. Amplification and the reactions for PCR were prepared according to the manufacturer's recommended protocol. Approximately 1.0-2.0 ng of the extracted DNA from each sample was used for amplification with the Y-PLEX™6 amplification kit. The amplified products were analyzed by capillary electrophoresis on an ABI PRISM® 310 Genetic Analyzer instrument. The data was analyzed by GeneScan® Analysis Software. Y-Typer template was used for the automated genotyping of the 6 STR loci.

Results indicated that Y chromosome specific STR locus profiles can be generated from a wide variety of samples using Y-PLEX™6 STR kit. The data can be used for y-chromosomal analysis in forensic casework. Alleles were not detected using non-human DNA, thus the primers used are human specific.

Y Chromosome, Multiplexing, STR

B41 The Contest Between Mitochondrial and Nuclear DNA: What is the Best Target in Degraded Forensic Samples?

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The goals of this research project are to present a brief review of the forensic uses of mitochondrial and nuclear DNA, followed by a more detailed discussion on how these two DNA types behave differently in degrading samples, what characteristics cause the differences in this behavior, and how this knowledge can and is being used to develop more robust DNA identification methods for the forensic sciences.

Identification of an individual or biological substance through the isolation and typing of DNA has become one of the most commonly used and scientifically accepted tools in forensic science. Today, single copy nuclear DNA markers employed for forensic identification (the so called microsatellite DNAs or short tandem repeats (STRs)) can distinguish an individual (excluding identical twins) so thoroughly that the likelihood of a random match is one in the hundreds of trillions, or thousands of times the Earth's population.

Unfortunately, DNA and other large bio-molecules of forensic interest often must be obtained from less than ideal specimens. Samples may have been exposed to the elements for prolonged periods of time, and during this exposure DNA will begin to degrade. In old, decomposing, or otherwise adulterated forensic samples, amplifying and analyzing STRs can become difficult or impossible, with the larger alleles disappearing initially and smaller ones following as the DNA becomes progressively more fragmented. In these cases forensic scientists have increasingly turned to mitochondrial DNA (mtDNA), a small (approx. 16.5 kilobase), maternally inherited, circular piece of DNA found in multiple copies in each cell's mitochondria, and thus separated from the nuclear DNA. In samples where standard STR loci cannot be amplified, including old bones, shed hairs, pieces of fingernail, etc., mtDNA can often be isolated, amplified and used for forensic purposes. Unfortunately, many individuals, including those along the same maternal line, share identical mtDNA types and cannot be differentiated. Further, the most common mtDNA sequences are shared by 5% or so of all individuals, meaning hundreds of millions of people are the same, and thus forensically useful identification is severely limited.

We are thus left with a Catch-22: In forensic cases it would be desirable to analyze established nuclear loci with their high resolving power, but these do not work well in degraded samples; and, it would be desirable to analyze mitochondrial sequences which often can be obtained from highly degraded samples, but these do not have high resolving power. Obviously, the ideal genetic marker would fit both of these needs, but presently none is available to the forensic community. However, while such markers are not used today, the tens of thousands of genes in the human genome, and orders of magnitude higher number of non-coding loci found in the nucleus, suggest that markers that fit both criteria might exist. The first step in identifying them, if it is indeed possible, is to objectively and thoroughly understand what feature(s) of mtDNA make(s) it so much more advantageous when it comes to isolation from poor or degraded samples.

In this study, the three primary features of mtDNA that distinguish it from the single copy nuclear STR markers were examined: mtDNA's higher copy number in a cell, its sequestration in the mitochondria away from the nucleus, and its circular structure. Mice, which behave similarly to other mammals in the successful isolation and amplification of DNA types, were used to generate fresh tissue samples. Liver, brain and muscle were harvested from multiple individuals. One portion from each tissue was frozen on dry ice, while other portions were allowed to degrade for one week at 4, 24 and 37° C either in situ or following tissue homogenization (to place all DNAs in a similar cellular environment). The relative levels of a specific single copy nuclear gene, a high copy number nuclear gene, and a mitochondrial gene from each tissue were determined using quantitative, real-time PCR. In a parallel study, exogenous circular and linearized DNAs were added to tissue homogenates to determine if structure plays a substantial role in DNA degradation.

The results show that the efficacy of mitochondrial vs. nuclear DNA typing in forensic investigation of poor or degraded samples is a more complicated phenomenon than the most simplistic model based on DNA copy number. Degradation rates of these DNAs are not equal, and appear to be influenced by a number of factors including not only cellular location, but characteristics of specific loci or gene families. Most importantly, the results indicate that it may well be possible to identify and utilize more discerning nuclear markers—markers which can remain typable long after standard STR and mitochondrial loci have degraded.

Mitochondrial DNA, Nuclear DNA, DNA Degradation Rates

B42 Interlaboratory Studies on Multiplexed mtDNA HV and Y Chromosome SNP Kits Using an Automated Liquid Bead Array System

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The goal of this research project is to acquire knowledge on the basics of the MiraiBio Luminex 100 system and to understand the utility and performance of the mtDNA HV and Y SNP kits.

MiraiBio Inc. has recently introduced an automated liquid bead array system. This system, Luminex 100, is capable of conducting multiplex analysis of up to 100 different tests in a single tube. Using the XYP platform autosampler, it is possible to process 96 samples for 100 different SNPs in less than 1 hour.

This technology is extremely flexible and has already been used to conduct both DNA and protein assays (SNPs: Cai, H. et al. 2000. *Genomics* 66: 135-143; Chen, J. et al. 2000. *Genome Res.* 10:549-557; Taylor, JD et al. 2001. *Biotechniques* 30:661-669; Yang L. et al. 2001. *Genome Research* 11:1888-1898; Iannone, MA. et al. 2000. *Cytometry* 39:131-140, Carlson, D. 2000. *Microsphere assays for Y-chromosome SNPs.* 11th International Symposium on Human Identification. *Promega Abstracts*, Carlson, D. et al. 2001. *Screening Mitochondrial DNA Polymorphisms with Liquid Arrays.* *Proc. American Academy of Forensic Sciences.* Vol VII:77: Cytokines-Kellar KL et al. 2001. *Cytometry* 45:27-36; Carson, RT. et al. 1999. *J. Immunological Methods.* 227:41-52). Several different types of kits are either already commercially available or soon to be released. These include ultiplex cytokine antibody kits (BioSource-www.biosource.com) and mitochondrial hypervariable regions I and II and Y chromosome SNP kits (www.marligen.com).

The forensic utility of mtDNA and Y chromosome markers are well established. MtDNA HVI and HVII regions have been used by forensic laboratories on degraded minute samples such as bone and hair samples. Due to the high copy number of mtDNA it has been used to assist in forensic casework when the sample is limited and/or degraded. In addition, since mtDNA is maternally inherited, a reference sample can be acquired from the maternal lineage for comparative purposes even in the absence of a reference standard from the suspect or victim. Y chromosome markers have also been useful in forensic DNA casework. Y chromosome specific markers may provide a useful screen on sexual assault evidence to eliminate potential donors before conducting a differential extraction. Furthermore, they will also be useful in paternity cases.

Liquid arrays of allele-specific oligonucleotides for mtDNA HV 1 and HV2 and Y chromosome polymorphic sites were coupled to fluorescently tagged latex microspheres. Each oligonucleotide was associated with a particular "color" microsphere. DNA samples were amplified by PCR with primers labeled with a fluorescent reporter dye. The labeled amplification products were hybridized to the virtual array of oligonucleotides on microspheres, and then analyzed directly, without washing in the Luminex 100 flow system. This instrument automatically samples each well in a 96 well microtitre plate and then computes the median fluorescent intensity of reporter dye associated with each color classification of microsphere, and hence with each allele-specific oligonucleotide.

In order to evaluate the performance of the Luminex 100 system and the mtDNA and Y SNP kits, MiraiBio Inc. and Marligen BioSciences initiated a developmental validation study. A haplotyping consortium was formed consisting of eight laboratories from forensic, industrial and academic communities. Participants were trained to use the instrument and SNP kits in a three-day training. Studies were initially conducted on known amplified samples. Five to six well characterized samples were amplified, pooled and then split so that each participant would start with

an equal set of 5-6 amplified samples. This was done to minimize variability in results due to a small difference in the efficiency of amplification which would likely occur between laboratories. Each participant laboratory independently ran 5-6 samples in triplicate for both mtDNA and Y SNP kits on the Luminex 100 with the XYP platform. Panels of both mtDNA for HV1 and HV2, as well as Y chromosome SNPs plus the amelogenin locus, were used to successfully genotype samples. Haplotyping results on a subset of these samples using the Luminex system were corroborated by subsequent sequencing. The availability of more mtDNA and Y polymorphic sites will allow the expansion of these panels to further increase their power of discrimination.

Results from these and other mtDNA and Y SNP liquid bead array studies will be presented. Results on the same samples using Y STRs vs the Y SNPs will also be presented. MasterPlexGT software from MiraiBio Inc. will also be demonstrated. Luminex 100 output files can be directly loaded for the analysis of any SNP data and the software provides the user with the ability to rapidly screen samples from many different runs for potential exclusions and inclusions.

SNPs, mtDNA, Y Chromosome

B43 An Investigation of the Frequency of Contamination Detected by mtDNA Analysis of Blood Samples Extracted for RFLP and PCR Based Typing

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The goals of this research project are to gain knowledge of the frequency of contamination detected by mtDNA analysis of blood samples extracted using standard procedures with no additional precautions beyond those normally employed for RFLP- and PCR-based typing and learn how to more readily distinguish contamination from heteroplasmy.

An Investigation of the Frequency of Contamination Detected by mtDNA Analysis of Blood Samples Extracted for RFLP Learning Objective: The participant will gain knowledge of the frequency of contamination detected by mtDNA analysis of blood samples extracted using standard procedures with no additional precautions beyond those normally employed for RFLP- and PCR-based typing and will learn how to more readily distinguish contamination from heteroplasmy.

The immobilized sequence-specific oligonucleotide (SSO) linear array, targeting 18 positions across both hypervariable regions I and II (HVI/HVII) of the human mitochondrial genome, has proven to be a rapid screening tool for various types of evidence samples. This linear array utilizes 33 probes striped in 31 lines on a nylon membrane and each detects between one and three nucleotide differences. Additionally, linear array typing has proven to be a more sensitive method of detecting sequence polymorphisms within mixtures than sequencing as well as more accurate at reflecting the true ratio of two sequences. Consequently, the linear array not only provides for a rapid screening tool, but also aides in overcoming interpretation challenges posed by mixtures of mtDNA sequences, attributable to either heteroplasmy or contamination. Both heteroplasmy and contamination appear as a mixture of sequences, therefore mixtures must

be carefully interpreted. Typically with additional experiments and observations, heteroplasmy and contamination are distinguishable. While much of our work has focused on characterizing heteroplasmy, in this study we address the concerns of contamination. Contamination may occur at any step in the process between collection of the sample and analysis. A contaminant may be introduced by the handler of the sample at the time of collection or the DNA analyst and may originate from a source in the lab or even a random source. When handling samples destined for mtDNA analysis, extreme measures to prevent contamination are carried out. For low-copy number samples such as bone and shed hairs, this practice is essential, because even a very small amount of contamination will likely be detected by mtDNA analysis due to the contaminant to sample ratio. However, we address here the frequency of contamination in high-copy number samples that have been extracted using standard procedures with no additional precautions beyond those normally employed for RFLP- and PCR-based typing. Examples of these types of samples would be liquid blood and bloodstains extracted for generating population databases for nuclear markers. These observations will be particularly useful to laboratories that plan to establish a mtDNA database from previously collected blood samples.

We will summarize a series of studies looking at the contamination frequency in samples extracted in a crime lab setting for RFLP or STR analysis, without mtDNA analysis in mind. While additional precautions to prevent contamination were not carried out during the extraction procedure for these high copy number samples, great measures to prevent contamination during sample handling and PCR set-up were followed. In one collaborative study with the San Bernardino County Sheriff's Department, 106 samples were taken from previously extracted proficiency test samples. These samples were amplified with the HVI/HVII duplex primers and typed with the HVI/HVII SSO linear arrays. Of the 106 samples, 53 were extracted bloodstains, 5 were positive amplification controls from cell lines, 30 were extraction and reagent controls, and 18 were amplification set-up controls. There was no detectable contamination (i.e., multiple signals in more than one region) observed in any of these samples. However, one reagent control had faint signals with the first amplification and upon re-amplification and typing, but amplification and typing of a new dilution of the original extract yielded clean results. Therefore, contamination of this control sample likely occurred while setting up the dilution and not during the extraction procedure. Two population studies using previously extracted blood samples and carried out with the SSO linear arrays also provide evidence that when mtDNA typing is performed on samples containing a high copy number, the most likely points of introducing contamination are dilution of the extract and PCR amplification set-up. The samples used for the population study of 689 individuals published by Reynolds et al. (2000) in the Journal of Forensic Science had no detectable contamination. These samples had been batch extracted in a large, busy paternity laboratory and had been diluted and accessed by many individuals over a seven-year period prior to being used for mtDNA typing. When the same 689 samples were amplified and typed with the duplex primer set and the expanded SSO linear array several years later, a few examples of contamination were observed and all examples were investigated to determine the origin.

From these results we conclude that the methods of bloodstain and liquid blood extraction used for RFLP and PCR work are likely to yield samples free of contaminating mtDNA or containing such a low amount that the contaminant cannot be detected. Consequently, laboratories that plan to set up mitochondrial DNA databases probably will not have to re-extract all of the previously collected blood samples, nor will extractions of new blood samples for mtDNA database work need to be performed in a specially equipped, separate facility. However, casework analysis of hairs and other low copy number samples as well as previously extracted low and high copy number samples should always be performed in a dedicated room or hood.

SSO Linear Array, mtDNA, Contamination

B44 Expansion and Optimization of a Linear Probe Array for the Analysis of Sequence Variation in the Control Region of the Mitochondrial Genome

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The goals of this research project are to understand how the original mitochondrial DNA linear array assay was modified to create an expanded version that detects sequence variation in both of the hypervariable regions of the control region. Guidelines for casework strategy and the interpretation of linear array results also will be discussed.

Analysis of sequence variation in the two hypervariable segments (HVI and HVII) of the mitochondrial genome is applied to the study of human populations and used to resolve questions of human identification. The most widely used method of analysis for forensic and human identification applications involves PCR amplification of mitochondrial DNA (mtDNA) extracted from biological samples followed by direct sequence analysis. While DNA sequencing provides the most discriminating information, the procedure and subsequent interpretation of data are very time consuming and expensive. Few forensic laboratories have the resources necessary to perform DNA sequence analysis on a routine basis. Consequently, many opportunities to solve a case or identify remains are lost. Over the past several years, we have been developing a rapid method of analysis of sequence variation in HVI and HVII utilizing the established technologies of PCR amplification and immobilized probe hybridization. The original linear array for mitochondrial DNA sequence analysis was comprised of 17 sequence-specific oligonucleotide (SSO) probes immobilized on a strip of nylon membrane that detected sequence variation at positions 73, 146, 150, 152, 189, 195, 198, 200, and 247 within HVII. One of the 17 probes distinguished between the presence of 7 and 8 cytosine residues within the HVII "C-stretch" and another served as an intensity control probe. The HVII linear array assay and population data collected from 689 individuals in four population groups have been described in detail in Reynolds et al. (2000) *Journal of Forensic Science*.

To increase the value of this assay, we incorporated a primer pair for the HVI region into our PCR amplification reaction and added 18 additional probes to detect sequence variation in four regions of HVI and at two additional heteroplasmy hotspots (16093 and 189). The "C-stretch" probe and the intensity control probe from the original array were removed, resulting in a total of 33 probes in the linear array. Because probes designed to detect sequence variation and heteroplasmy at position 189 span position 195, both of which are present at a high frequency in the population, four probes covering the four possible combinations of bases at positions 189 and 195 were included in the panel. However, to restrict interpretation to position 189, the four probes have been combined onto two lines in the array such that the base at 195 is not distinguished. Therefore, the final version of the HVI/HVII linear array assay consists of two primer pairs for co-amplification of HVI and HVII PCR products and 33 probes immobilized in 31 lines for detection of sequence variation at 18 positions spanning both hypervariable regions. The linear array assay can be performed in approximately 5-6 hours, including amplification time, on up to 40 samples. Positive signals are detected as blue lines following a color development reaction and the pattern of blue lines represents an individual's mitotype. Interpretation of the patterns can be done immediately after developing the arrays, either visually or by scanning. In addition to being rapid and informative, the linear array assay consumes only one-half to one-quarter the amount of extracted sample as sequence analysis because the HVI and HVII regions are amplified simultaneously

rather than in two or four separate reactions. Also, the PCR products amplified for the linear array assay can be used for sequence analysis. Additional material does not have to be consumed to perform sequence analysis of samples of which a suspect is a possible donor. We recommend that the linear array assay be performed prior to sequence analysis because these two technologies are complementary and should be used together to achieve the most efficient and accurate analysis of samples that do not contain sufficient nuclear DNA for STR analysis.

To determine the value of the expanded HVI/HVII linear array assay as a screening method, we typed the same 689 samples described above as well as 105 Croatians and 200 US Georgians. We also sequenced the HVI and HVII regions of many of the samples. We found that this panel of SSO probes captures a significant level of genetic diversity within the control region in all of these populations. The original HVII linear array also has been tested on 208 samples taken from 20 cases. Of these samples, 186 yielded sufficient PCR product for linear array assays and sequence analysis. Using the HVII region probes alone, all but 51 (27%) of these samples were excluded as being probative. Consequently, only 51 out of 186 samples needed to be sequenced. Sequence analysis of HVI and HVII in these 51 samples resulted in the exclusion of seven additional samples as originating from the suspects. Clearly, as a result of using the linear array assay to screen samples, the sequencing effort in this laboratory could be directed toward the most probative samples, resulting in a significant decrease in casework turnaround time. To estimate the amplification success rate of the HVI/HVII linear array assay, we collected over 2000 hairs from approximately 120 individuals. Each hair was characterized microscopically and photographed at x100 magnification prior to extraction. We amplified a shaft portion of each hair with the duplex HVI/HVII primer pair. We also designed and tested primers for amplifying smaller fragments of the HVI and HVII regions. Their amplification success rate on samples that cannot be amplified with the duplex primer set will be determined. Because we have photomicrographs of the hairs, we are able to analyze the data to determine which, if any, characteristics of hair compromise amplification efficiency. We concluded from these studies that the linear array assay is a simple, rapid screening tool for casework analyses because it is robust and provides a high degree of discrimination in a relatively short period of time.

To maximize the robustness and sensitivity of the linear array assay, we have carried out numerous optimization experiments to investigate the effects of temperature and reagent component concentrations on both the PCR amplification and hybridization steps of the assay. These experiments allow us to determine, for example, which probes are most likely to cross-hybridize with other sequences when the assay is not performed under optimal conditions. We also can identify the changes in assay parameters that are most likely to affect amplification of each of the PCR products. All of this information can be used when interpreting results and to troubleshoot problems encountered in the laboratory. Results from some of these experiments will be presented to illustrate approaches to interpretation and resolution of inconclusive results obtained by running the assay under non-optimal conditions.

mtDNA, HVI and HVII, Linear Arrays

B45 Evaluation of Multicapillary Electrophoresis for Use in Mitochondrial DNA Typing

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The goal of this research project is to describe the evaluation and implementation of the ABI Prism 3100 Genetic Analyzer for mitochondrial DNA sequencing.

Mitochondrial DNA sequencing is a useful tool for genetically characterizing biological samples that contain minute quantities of nuclear DNA or that have been severely degraded. The current method for typing of the mtDNA (after Sanger sequencing) is by detection of fluorescently-labeled fragments that are separated during slab gel electrophoresis. Slab gel electrophoresis has been the method of choice because a large number of samples (24 to 96) can be analyzed in parallel. Capillary electrophoresis (CE) offers an alternative electrophoretic approach for the fractionation of DNA molecules. The use of a CE instrument is desirable because it can enable automation of portions of the analytical process. Unfortunately, CE instruments that have been available in forensic laboratories to date do not have the throughput capacity of slab gel systems. However, automation and high throughput can be realized with the advent of multicapillary systems. The use and performance of the ABI Prism 3100 Genetic Analyzer (Applied Biosystems, Foster City, CA), a 16 capillary instrument, was evaluated for mtDNA sequencing capabilities and the performance was compared with the slab gel-based platform currently in use in our laboratory (the ABI 377 DNA Sequencer, Applied Biosystems). In addition, the mtDNA sequencing performance of the ABI Prism 310 Genetic Analyzer (Applied Biosystems) was tested to evaluate the usefulness of this single capillary instrument to serve as a back-up instrument for sample re-runs (although the instrument can be used independently). The parameters tested included: sequence quality on each platform, resolution of the bases, resolution of mixtures, typing of heteroplasmic samples, sensitivity of detection, assessing array quality, assessing results from within and between arrays comparisons, sequencing effects due capillary length, effects of TSR vs. formamide, prepared sample stability after injection, and injection time. DNA sources included: cell lines, blood, saliva, bone, and hair. Regions HVI and HVII were sequenced using standard operating protocols and primers to prepare the samples. The use of a multiple capillary electrophoresis instrument eliminates the need for gel pouring and manual sample loading. As many as 192 samples can be loaded and injected automatically on the ABI Prism 3100. Run time is approximately 105 minutes (for 16 samples simultaneously) for a capillary with a 50 cm length. The data support that valid typing results can be obtained using either CE instrument, and the reliability of these CE instruments is at least equal to the performance of the ABI 377 DNA Sequencer for mtDNA sequencing.

Multicapillary Electrophoresis, Mitochondrial DNA, DNA Typing

B46 Characterization of the Caucasian Haplogroups Present in the SWGDAM Forensic mtDNA Database for 1771 Human Control Region Sequences

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The goals of this research project are to characterize the Caucasians haplogroup patterns found in the SWGDAM forensic mtDNA database. Such an assessment will assist in determining whether the database is relevant and representative of Caucasians. The comparisons carried out are both the observation of variable sites within the control region (CR) and the selection of a subset of these sites which partition the human variation into clusters (i.e., haplogroup designation) using a phylogenetic criterion.

The SWGDAM forensic mtDNA database is representative of Caucasians. The ten previously defined haplogroups (i.e., H, I, J, K, M, T, U, V, W, and X) observed in North American and European Caucasian populations also were found in this forensic database. Over 200 Single Nucleotide Polymorphisms (SNPs) also were found in the database. Many of these SNPs correspond to important variable sites that define haplogroups.

Human mtDNA genetic variation has been extensively studied over the last decade and general patterns have emerged. Approximately 99% of the known European and North American Caucasian mitochondrial variation can be categorized within ten defined haplogroups (i.e., H, I, J, K, M, T, U, V, W, and X) (Torroni et al. 1996, *Genetics* 114:1835-1850). Single Nucleotide Polymorphisms (SNPs) have been identified and tabulated, as have numerous partitions of the major clusters within European and American Caucasians (see Torroni et al. 1996; Finnila et al. 2001, *Am. J. Hum. Genet.* 68:1475-1484; Helgason et al. 2001 *Am. J. Hum. Genet.* 68:723-737 and references therein). Currently, a large forensic mtDNA database (SWGDAM) is used to infer the relative rarity of mtDNA profiles (i.e., haplotypes) obtained from evidence samples and for use in identification of missing persons. The goal of this study is to characterize the Caucasians haplogroup patterns found in the forensic database. Such an assessment will assist in determining whether the database is relevant and representative of Caucasians. The comparisons carried out are both the observation of variable sites within the control region (CR) and the selection of a subset of these sites which partition the human variation into clusters (i.e., haplogroup designation).

The matrix was analyzed to determine both single nucleotide polymorphisms (SNPs) in a phylogenetic context, as well as to check and standardize haplogroup designations with a focus on determining the characters that define these groups. To validate our database, we compared our results to the haplogroup identifications and frequencies reported from other published studies.

The SNPs were determined from phylogenetic analysis of the Caucasian subdivision of mtDNA control region sequences found in the SWGDAM forensic database. The SNPs were organized into three categories. The first category included all SNPs observed in two or more individuals. These variable sites should be useful for diagnosing haplogroups. After constructing a tree, characters were carefully examined from a phylogenetic perspective. Character states that were different from the CRS were used as diagnostic sites for distinguishing clusters of taxa. To reduce the number of SNPs, an arbitrary cut off was made for sites that defined clades ($n \geq 10$, the second category). To improve and refine the SNP choice, a third rating of sites was made, which included sites that seemed best for distinguishing the major groups. This final selection was an attempt to reduce the redundancy among SNPs by eliminating ones that were closely associated with one another. Our reduced list of SNPs identifies all clusters in the database with 30 or more individuals.

The same 10 haplogroups defined by Torroni et al. (1996) also were observed in this forensic database. We also surveyed for additional haplogroups that may have been present due to the diversity found among American Caucasians. Similar site variation and frequency patterns were observed when compared to other published data sets, suggesting that the forensic mtDNA SWGDAM database is representative of the general European Caucasian population. Haplogroup H is the most commonly observed mtDNA type of the forensic samples. The next most common haplogroups represented in our database include clusters T (10.5 %), J (10.0 %), K (8.9 %) and U (8.4 %). The less frequently observed haplogroups were types W, X, I, V, and M. Each of these clusters was observed in 2 % or less of our samples. Similar patterns of haplogroup frequency distribution have been reported for Caucasians.

SWGDAM Forensic mtDNA Database, Haplogroup Designation, SNPs

B47 The Use of Elemental Composition to Compare Items of Physical Evidence

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The goals of this research project are to learn: 1) the circumstances under which elemental composition can provide highly significant discrimination among sources of materials recovered as trace evidence; 2) the limitations of using elemental concentrations as points of comparison of physical evidence; 3) consideration to be used in choosing an analytical method for a particular application.

The calculation of statistical significance based on population databases has been so successful in the characterization of biological material that it has received widespread acceptance. As a result, there have been several attempts at making statistical frequency-of-occurrence calculations for fingerprints and firearms evidence. Elemental composition has been used as a point of comparison for items such as glass, polymers, and metal alloys, particularly projectile lead, for over 30 years with many notable successes. Improvements in analytical methods and their more widespread availability to a large number of forensic laboratories, coupled with implementation of new criteria for legal acceptance, make this an appropriate time to reconsider the principles underlying compositional comparison of trace evidence. Of particular concerns are whether one can assign a significance measure to an opinion when two or more items are found to be indistinguishable and, if so, by what means should that significance be determined.

Comparison of recovered glass fragments with a broken window is, perhaps, the best example of the power inherent in the determination of elemental composition. Several analytical methods are available to determine the concentrations of from 10 to 50 elements in glass fragments with a high degree of accuracy and precision. The excellent discrimination capability is a result of the efficient mixing of molten glass during production of glass objects, resulting in variation in concentrations of an element throughout a glass object that is much smaller than the variation across objects. Using as few as five elements, it has been demonstrated that discrimination of float glass can be made over distances of several meters on a continuous production line. The concentrations of ten elements in samples collected over a ten-year period will be used to demonstrate the degree of discrimination obtainable and comment on the selection of match criteria and the significance of an indistinguishable pair of samples.

Other materials of forensic interest can be more challenging than glass, both for the development of analytical protocols and the interpretation of results. Five potential problems that may be encountered in the use of element compositions for source discrimination will be presented. For each one, recommendations will be given concerning appropriate means of interpreting the results in a forensic context and the limitations imposed on the significance of any opinion formed. The five areas of difficulty include:

1. poor precision or lack of quantitative results – altering interpretive criteria to allow good discrimination without accurate quantitation.
2. low concentrations of analyte elements – development of analytical protocols and effects of poorer precisions when working near analytical detection limits.
3. contamination/alteration of questioned samples – replication of results to distinguish contamination or alteration of questioned samples not present in source components.
4. sampling of heterogeneous sources – source heterogeneity and its effects on collection of appropriate known-source samples.
5. manufacturer effects – interpreting results when the manufacturer's unit of sale does not align with ultimate source production.

Methods for meeting each of these challenges will be illustrated using the results of analyses of copper wire, plastic trash bags, solder, soil, bullet lead, and other materials. Data from ICP-AES, ICP-MS, NAA, and SEM/EDX measurements will be used as examples.

Trace Evidence, Elemental Analysis, Source Discrimination

B48 PLM Examinations of Clear Packing Tape and Determination of Monoaxial or Biaxial Orientation

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The goal of this research project is to learn about polarized light microscope (PLM) techniques which are useful in discriminating clear packing tapes.

Microscopic examinations of clear packing tapes offer quick and easy discrimination between tape manufacturers and often between different batches from the same manufacturer's product.

Clear packing tapes are occasionally received in forensic labs for comparison. They may be used as gags, ligatures, restraints or in the packaging of explosive devices or illegal drugs. These tapes all have a transparent oriented polypropylene film with a clear adhesive and are usually 2 inches wide. The total thickness will vary with tape quality. The initial macro/stereoscopic exams offer few clues to differentiate clear tapes that have different sources. The techniques described in this presentation are capable of showing within and between manufacturer variations and are more discriminating than some of the more time-consuming instrumental methods such as FTIR and Pyrolysis GC/MS. These described techniques and microscopic observations of clear packing tape are apparently unpublished in forensic circles at this writing.

The film or clear packing tapes are referred to as monoaxially or biaxially oriented polypropylene (MOPP or BOPP) depending upon how they are stretched in the manufacturing process. In fact, it is the variations in this stretching that imparts upon the film some of the optical differences peculiar to the different manufacturers. MOPP tapes are stretched in one direction and are referred to as "hand tearable." The BOPP tapes are stretched in two directions giving them a more tensile stretch. Even within the same manufacturer, differences may be seen between different rolls due to production fluctuations and end use specifications.

The microscopic examination involves mounting the tapes on glass slides adhesive side down. The adhesive is isotropic and therefore does not interfere with the PLM observation of the film. The film itself behaves optically like a biaxial crystal. The two refractive indices in the plane of the film will be used to make the following observations:

1. To determine whether the tape is a MOPP or BOPP tape by observing hatch marks visible at near extinction. In addition, the angle of the hatch marks in the BOPP will vary between manufacturers.
2. To determine the extinction angle of the film relative to the machine edge. This may vary anywhere from 0 to 15 degrees.
3. To determine the direction of the fast wave and the retardation of the film as a measure of tape thickness.

In addition to the above optical properties, other observations may include particles added to the film or adhesive, such as talc or starch, which would further serve to discriminate different tapes.

PLM, Packing Tape, Polypropylene Tape

B49 Extraction of Aqueous Solutions With Water Miscible Solvents

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The goals of this research project is to: 1) know more about liquid/liquid extraction and the effects of salts on the miscibility of liquids, and 2) become aware of possible new applications of liquid/liquid extraction.

Chemists have long used added salt (usually sodium chloride) to aid in the liquid/liquid extraction of organic moieties from aqueous solutions. The use of polar extraction solvents that are also easily removed by evap-

oration would often be desirable. Unfortunately, the use of solvents like acetonitrile, acetone or tetrahydrofuran directly in liquid/liquid extractions from aqueous solution is ordinarily not possible, because of their complete water miscibility. A few years ago a paper (1) described the use of sodium chloride at high concentrations to allow extraction of an aqueous solution with acetonitrile. The utility of the method was somewhat compromised because, even in the presence of considerable sodium chloride, the acetonitrile still showed considerable water solubility.

It is widely known that addition of a second salt, with no common ions, will often improve the extraction efficiency of organic solutes from aqueous solutions where sodium chloride has been added as a "salting out" agent. We examined a number of different combinations of sodium chloride with other salts and selected the combination of sodium chloride and magnesium sulfate. The, so called, double salt solution, used in the rest of the work contained 25g of sodium chloride and 18g of magnesium sulfate per 100 ml. of distilled water. This double salt solution was found to be quite stable. The double salt solution showed no cloudiness or precipitate when placed in a refrigerator overnight, or when four grams of additional sodium chloride per 100 ml were added or upon addition of any of the extraction solvents. The use of salt allows the formation of a distinct organic layer with acetonitrile or tetrahydrofuran, but not with acetone. The double salt results in a larger organic layer with both acetonitrile and tetrahydrofuran and the formation of an organic layer with acetone.

One possible forensic application for double salt enhanced extraction would be in extracting explosive residues from aqueous washings of debris collected from an explosion incident. We compared the ability of methylene chloride, tetrahydrofuran, acetonitrile and acetone to extract two nitroaromatic model compounds from dilute aqueous solutions. The model compounds selected were 1,5-dinitronaphthiene and 1,3-dinitrobenzamide. The first is a simple nitroaromatic, and the second, aromatic, being more oxidized, would be expected to be a less soluble nitroaromatic.

The recovery of both model compounds by extraction with methylene chloride was found to be significantly better from the double salt solution than from distilled water as would be expected. The recoveries obtained when using tetrahydrofuran or acetonitrile with the double salt solution were as good or better than with methylene chloride. Acetone is not quite as efficient as the other three for these model compounds but does give a better recovery of 1,3-dinitrobenzamide than methylene chloride from distilled water. With these model compounds the tetrahydrofuran appears to be the best extraction solvent of those tried.

In addition to fairly high recovery, the double salt has the advantage of allowing direct extraction into the polar water miscible solvents. If the next step in the analysis scheme were HPLC, extraction directly into acetonitrile might be particularly advantageous. The fact that the double salt makes it possible to use acetone as an extractant might prove valuable for some very water soluble organic compounds. To further demonstrate the utility of the double salt mixture, an experiment was carried out under conditions more similar to those, which would be encountered in most applications. The solute was added to distilled water and then an appropriate weight of the pre-mixed salts was added. Similar extraction efficiency was observed. The use of double salt extraction would seem to offer a number of other possibilities for application to forensic problems.

Extraction, Explosive Residues, Sample Preparation

B50 Calibration and Database Considerations for Automated Refractive Index Measurements

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The goals of this research project are to learn about the experimental and interpretive issues related to the calibration of automated refractive

index measurement instruments and the combination of automated and manual refractive index results for database construction.

Refractive index (RI) is the parameter most commonly measured and compared in forensic case work involving glass evidence. Historically, RI measurements in forensic laboratories have been made manually, principally using the Emmons double-variation method, and are reported at a standard temperature (typically 20°C). An increasing number of U.S. laboratories are replacing or complementing their manual methods for RI determinations with automated systems. However, data collected using automated methods cannot be readily compared with manual method results. This incompatibility results because the RI of glass changes with temperature, and the manufacturer-recommended calibration and data reporting for the automated system are at the match-point temperature, rather than at the standard temperature. Therefore, the direct use of historical databases of manually-acquired data for the evaluation of results obtained by automated methods is precluded, and the databasing of RI data acquired on different automated systems is further complicated. The FBI Laboratory has compiled over 35 years of manually-acquired RI data from glass evidence submissions, which is used to assist examiners in interpreting the significance of source associations based on RI measurements. This paper presents a method of data reporting for automated systems that is consistent with the historical data, which permits the continued use of this sizable historical database, and enhances the ability to interpret RI measurements of glass evidence.

For most types of glass that are encountered as evidence, the change in RI with temperature (dn/dT) for the solid glass is small, typically on the order of 10^{-6} . A correction for dn/dT of the glass is included in the construction of the Hartmann dispersion net used in the manual double-variation method. Correction for dn/dT of glass has been ignored in automated measurement systems, because the measured RI is generally reported at the match-point temperature. For samples with match-point temperatures that are well above the standard temperature of 20°C, the difference between the measured RI at the match point and at 20°C will be on the order of 10^{-4} . While such a difference will not adversely affect a typical case comparison, uncorrected automated measurements pose a problem for laboratories that are attempting to database data from multiple automated systems, and those trying to combine data acquired by manual and automated methods in databases for frequency-of-occurrence information.

Two approaches that can be utilized to obtain automated RI data at a standard temperature have been studied. The first approach is correction of the RI at the match-point temperature back to a standard temperature using a fixed dn/dT . This dn/dT can be based on an average dn/dT for evidentiary glass specimens. This type of correction requires an additional manipulation of the data prior to its entry into the database. An alternate approach is to construct a calibration curve with RI at a standard temperature, where results calculated from the curve will be reported at the standard temperature. This second approach assumes a fixed dn/dT for evidentiary glass based on the average dn/dT of the calibration standards. The error associated with either of these two approaches will be a function of the difference between the applied dn/dT and the true dn/dT of the glass. This error will be compared with the errors associated with the linear regression lines of the calibration curves.

Both of these approaches have been tested using replicate measurements of standard reference and known-source glass samples of various types with both manual and automated methods. The effects of the match temperature and the true dn/dT of the glass sample on the accuracy of the measured RI using these two approaches will be discussed. A statistical comparison of the data acquired using manual and temperature-corrected automated methods performed to evaluate the accuracy of the calibration procedure and assure compatibility of the automated data with the historical database will be presented.

Trace Evidence, Glass, Refractive Index

B51 A Study of the Effects of Washing, Substrate, and Primer Composition on Gunshot Residue Patterns

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The goal of this research project is to present to the forensic science community the results of a study of the effects of primer type, laundering and fabric type on gunshot residue patterns.

Gunshot residue patterns often provide important information for the reconstruction of shooting incidents. A number of methods are currently available for the chemical visualization of gunshot residue patterns. Some methods rely on the presence of nitrates and nitrites from combustion of the propellant, while others rely on the detection of lead from the primer in the cartridge. Ammunition manufacturers are gradually phasing out lead-based primers; this change in the composition of cartridge primers has been accompanied by changes in the formulation of the propellant which may affect the density and the size of gunshot residue patterns. Gunshot residue patterns may also be encountered on a wide variety of target surfaces. In particular, patterns may be found on items of clothing that vary in fiber composition (e.g. natural versus man-made), fabrication (weave and knit patterns) and finish. Another concern for the firearms examiner is the possibility that the perpetrator of a crime may attempt to remove gunshot residue patterns and associated blood evidence by washing garments.

This study examined the effects of primer composition, washing, nature of fabric substrate and range of fire on the detection of lead and nitrites in gunshot residue patterns. Three calibers of ammunition (.38 Special, .45 Auto and 9 mm) having lead-based and lead-free primers were used to fire gunshot residue patterns at the following ranges: contact, 6 inches, 12 inches and 24 inches. The following weapons were used in the study: a Ruger Redhawk .357 Magnum revolver firing .38 Special ammunition; a Colt MKIV Series 7 semiautomatic pistol firing 9mm Luger ammunition; and a Einfeld .45 revolver firing .45 ACP ammunition. The targets were composed of 100% polyester, 100% nylon, 100% rayon and 100% acetate. The targets were divided and one half of each target was washed using normal laundering procedures. A modified Griess test was used to detect nitrites on one-half of each of the washed and unwashed targets (i.e. one-quarter of the original target) and the sodium rhodizonate test was used to detect traces of lead on one-half of each of the washed and unwashed targets. The gunshot residue patterns were transferred by ironing to sheets of Whatman hardened low ash grade 54-filter paper for the Griess and sodium rhodizonate tests. Before the Griess test was performed each transferred residue pattern was sprayed with an aqueous 5% sodium hydroxide solution.

Nitrite patterns were detected on the targets even after washing; washing also appeared to cause no redistribution of nitrite residues. A significant source of the nitrites detected in the modified Griess test is the nitrocellulose particles from the propellants; treatment of nitrocellulose with base causes a disproportionation reaction which releases nitrite ions. Microscopic examination of the surfaces of the targets revealed that molten propellant particles were fused to the surfaces of yarns. These fused particles were probably retained on the target surfaces through the laundering process. Primer residue patterns could also be detected on the washed targets. Primer residue patterns were often developed from lead-free primers with sodium rhodizonate. This may be the result of lead traces left in the firearms or the result of sodium rhodizonate reacting with other metallic cations in the primer residue. An unanticipated finding of this study was that the 100% acetate fabric retained more gunshot residue than the other fabrics used as targets. This may be a consequence of the finer weave of the acetate fabric.

This study reached the following conclusions: (1) laundering does not remove or redistribute gunshot residues; (2) there is variation of powder patterns among fabric types probably due to differences in weave

density and fabric processing; (3) lead primer residue patterns may be developed on targets fired with lead-free primer ammunition, a possible consequence of lead traces left in firearms which had been previously used to fire ammunition containing lead-based primers; (4) the type of primer used in ammunition did not have an effect on the nitrite residue patterns.

Griess Test, Gunshot Residue Patterns, Lead-Based Primers, Lead-Free Primers

B52 Effective Sampling for Organic Gunshot Residues (OGSR)

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The goals of this research project are to have forensic investigators learn a new way to investigate firearm crimes based on determining the organic gunshot residue (OGSR) additive composition. In this presentation, we investigate approaches to OGSR collection including both hand and head hair sampling.

The application of gunshot residue analysis has been somewhat limited by the success of collecting residues. Adhesive tape or stub lifting from the hand has been the primary means for the collection of the inorganic primer residue metals, such as barium, lead, and antimony. The metals are then most commonly determined by SEM/EDS. Recently, Zeichner et al (1, 2) have been testing the idea of hair sampling using tape lifting and a swabbing-and-comb method as alternative collection approaches to hand lifts. Since the inorganic gunshot residues (IGSR) spherules are generally smaller than ten microns in diameter, an ethanol moistened pad was added to the teeth of the comb to help retain particles. This approach proved successful in casework (2).

An alternative approach to the detection of firearm use is the analysis of the incompletely combusted smokeless powder (3, 4). This OGSR comprises the bulk of the residue material from weapon use. The OGSR particles may be relatively large (up to 1 mm diameter) and may be collected directly by a very fine comb or by tape lifting. To detect firearm use, the OGSR is recovered from the extracting medium with an organic solvent. The residue analysis depends on the analytical measurement of three primary characteristic organic gunpowder components (COGC): propellant nitroglycerin (NG) and two stabilizers, diphenylamine (DPA) and ethyl centralite (EC). In a study of the possible occurrence of the COGC in the general population, none of these analytes was found (5). Thus, detecting these components is a good indicator of exposure to firearm residue. For this work, OGSR analysis was conducted using ultrasonic solvent extraction (USE) of the collected residues with an alcoholic solvent system, followed by a micellar capillary electrophoresis (CE) determination. The USE/CE analysis takes a total of less than one hour for each sample.

The goal of this study was twofold. The first goal was to determine some of the factors that affect the collection/retention of residues on the shooter. The second objective was to look for effective means to collect OGSR from shooters. The first goal was approached by examining the effects of sweat, static, and skin oil on the collection of residues. Each factor was simulated in the following ways: sweat by 'bagging' the shooter's hand in plastic; static electricity by charging the hand using friction with a latex balloon; and oily skin by rubbing the firing hand with jojoba oil. After shooting a 38 caliber revolver, the hands were examined for OGSR with a digital microscope. Following microscopic analysis an attempt at tape-lifting the residues was made by dabbing adhesive tape squares on the forefinger/thumb/web area of the hand. Skin oil seemed to have the most dramatic effect, greatly enhancing the collection of residues. However, the skin oil increased the difficulty of tape-lifting the particles from the hand.

The effectiveness of two residue collection media, tape lifting and hair combing, was then evaluated. Past work has shown that adhesive tape may be used for lifting OGSR. However, different tapes can present

problems in the organic analysis, as the tape adhesives or primary film may dissolve the solvent used to recover the COGC. This can result in both physical interference, such as the precipitation of soft polymers upon addition of the aqueous CE buffer, and/or chemical interference, particularly from the contamination of the extract with other UV-absorbing organic compounds (4). In this study, we evaluated a number of types of evidence tape for their suitability in collecting OGSR. The tape was used to collect OGSR from the web of the firing hand and also from the head hair of the shooter.

Combing was also tested as a means of collecting OGSR from the firearm shooter using a fine-toothed comb (a flea comb for pets). Although these combs do not have tooth spacing as small as the target micron to millimeter sized OGSR particles, preliminary hair combing experiments demonstrated the collection of particles substantially smaller than the tooth spacing. Following weapon firing, the hair on the back of the hand was combed. A separate comb was used to evaluate the collectable residues on the head hair. For the OGSR analysis, the comb was placed in a small, resealable plastic bag and a few milliliters of an alcoholic solvent was used to extract the COGC from the comb in an ultrasonic bath. The solvent extract was recovered and evaporatively concentrated for CE analysis. We found that small background of non-COGC could be further reduced by pre-extracting the bags and combs with methanol. Overall, the combing protocol was found to provide good recovery of OGSR from the shooter with much less interference from impurities than was noted with tape lifts. The effect of the position of the head hair relative to the weapon on OGSR collection was also tested. Mannequin heads covered in human wig hair were positioned relative to the weapon in a manner simulating a shooter, a by-stander, and a victim. Four weapons—revolver, semi-automatic handgun, semi-automatic shotgun, and rifle—were used to determine the effect of the weapon type. Results of these studies will be summarized.

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Gunshot Residue, Organic Analysis, Characteristic Organic Gunshot Components

B53 Fluorescein as an Alternative to Luminol for Use in Crime Scene Investigation

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The goal of this research project is to discuss and compare fluorescein as an alternative to luminol in detecting latent bloodstains at crime scenes.

This poster will present research done by this author over a period of three months based on the previous research of Robert Cheeseman and Charlene Marie. The procedures used were provided by the above researchers and were tested in the Hennepin County Sheriff's Crime Lab in order to determine if fluorescein is a feasible alternative to luminol.

In the literature, fluorescein was said to have sensitivity higher than that of luminol. Fluorescein will fluoresce when in contact with blood, under an alternate light source (ALS) at a wavelength of about 450nm. Experimentation included four different preparations of the reagent *fluorescein*. The comparisons made between the four procedures were the sensitivity of the fluorescein reagent compared to luminol, the ease of preparation, application, and photography. Of the four preparations only one was found to be truly field-friendly. This procedure was used throughout the remainder of the testing as it was simple and appeared to

obtain better results. Samples were made up using substrates common in crime scenes (i.e., walls, carpets, tiles, and clothing).

The reagents in the protocols that are referenced were altered in dilution and amounts to find a suitable strength. Once a suitable dilution was found, the author's own blood was diluted in distilled water to resemble latent stains and was applied to the sample substrates and allowed to dry. These were then treated with the fluorescein solution that was chosen and results were recorded in tables. The results obtained from the experimentation did not correlate with current literature on the subject. Fluorescein was not found to have a higher sensitivity than luminol in all cases. It proved to be of an equal or slightly lesser value in most cases. Both methods boast the ability of detecting blood at dilutions of over 1:100,000. Testing done on linoleum made it possible to detect blood at that level, but it was extremely difficult to ascertain the pattern. On substrates that are porous, dilutions of 1:10,000 became difficult to detect. Any fluorescence occurring at a dilution greater than that was unpredictable as the background staining increased to a degree in which it was virtually impossible to distinguish a stain from the naturally oxidized fluorescein.

When observed, fluorescein appears brighter than luminol and lasts longer. The time that luminol fluoresces is approximately 30 seconds whereas fluorescein will fluoresce from five to ten minutes depending on the dilution of the blood. It is possible that this is a property of the color. Luminol is blue whereas fluorescein is a bright green. Photography of fluorescein can be difficult due to the added necessity of an alternate light source (set at approximately 450nm), colored filters and a source of electricity. It is important that the ALS not be close to the stained region to keep the background fluorescence low. Once luminol loses its brightness, it can be sprayed again provided the substrate is not saturated, and the color will return allowing more photographs to be taken. This experiment found fluorescein to lack this ability, contrary to the literature. The background of fluorescein becomes severe after a re-spray, and photographs may not develop with enough detail to provide the needed evidence.

Health hazards are not present in the fluorescein method. Although the MSDS states that fluorescein is as toxic as luminol, in the reduced and diluted state it is not hazardous. There are no fumes as with luminol and thus it does not require a mask when in use. When an experienced crime scene technician used this method, it was noted that the procedure was as simple, if not simpler than that of luminol, lacked the mask requirement, and because of the extended amount of time of fluorescence, allowed more time for photographs to be taken.

Fluorescein appears to be a valid and suitable alternative to luminol in the detection of latent bloodstains at a crime scene. Although fluorescein lacks some of the properties of luminol, it has advantages that when employed in the right settings could be more beneficial than luminol.

Fluorescein, Luminol, Latent Blood Detection

B54 Fundamental Processes in GSR Formation as Deduced From ICP-AES and SF-ICPMS Experiments

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The goals of this research project are to encourage participants to appreciate the potential of ICP-AES and ICPMS in linking GSR to ammunition parts as well as having a better insight into GSR formation processes.

The fate of residues produced upon firing a gun was investigated, both to obtain a more fundamental forensic insight into the processes

taking place upon firing and as part of a larger project to explore the forensic potential of linking suspects to a crime through material investigations.

Four sample types of Gun Shot Residue (GSR) were studied. They were collected from the cartridge case, the barrel, the target and the residues that exit the chamber via the breech and may cling to the hands of a shooter. Samples were dissolved in dilute nitric acid and Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES) was used to determine the proportion of lead, antimony and barium in each sample. Sector Field - Inductively Coupled Plasma Mass Spectrometry (SF-ICPMS) was used to measure the lead isotope ratios of the different GSR sample types from which the contributions of the two lead sources in our experiments (the bullets and primer) to the different GSR sample types could be determined.

Six primer-bullet combinations were tested: Federal 100, 200 and CCI 500 primers in combination with either almost lead-free bullets (from Dynamit Nobel action 3™ cartridges) or Full Metal Jacket bullets (unspecified brand, containing lead from several production batches). Custom made cartridges were prepared at NFI using a RCBS 'Rock Chucker' press. For each primer-bullet combination five shots were fired and evaluated. Barrels were cleaned between experiments.

For the lead-free bullets, the three primers could be distinguished by using the ICP-AES results (Pb/Sb/Ba proportions) of each sample type (cartridge case, barrel, target, and breech). Highest relative lead concentrations were found in the target samples; lowest relative lead concentrations in the cartridge samples. Discrimination between these primers was even more obvious when their lead isotope ratios were considered, reflecting the different lead isotope ratios of the primers. These results demonstrate the potential of using GSR samples of the same type (especially targets and cartridge cases to discriminate between primers, when, and if, combinations of Pb/Sb/Ba primers and lead free bullets are being compared.

For the lead core bullets, the ICP-AES results were less conclusive than for the lead-free bullets. The Pb/Sb/Ba proportions for the different sample types, within a set of five shots, varied between the five shots. To some extent this behaviour was reproducible for the various sets of firings but it also resulted in some overlap when all the results were combined in one grand ensemble. However, when the lead isotope ratios for a given GSR sample type were considered, it was possible to discriminate between the three primers.

Furthermore, the lead isotope ratios for the primer and lead bullet in two out of the three combinations differed substantially, reflecting the well documented geographical variation in lead isotope ratios. Primer lead isotope ratios were determined by firing a lead free bullet and measuring the lead isotope ratio in the spent cartridge (cartridge sample type). Bullet lead isotope ratios were measured directly on the bullet lead. Since these are the only two sources of lead for GSR formation, the lead isotope ratios in the GSR samples will be linear combinations of the lead isotope ratios of the bullet and the primer. By determining the lead isotope ratios of the GSR samples, the contributions from the primer and the bullet could be distinguished (if the lead isotope ratios of the two differ) and the percentage of lead originating from the primer could be determined for each sample type. For the Fed 100 primer, the percentages of lead originating from the primer for the GSR recovered from the cartridge case, the breech, the barrel and the target are respectively 93%, 82%, 79% and 56%.

These results demonstrate the potential of ICP-AES and ICPMS in linking GSR to ammunition parts as well as providing more insight into GSR formation processes. In casework investigations, the barrel may still be "dirty" from previous shootings. Certain factors, e.g., ammunition with a different chemical and/or lead isotopic composition, may mean this "dirt" influences the composition of barrel and target samples. In a subsequent study, we will investigate these effects and examine a wider range of bullets and primers.

GSR, ICPMS, Lead Isotope Ratios

B55 Analysis of Herbal Preparations for the Presence of Kavalactones

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The goal of this research project is to familiarize forensic chemists with herbal kava products and provide an analytical method for the analysis of kava products.

Kava Kava root is an herbal product that is reported to have anti-anxiety and sedative properties. It has been used as an herbal supplement or medication to treat nervous anxiety, insomnia and restlessness. Kava is available as the dried root material, in tea bags for brewing beverages, and as root extracts for direct ingestion.

Most herbal products that contain Kava are labeled with warnings that state that individuals should use caution or refrain from operating motorized equipment after ingestion. Several cases have been reported in the literature in which individuals that have ingested Kava products have been stopped by law enforcement personnel for investigation of driving under the influence. Roadside sobriety tests indicated that there is some degree of impairment. But when questioned about their activities and whether alcohol has been ingested, suspects have denied the use of alcohol but have admitted to ingesting Kava tea. Subsequent analyses of the appropriate specimens for ethanol have been negative.

The active ingredients in Kava Kava root are listed as kavalactones. Seven major kavalactones can be isolated from kava plant material. Our experiments were designed to test for the relative concentrations of kavalactones in various herbal products as well as tea brewed from several kava sources. Three different kava capsules, three different kava tea brands and one standardized kava extract were tested to determine the concentration of kavalactones present. A standard brewing procedure was developed to produce a brewed tea sample for each of the tea products. The concentration of individual kavalactones in each kava preparation, tea bag or brewed tea sample was calculated by comparing response against purified reference material. Samples were extracted by using a simple solvent extraction of the dried plant material or by using a solid phase extraction procedure for the brewed tea samples. Each extracted sample was analyzed by GC/MS.

Differences in the total amount of kavalactones per preparation were seen when comparing different kava products. There were also variations in the relative ratios of the individual kavalactones per kava source. A table showing the concentrations of kavalactones for each preparation will be shown. A chromatogram showing the separation of kavalactones in a typical kava product extract will be included in the data. Representative mass spectra for the seven major kavalactones will also be shown.

Kava, Kavalactones, Herbal Medicines

B56 A Taxonomy of Errors

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The goal of this research project is to provide the forensic science community with a common set of terminology for use in discussing error analysis of forensic science examinations.

The purpose of accreditation, certification, quality assurance and similar activities in forensic science is to increase reliability, that is, to control errors. In addition, the *Daubert* decision virtually mandates that forensic scientists be able to discuss the reliability of their examinations. In particular, they must be able to express an assessment of the errors involved in an examination whose results are being proffered in court. However, the concept of errors, and in particular, error rates, is not straightforward. And, if a concept be convoluted, the application of that concept almost certainly will be. That indeed is the situation in forensic science.

Taxonomies are purpose generated. In the case of forensic science, most error analysis focuses upon the actual measurements being made in a case. There are two problems with this approach. One, it is discipline specific. For example, procedures developed for chemical analyses are not easily adopted, evaluated or otherwise used in non-chemical analyses. Two, it is too limited in scope. A forensic science examination involves more than just the measurements being performed. This paper develops a taxonomy of errors to overcome those two problems.

The taxonomy is based on the scientific method rather than on a specific discipline. Various authors consolidate or break-down the number of steps in the scientific method according to their particular perspective. A seven-step process is presented with the steps delineated such that a different form of error(s) exists at each step. That is, the scientific method itself is designed to accommodate an error analysis. The scientific method may be used to generate the basic principles upon which examinations are based, or, it may be used to apply those principles in an examination. The seven steps — posit theory, postulate hypothesis, operationalize experimental technique, apply measurement protocol, organize test results, evaluate the results against the hypothesis, generalize the results to the theory — are the same in both basic science and applied science, but the errors differ somewhat.

One way to look at error analysis is as an expression of the uncertainty in an examination. Three types of uncertainty are presented — ambiguity, vagueness, and variation. Their relation to the seven steps in the scientific method — to the two general purposes for examination, identification and explanation, and, to the three general types of forensic science examinations — classification, individuation, individualization — is an integral part of a taxonomy of errors.

Finally, knowing what cannot be calculated in an error analysis is as important as knowing what can be. Forensic scientists do not work in a vacuum. They receive evidence with no guarantees of its integrity and produce analyses for a client/employer with no guarantees of their ethical use. This taxonomy incorporates not only the activities of the forensic scientist but also those of the evidence producers and the evidence collectors. It also incorporates the decisions of the collectors and users of the evidence in addition to the decisions of the examiners of the evidence.

The examinations of a forensic scientist are in the middle of the litigious process. Forensic scientists obviously must be aware of the impact of contamination and other handling errors that may have occurred prior to their receiving the evidence but they are not responsible for calculating an error rate based on them. Likewise, they usually have no control over either the selection of evidence collected at a scene or the selection of the evidence presented in a trial. The bias built into a case due to the selection of evidence either at the scene or in the trial is an ethical concern but cannot be calculated in an error analysis.

Error Analysis, Forensic Science Exams, Taxonomy

B57 A Graphical Approach to Questioned and Known Sample Comparisons of Smokeless Powder

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The goals of this research project are to learn a new approach for the reliable presentation of questioned and known measurements that provides a traditional statistical evaluation as well as a visual graphical presentation of the information.

The “sameness” of questioned and known measurements was compared, providing a known level of certainty for measurements of the organic additive composition of smokeless powder from commercial ammunition.

Forensic scientists are often faced with judging how well measurements on a questioned sample can be associated with one or more known samples. The quality of such judgments relies greatly on proper maintenance of a “database” of measurement results from many different known samples and the experience of the evaluator. In this presentation, we will discuss an approach for evaluating questioned sample / known measurements that graphically represents the probability that all of the measurements belong to one single population as well as providing quantitative estimates of match certainty. This empowers the forensic investigator to present results that are easily interpreted, increasing the evidential value of the measurements.

For this study, the focus was on evaluating the variability of smokeless powder recovered from commercial handgun ammunition. Powder blending, compositional changes of feedstock, and finished powder all conspire to complicate smokeless powder categorization. To address the problem of making reliable associations, the organic additive composition of smokeless powder in commercial handgun ammunition was evaluated. Such compositional measurements have been used as an essential component of the categorization of smokeless powder residues from improvised explosive devices and from handgun use.

The organic additive compositions of cartridge powder taken from all of the cartridges in two boxes of commercial ammunition were examined. The concentration of propellant nitroglycerin (NG) and stabilizers, diphenylamine (DPA), N-nitrosodiphenylamine (NnDPA – a decomposition product of DPA), and ethyl centralite (EC) were determined by an ultrasonic solvent extraction/capillary electrophoresis technique. In previous compositional evaluations, the propellant to stabilizer ratio (P/S) provided a reliable characteristic feature for comparisons of unfired smokeless powders and their associated residues.

Despite possible heterogeneity in powder composition among different cartridges of a single box, the P/S results for both boxes were normally distributed (i.e., described by a Gaussian curve with a characteristic mean and standard deviation). Because a single population existed for each box, classical sampling theory was used to determine the minimum number of samples that would be required to characterize a box of ammunition. Classical statistics indicated that both boxes could be characterized to a 95% confidence level by two to three cartridge measurements. However, to achieve a 99% confidence interval, 34 to 66 measurements were needed. It is not practical to make such a large number of measurements, as the analyst may be limited by the number of known cartridges submitted or the lack of laboratory time available for the evaluation.

It is often important to maximize the amount of information gained from a limited number of questioned and known samples. Monte-Carlo “bootstrap” random resampling uses a limited number of measurements to effectively approximate results expected from a larger sample population. One thousand bootstrap data sets of three, six, or nine cartridge measurements were used to characterize the P/S ratio population within boxes of 50 cartridges, including “virtual boxes” containing cartridges from different powder populations.

In addition to verifying classical statistical information about the compositional measurements, bootstrapping enables visual demonstration of where an analyzed questioned sample falls into the distribution of the known samples to which it is being compared. Quantitative certainty envelopes are easily determined and can be presented at any desired confidence interval. Conversely, it is possible to graphically interpret what percentage of the known population with which a questioned sample measurement is consistent. For example, a single cartridge measurement evaluated from a box of known composition was shown to be consistent with 36% of the population at 95% confidence. Increasing the number of known samples evaluated allows for a larger portion of the population to be included in the confidence envelope. For a sample size of three, one-half of the population can be described with defined certainty; increasing the sample size to nine allows eighty percent of the population to be quantitatively bounded.

Evidential Value, Questioned and Known Comparisons, Monte-Carlo

B58 A Study on the Determination of Engine Oils by Proton Induced X-Ray Emission and X-Ray Fluorescence Spectrometry

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The goal of this research project is to present the identification of absorbed lubricants for victims on the PIXE analysis.

There are many case of absorbed lubricants for a victim's clothing, shoes, gloves, mortal, weapons and tools amongst picking evidences at criminal sites. The analysis of lubricants for their variety and examination for uses or appraisal on identity shall be contributed greatly for the purpose of criminal arrest; and, another appraisal for identity of a suspected vehicle with absorbed lubricants on a sufferer's clothing and other pertinent substances at traffic accident sites shall also be assisted remarkably in order to solve the related case. Therefore, we hereby present this specific thesis upon successful performance (for several years) of the analysis on lubricant's kind by HPLC, TLC, IR, GC, etc.

The samples were analyzed by 2.5 MeV proton induced X-ray emission (PIXE) and X-ray fluorescence Spectrometer. The energy resolution of HpGe detector for PIXE is about 145 eV for the 5.9 keV X-ray of ⁵⁵Mn or ⁵⁵Fe radioactive source; the detector position is about 135° with respect to beam direction to get a better signal/background ratio. The advantages of using PIXE, XRF lies in the fact that the continuous background coming from bremsstrahlung is lower in the case of ion excitation, by a factor of 102 - 103 relative to conventional X-ray or electron excited X-ray fluorescence analysis. The main constituent elements of samples were Mg, Ca, Fe, Zn, Cu, S, Al, Si and P. The species of oil samples can be differentiated by a concentration ratio of elements and a constituent element of each sample.

Lubricants, PIXE, Traffic Accident

B59 Visualization of Fingerprints on Paper Surface—Application of 1,2-Indanedione in Dry State

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The goals of this research project are to familiarize the participants with: (a) the dry-state procedures for the application of 1,2-indanedione, ninhydrin, and 1,8-diazofluorene-9-one (DFO); and (b) the advantages in combining the dry-state approach, 1,2-indanedione, and subsequent metal salt treatment to the visualization of fingerprints on paper.

The effectiveness of 1,2-indanedione in the visualization of fingerprints on porous surfaces has been compared to the well-established ninhydrin and DFO reagents (1-5). In this current study, 1,2-indanedione is synthesized and applied in dry-state to various paper for the visualization of fingerprints. Luminescence enhancement by subsequent zinc chloride treatment is also evaluated.

1,2-Indanedione is stored in filter paper in dry-state by first soaking the paper in 1.0% 1,2-indanedione solution (w/v in ethyl acetate) for five seconds. Filter paper is then removed and air-dried. The test document is sandwiched by two pieces of 1,2-indanedione-treated filter paper. The external sides of the filter paper are further protected by two layers of facial paper. Fingerprint on the test document is developed by applying an

iron on the facial paper. Parameters studied include three temperature settings with or without steam.

The hereby described dry-state application procedure generates excellent results. Higher temperature without steam or mid-temperature with steam produce the best results. Unlike ninhydrin or DFO, subsequent treatment by zinc chloride does not produce intense background color. Furthermore, the final product generates more intense luminescence. Since the dry-state application procedure does not damage the paper or dissolve the ink used in the test document, it is safer than the conventional approaches in which solution is used for application.

1,2-Indanedione, Latent Fingerprints, Development

B60 Characteristics and Trends of MDMA and MDMA-Alleged Samples Seized in Taiwan During the Period of January 2000 - May 2001

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The goals of this research project are to familiarize the participants with (a) the nature and the extent of MDMA/ketamine abuse; and (b) the characteristic and trends of MDMA/ketamine-related seizures in Taiwan during the January 2001 - May 2001 period.

With apparent decline in heroin and methamphetamine abuse, Taiwan is now experiencing an increased use of drugs, especially MDMA, among the younger population. During the Jan. 2000 May 2001 period, law-enforcement agencies have made approximately 554 submissions of MDMA- and ketamine-alleged samples to various forensic laboratories for analysis. The total number of tablets, capsules, and powder doses included in these seizures was approximately 74,427. Samples in all three forms are usually colorful, while tablets are typically with coarse texture and imprints of various designs.

Seized samples were typically photographed, extracted (typically methanol), and then analyzed for MDMA (or other drugs as requested), using GC-MS (full-scan) methodologies. Efforts made to identify the presence of non-requested components vary from laboratory to laboratory. Over-all quality on the identification of MDMA and other identified components is good, although it is possible that a few of these identifications may actually be due to the presence of other structurally closely related compounds. Numbers of seizures and associated doses are summarized in Table 1. These data show the following characteristics:

Frequencies of MDMA and ketamine seizures are definitely increasing from the first quarter of 2000 to the second quarter of 2001, This trend may have resulted from increased police activities which may reflect increased abuse and related events reported to law enforcement agencies.

The large number of doses seized in a specific quarter often reflects one single large seizure. For example, the high number of doses observed for MDMA/caffeine in the first and the 2nd quarters of 2001 are due to two single large seizures (5184 and 2001, respectively).

MDMA seizures often include non-controlled caffeine and other controlled drugs, such as methamine and ketamine.

Table 1. Drugs and drug combinations and the numbers of seizures and doses ^a

Drug combination ^b	01-03/00	04-06/00	07-09/00	10-12/00	01/03/01	04/05/01	Total
MDMA only	4 (14,841)	5 (36)	10 (95)	16 (197)	35 (7,341)	31 (1,777)	101 (22,687)
MDMA/caffeine		1 (21)	6 (27)	8 (32)	13 (5,238)	17 (2,416)	45 (7,734)
MDMA/amphetamines ^{c,d}		1 (13)	4 (20)	8 (35)	9 (19)	8 (31)	30 (118)
MDMA/ketamine ^c		1 (1)	5 (65)	5 (106)	3 (33)	8 (210)	22 (415)
MDMA/amphetamines/ketamine ^c			6 (271)	8 (247)	4 (6)	3 (9)	21 (533)
MDMA/other drug(s) ^e			1 (18)	6 (3,791)	5 (145)	12 (3,954)	
Ketamine only			10 (136)	4 (50)	4 (28)	11 (5,762)	29 (5,976)
Ketamine/other drugs ^f			6 (12)	13 (862)	16 (49)	20 (5,888)	55 (6,811)
Other controlled drug(s) ^g	29 (11,421)	33 (11,910)	20 (268)	17 (119)	7 (51)	38 (576)	144 (24,345)
No controlled drug	18 (380)	19 (638)	18 (263)	21 (334)	9 (85)	10 (154)	95 (1,854)
Total	51 (26,542)	60 (12,619)	85 (1,157)	101 (2,000)	105 (12,957)	151 (15,368)	554 (74,427)

- ^a Numbers shown inside parentheses are total doses in the associated seizures.
- ^b Low levels of syntheses by-products (or precursors) are not considered drug combinations.
- ^c Some of these samples also include caffeine.
- ^d A few cases involving MDA (instead of MDMA) are included in this category. Methamphetamine is the most common amphetamine included in these cases.
- ^e Cases including amphetamines, ketamine, benzodiazepines, and caffeine are included in the above categories; thus, they are excluded from this category. Examples of other drugs are heroin: 1 (3684) (also include methamine in this case); acetaminophen: 3 (4; also include caffeine in these cases), etc.
- ^f Excluding MDMA or MDA, but including other amphetamines.
- ^g Included in this category are: Flunitrazepam: 22 (4,217); LSD: 4 (269).

MDMA, Ketamine, Taiwan

B61 Studies of the Contamination Deriving From Embedding Media on the Examination of Automotive Paints With Micro/FTIR

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The goals of this research project are to familiarize the participants with the interference factor affecting the examination of trace automotive paints with micro-fourier transform infrared spectroscopy (Micro/FTIR). This current study is placed on (1) selection appropriate embedding media for intact paint chips consisting of multiple layers; (2) comparing variation of the interference deriving from embedding media for intact and smear samples.

The limited samples were often embedded and microtomed a thin film without the risk of losing them. An ideal embedding medium should be free from interference when it is used for the mounting purpose. In the study, seven embedding methods including Spurr's kit, acrylic, polyester, water-soluble, cyanoacrylate, fast epoxy adhesive, and wax types were used in parallel for the comparison purpose. Six intact paints (three original and three refinish paint chips) were provided by the automotive repair shop. Smear samples were scraped from the outer surface of each intact paint chip with a # 11 surgical blade. Intact and smear samples were mounted with seven embedding methods, microtomed 5µm film, and pelleted using KBr crystal just like sandwich-mode structure. A Jasco Micro/FTIR system under transmission mode was performed to investigate the cross-sections layer by layer and evaluate the distribution of interference.

Acrylic, polyester, and water-soluble types were found to have inferior effectiveness with serious interference to most samples. Spurr's kit and cyanoacrylate embedding media interfere with some samples no matter what the individual layer or intact paints are. Neither of them is admissible because of "chain-of-custody" consideration. Fast epoxy adhesive and wax types are the most effective to all intact samples without interference. Some resulting data are shown in Table 1. Whether the samples are intact or smear states, they are found to seriously interfere with acrylic, polyester, and water-soluble type embedding media. Spurr's kit and cyanoacrylate embedding media could interfere with some of the intact samples. However, an unexpected observation is found that embedding media (Spurr's kit, cyanoacrylate and wax) have no interference with intact samples, but with the smear samples, they do. This phenomenon shown in Fig. 1 indicates that the incompact structures of smear paints might be soaked into embedding medium due to shrinkage upon curing. Fast epoxy adhesive appears most effective to all samples without interference.

Table 1. Comparisons of seven embedding media having interference with intact paint chips.

Embedding Media	Layers in intact refinish paints						
	Clearcoat of # Brown	Basecoat of # Brown	Clearcoat of # Purple	Basecoat of # Purple	Topcoat of # White**	Surfacer of # White	Primer of # White
Spurr's Kit	O*	O	O	O	X	O	O
Acrylic	X*	X	X	X	X	X	X
Water-soluble	X	X	X	X	X	X	X
Polyester	X	X	X	X	X	X	X
Cyanoacrylate	X	O	O	O	X	O	O
Fast Adhesive	O	O	O	O	O	O	O
Wax	O	O	O	O	O	O	O

* "O" indicates no interference, and "X" indicates interference with embedding media. ** # white is the solid paint having no clearcoat.

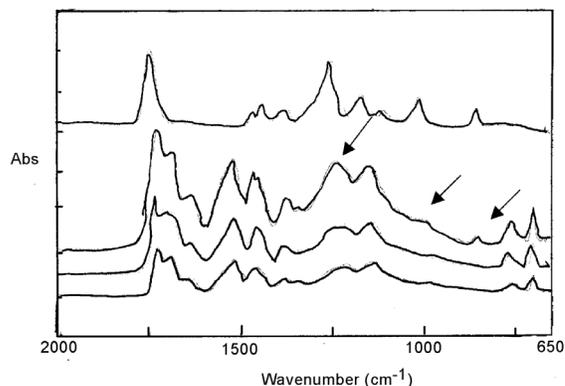


Fig. 1. Comparison of infrared transmittance spectra obtained from cyanoacrylate embedding medium (top), smear clearcoat of #Purple refinish paint embedded with cyanoacrylate medium (second from the top), intact clearcoat of #Purple refinish paint embedded with cyanoacrylate medium (third from the top), intact clearcoat having no embedding medium (bottom). The arrow mark indicates that bands of contamination of the embedding medium add into the IR bands of the #Purple clearcoat.

Embedding Method, Automotive Paint, Micro/FTIR

B62 Identification of a Bullet by Superimposing Photographic and Radiographic Images: A Case Study

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The goal of this research project is to show participants that radiographic images of bullets can be used in "bullet identification."

In this case, the radioopaque image of a highly deformed bullet was superimposed on the photographic images of the suspected bullets.

In recent years, due to the progress in computer capabilities, advanced imaging and image editing techniques have been widely used in most fields of forensic sciences. Various kinds of photographic superimposition techniques are also used for forensic purposes. It's considered that combined uses of imaging instruments can be useful for evaluating the evidence in criminal cases.

VSC 2000 Video Spectral Comparator (Foster+Freeman) is such an equipment used in forensic document examination since it has various capabilities of imaging and comparison. The software which comes with VSC 2000 allows applying photographic superimposition on any images.

Sony DXC-950P CCD Camera mounted on Leitz comparison microscope is an equipment which allows controlled magnification and photographing of bullets, cartridge cases, or any parts of guns used in firearms examinations.

By this case, it's studied to identify the substances which form radioopaque images in radiograms by using superimposition methods. As a result of a confusion occurring during an investigation period, there were 3 bullets to be asked which one is surgically removed from victim's body. After establishing that there was no available biological material for DNA analysis on the bullets, they were sent to the Physical Examinations Department with the medical records of the victim including radiograms of the wounded body part. Radiograms were taken with two different angles of the left forearm. Photographs of suspected bullets were taken with Sony DXC-950P CCD camera in the same positions as the images on radiogram of left forearm of the victim. By using VSC-2000 Video Spectral Comparator, images of each of these photographs were captured and magnified to the same dimensions with the image on the radiogram, and then they were compared by superimposing the two images. It was proved that one of the bullets had the same shape with the one on the radiograms.

When investigating a criminal case, all evidence should be separated and recorded with great care. When bullets or cartridge cases are recovered, they too must be handled carefully and labeled for identification. When marking a bullet, extreme care must be taken so as not to destroy any trace evidence on it. In our case, although the bullet is removed from the victim's body, it appears to be a wrong action not to handle and record the bullet properly. This neglect then caused a complex problem in identifying the bullet, because of recovering two other bullets in the crime scene. Unfortunately these two bullets have not been handled and recorded with an adequate care either.

At the final stage, it was a chance to have the radiograms of the wounded body part taken after the injury, so it could be possible to compare the bullet images with the images on radiograms. The highly deformation of the bullet with its specific figure was an advantage in identification.

Sometimes, restricted or faulty investigation obliges examiners to look for different methods for evaluating evidence. Although it's not a common technique of identification in firearm and ballistic examinations, in this case, photographic superimposition of radiographic image of the deformed bullet with the photographic images of the suspected ones helped in making a conclusion. Also, it's thought that this method could be used in comparison of unremoved foreign objects proved in radiograms before being buried, with the foreign objects recovered from buried and/or decayed bodies.

Bullet, Radiogram, Superimposition, Imaging

B63 Forensic Analysis of Cartridge Fragments by FTIR and Raman Microspectroscopy in a Case of Murder

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The goal of this research project is to show that even minute plastic fragments can become fundamental in solving a murder.

The authors describe an unusual case of murder committed with the use of a revolver calibre .38 special, loaded with CCI shotshell ammunition, usually classified as "non lethal" because of its minimum energy. They illustrate the methods used to identify the cartridges and the analytical techniques used to prove that these could be attributed to a weapon found on a suspect.

An external examination revealed an entrance perforation caused by a firearm just below the victim's left cheekbone. X-rays revealed the presence of small radiopaque pellets in the left maxillae and facial soft tissues, but no penetration in the skull. The autopsy proved there were no fractures in the cranial base nor brain lesions. The death was to be attributed to aspiration of blood from the palate and pharynx. Lead pellets, blue plastic fragments and a small plastic wad were found in the track of the wound. These exhibits were at first considered compatible with CCI shotshell ammunition.

Investigations were concentrated on a criminal wanted for robbery who was found with a revolver calibre .38 special. The weapon was impounded and examined: it had been recently cleaned and lubricated, but inside the first section of the barrel two minute particles were found which were very similar in consistency and colour to the two plastic fragments found in the victim's skull.

After the preliminary analyses with the comparison microscope, the plastic fragments were examined by means of FTIR and Raman Microspectroscopy, in order to identify their composition and measure their colour. The same analyses were carried out on experimental samples obtained after firing several CCI-SPEER cartridges belonging to the same type as the exhibits. The analyses proved that the fragments were fully compatible and it could be concluded that the plastic fragments found inside the revolver barrel belonged to the same type of ammunition used to kill the victim; moreover, it could not be excluded that they all came from a single cartridge. After reading the technical report, the suspect was asked to talk on the first day of the trial and he decided to co-operate and confess to the murder. He had understood that the scientific investigations had definitely implicated him.

This case is the only one, in Italy at least, in which a so-called "non lethal" cartridge was used to commit a murder, and, it proves how even minute plastic fragments, only a few millimetres big, can become fundamental in solving a serious crime.

Microspectroscopy, FTIR, RAMAN

B64 The Use of Image Processing for the Analysis of a Ring Print in a Case of Murder

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The goal of this research project is to present the development of digital image processing in analyzing elementary cutaneous lesions found during the forensic investigation for a murder Digital Image.

The case refers to a victim who had been assaulted and killed and whose body was found in the victim's garden. The autopsy revealed four stab wounds in the trunk; one had penetrated in the pleural cavity with massive hemothorax. The victim's wife told the investigators that she had heard her husband shout and had called for help at once.

A more accurate examination of the body revealed a hollow patterned lesion on his back, not far from the wound; this mark was rather difficult to interpret. At the end of the preliminary investigations, doubts were raised on the wife's innocence: she was suspected of being involved in the murder, and it was hypothesised that the lesion found near the wound had been caused by one of her rings.

Technical investigations were then concentrated on one of these rings, as it had a very peculiar shape. Different impressions were taken on different materials, such as on wax and on corpses' skins, in order to reproduce experimentally the lesion found on the victim.

The ring was then compared both with the experimental prints and the lesion found on the corpse by means of digital image processing techniques, and a full correspondence was confirmed.

The way the lesion was produced is still under debate, but it seems that the woman held her husband firmly down to the ground pressing hard on his back to stop him calling for help. Still debated are also the role of the thickness of the subcutaneous fatty tissue, the cooling of the body, and the methods used to compare the lesions, together with the possibilities offered by image processing, in order to prove such an extraordinary compatibility with the ring factor which greatly affected the outcome of the trial.

Digital Image Analysis, Pathology, Murder

B65 Ecstasy in Hong Kong

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The goal of this research project is to report the recent trend of Ecstasy seizures in Hong Kong, accompanied by a study on the analytical profiles and physical features of Ecstasy tablets which may provide invaluable information for law enforcement departments in tracing the source of the tablets.

Ecstasy is a street name originally designated for 3,4-methylenedioxymethamphetamine (MDMA). Nowadays, the term Ecstasy is used more loosely, so that what is being sold as Ecstasy may not contain MDMA but a combination of amphetamine group of drugs. Ecstasy was first encountered in Hong Kong in 1993. In the past, its use was confined mainly to expatriates in relatively small rave parties. However, it has been widely abused nowadays in local discos, nightclubs and karaoke bars by young adults. In 1995 the Government Laboratory received 27 Ecstasy tablets in 8 cases. However in 1999, 21,223 tablets were seized in 171 cases. The figures in 2000 showed a booming increase of a 180-fold in case number (i.e., 1,470 cases) and a 14,000-fold increase in quantity (i.e., 386,490 tablets) as compared with those figures in 1995. Based on the colors and markings, more than 120 types of Ecstasy tablets have been submitted to the Government Laboratory. Prior to 1999, the compositions of most of the Ecstasy tablets were rather simple. They normally contained a single active ingredient such as MDMA, 3,4-methylenedioxyamphetamine (MDA), N-Methyl-1-(1,3-benzodioxol-5-yl)-2-butanamine (MBDB) or 3,4-methylenedioxyethylamphetamine (MDEA). Occasionally, tablets containing a mixture of MDMA and MDEA were also found. However, the compositions of the Ecstasy tablets showed a change after 1999; the contents of the tablets became more complex and additives in various combinations were found. Among these, ketamine, caffeine, phenobarbital and diazepam were the most common additives. Although a wide variety of markings and colors on the tablets were found, different markings, in general, share common characteristics in terms of chemical compositions. These characteristics will be discussed. Based on

the types of amphetamines found, 4 groups of Ecstasy tablets can be classified: (i) MDMA and additives and/or impurities, (ii) Methamphetamine (MA) and additives and/or impurities, (iii) MDA and additives and (iv) amphetamine and additives. The most common markings on the tablets seized locally are those with "P", "CC", "CU" and "HQ".

Occasionally, some MDMA tablets were found to contain 1-(3,4-methylenedioxyphenyl)-2-propanone (MDP2P), 1-(3,4-methylenedioxyphenyl)-2-propanol (MDP) and/or 3,4-methylenedioxy-benzylamine (MDB) as impurities. The identities of MDP2P and MDP, and MDB were unambiguously confirmed by GCMS. MDP2P is a precursor chemical commonly used in synthesis of MDMA while the detection of MDP and MDB is quite peculiar as it is neither a product, a starting material nor an intermediate. The existence of MDP and/or MDB could be explained through the respective reductive amination of MDP2P and piperonal in the presence of appropriate reductant (e.g., sodium cyanoborohydride during the synthesis of MDMA). These impurities found in the tablets could serve as important information to trace the possible synthetic route of MDMA.

In the past, MDMA found in the tablets was in the hydrochloride form. Recently some of the tablets contained MDMA in phosphate form. Identification or confirmation of the phosphate can be carried out using the ion test, FTIR and electrospray ionization-mass spectrometry (ESI-MS). In Hong Kong, the law requires that the pure weight of amphetamines in the tablets be reported. As the ecstasy tablets are not proprietary products, their compositions are often complex and unpredictable. A brief discussion on the methodology used in the quantitation of amphetamines employed in our Laboratory will be presented.

Ecstasy, MDMA, Drug Trend

B66 Ultraviolet Spectroscopic Characteristics of Textile Fibers

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The goal of this research project is to learn about the UV spectroscopic characteristics of various fiber substrates to aid in their identification.

Many textile fiber substrates have their own ultraviolet spectral characteristics. This is in addition to the UV spectral characteristics of the fiber dyes. The purpose of this paper is to discuss the UV spectral characteristics of some of the more common textile fibers.

Microspectroscopy, Ultraviolet, Fiber

B67 Comprehensive Approach to Determine the Absolute Detection Limit for Organic Compounds in a Standard Accelerant Mixture Between GC/MS and GC/MS/MS

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This presentation will describe a comprehensive approach to optimize the operating procedures of GC/MS and GC/MS/MS for the analysis and identification of ignitable liquid residues, to determine the absolute detection limits for the widely used GC/MS method and a proposed GC/MS/MS method for the organic class of compounds in a standard accelerant mixture (SAM).

The authors and other workers have optimized the extraction parameters and analytical schemes involving GC/MS and GC/MS/MS for the analysis and identification of ignitable liquid residues. The results of this

study will focus on the optimization of the operating parameters of GC/MS and GC/MS/MS and the use of GC/MS/MS as a method to improve the selectivity of the identification of ignitable liquid residues.

The fragments and molecular ions that result from the sample can be stored in an ion trap and subjected to further fragmentation within an MS/MS experiment. This approach can improve the selectivity and the identification of ignitable liquids over GC/MS alone by improving the differentiation (and subsequent identification) of the target compounds of interest from co-eluting pyrolysis compounds within a fire debris sample.

The first part of this study is devoted to the optimization of the operating parameters for the GC/MS and GC/MS/MS experiments by using standard mixtures of analytes of interest. The standard mixture contains an alkane series from the even-numbered normal alkanes (ranging from n-octane through n-eicosane) and the following aromatic compounds: benzene, methylbenzene (toluene), m-xylene, o-xylene, p-xylene, ethylbenzene, 1-methyl-2-ethylbenzene (cumene), 1-methyl-3-ethylbenzene, 1,2,4-trimethylbenzene, 1,2,3-trimethylbenzene, p-cymene, 3-ethyltoluene, 1-methylnaphthalene, and 2-methylnaphthalene. The second part of the study is aimed at determination of the limits of detection for the organic compounds in the standard accelerant mixture for both GC/MS and GC/MS/MS methods.

Additional work will involve studying ion-molecule interactions within the ion trap detector in order to best identify and characterize those compounds that are characteristic of ignitable liquid residues and of pyrolysis products found in scene debris and from other sources.

Ignitable Liquid Residues, Fire Debris Analysis, Ion Trap Detector and MS

B68 Elemental Profiling of Forensic Glass by ICP-MS: Analysis of a Case

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After attending this presentation, the participant will learn about the use of ICP-MS for the elemental profiling of glass samples illustrated with the results obtained in an actual case.

The importance of glass evidence in forensic investigations has been recognized and studied for some time. Measurements of physical characteristics, such as thickness, density and color, and, optical characteristics, such as refractive index, are commonly used to compare recovered pieces to a known source or sources. Advances in the glass industry, including a rigorous quality control, limit the discriminating power of the mentioned measurements and have led to a need for the development of instrumental techniques for the elemental analysis of glass fragments that provide better discrimination between samples.

In previous work, the authors have presented the results from different studies that evaluated ICP-MS as an analytical technique for elemental profiling. The results of these studies identified the elements that were good discriminators for a selected float glass population. An element was determined to be a good discriminator if there were large variations of its elemental concentration among different glass samples but small variations of its concentration for repeated measurements on the same glass sample. Another study addressed the optimization, standardization and validation of a method for the analysis of small glass samples (~ 2 mg) using an external calibration and a multi-elemental approach. The method considered the limitations of the instrumental technique and the sample preparation protocol, including challenges in the dissolution of the glass. The most important of these limitations in ICP-MS is the inability to com-

pensate for the matrix effects observed in glass samples, when concentrations of some elements reach very high (percentage) values. The second part of that study incorporated the use of isotope dilution to overcome the limitation of matrix effects. In isotope dilution, a non-common isotope of the element is used as an internal standard by spiking the sample with it in order to reduce the mass bias effects common in ICP-MS, as well as the matrix effects for the high concentration elements. Improved precision and accuracy are obtained, and the sensitivity increases due to the increase of concentration during the addition of the spike.

This study addresses an actual case in which a subject breaks the glass of 15 cars in a parking lot in order to gain entry. A total of 17 known samples representing the windows on the cars, 14 pieces recovered from the police patrol and 28 pieces recovered from the outer garments of the suspect were submitted for analysis. The samples were first separated by color (with the naked eye), and the refractive index (RI) was measured for each of them. Using our external calibration /internal standard ICP-MS method, the concentrations of 16 elements were measured for all but 3 samples. Color assessment separated the 17 known fragments into 2 distinct groups, RI measurements resulted in 5 distinct groups and elemental analysis differentiated all the known samples from each other. The matching recovered samples were related to individual vehicles and the summary of the results are reported.

Trace Element Analysis, ICP-MS, Glass Analysis

B69 Data Management in Forensic Fire Debris: An Inexpensive Solution With MS Access©

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The goal of this research project is to provide a working knowledge of MS Access©. Attendees may use the presented information to develop a similar database template for their specific needs.

A database template has been developed for a low cost, off-the-shelf office application to incorporate and follow many elements of significance to forensic fire debris analyses.

This database template offers a means of following case demographics, evidence receipt and disposal, results and casework activities in MS Access©. This database template offers a means of reporting findings and retrieving results in a searchable dialog format that can be operated from a single desktop or laptop computer or a networked server. This database template does not link to nor does it import raw data from instruments. Rather, it is a low-cost manual data entry alternative to a full LIMS that includes the following features:

- Case demographics including case type, subject/suspect age and dates received and reported
- Submitting individual and agency address and case identification
- Evidence inventory including specimen type(s), containers, condition, source and dates received and disposed
- Results of individual analyses for individual specimens including analytes, methods and footnotes
- Casework activities expended in completing individual cases
- Technical and administrative review documentation
- Report generation
- Periodic caseload and activity reports
- Searchable result queries

Use of this database template requires that MS Access©97/2000 be installed in a Windows© 9x/NT environment. Prior versions of MS Access© or Windows© have not been investigated. A switchboard format serves as the user interface and minimal working knowledge of MS Access© is necessary to enter data and generate pre-formatted reports. Data entry forms include pull-down menus and "auto-fill" capabilities to limit choices for data fields and to reduce typing and typographical errors.

A significant working knowledge of MS Access®, but not of Visual Basic®, is necessary to make additional choices in pull-down menus available to the user or to create or modify tables, queries, forms or reports.

The laboratory system for which this database template was developed is a state law enforcement agency that accepts a large variety of evidence from a myriad of entities including State Fire Marshals and local, county and other state law enforcement agencies. Upon receipt of a case, the user enters demographic information and creates an evidence inventory. The user enters results upon completion of the analyses, then generates a summary report containing the evidence inventory and analytical results for technical and administrative review. Following the review, the responsible scientist/supervisor then enters a report date and generates the final report.

The user has the option, upon entering results, of whether to report them. This allows the laboratory to maintain a result for in-house or statistical purposes, but not necessarily for reporting. Evidence that is maintained in inventory will appear on an inventory report until such time as the evidence is disposed or returned and the user enters a disposition date for that evidence. A record of this evidence remains associated with the relevant case. The user may enter the individual laboratory tasks expended in completing a case, thereby allowing the laboratory to follow casework activities. Periodic reports include the cases completed as well as the expended activities. The user can also search for results based upon single or multiple selection criteria.

Database, Results Management, Evidence Management

B70 Gasoline Comparisons by Gas Chromatography-Mass Spectrometry Utilizing an Automated Approach to Data Analysis

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The goal of this research project is to understand how to implement a gasoline comparison method as part of a fire debris analysis laboratory, and how to utilize common software to automate most aspects of the technique.

Research in the late eighties demonstrated that comparisons of gasolines can be conducted, and that the finding of similarities in the compositions of gasolines may be meaningful in determining a potential common origin.^{i,ii} The work conducted by Mann, however, required substantial data processing by the analyst, and was fairly labor intensive in that aspect. This work utilizes many of the same principles originally presented by Mann, and was designed to determine the following: (1) Will these types of comparisons demonstrate meaningful discrimination amongst reformulated gasolines? (2) Can the data analysis be automated so as to simplify the process? (3) Are there particular components of gasoline which are better for comparative purposes than others? (4) Can a GC-MS be effectively used? and (5) Can gasoline additives be a useful discriminating feature in the comparison of gasolines?

It was hypothesized that, by careful selection of components, gasolines could be distinguished as having originated from different sources based on comparisons of sequential peak ratios. The use of sequential peak rationing has been validated, and involves comparing the abundance of one peak to the next eluting peak. This method of component comparison is used in order to minimize the potential effects of unequal states of evaporation amongst samples. Selecting the peak-pairs to be incorporated into the comparison method required that the ratios selected must be reproducible within a sample, and that they be useful in discriminating samples from different sources. It was determined that the analysis of additive packages would not be useful in a typical forensic examination

due to the low concentrations present, and the typical volumes recovered in forensic casework.

Gasoline samples were analyzed via gas chromatography-mass spectrometry. This data was then processed through a target compound program, which integrated and tentatively identified compounds of interest. The abundance values used in the ratio process were not total abundance values, but rather base peak abundance values. It is recognized that without quantitation via an external calibration chart, these values will not be useful for actual quantitation of an individual component. However, these values can be reproduced with precision, and are useful indicators of abundance. Approximately 87 peaks were initially loaded into the Hewlett-Packard Chemstation software® for target compound determination, based on retention time, base peak and qualifier ion. From this software, data regarding retention time and base peak abundance for each of the target compounds could be exported into a Microsoft® Excel template, which automated the data processing portion of the comparison. The template includes calculations of sequential peak ratios, calculation of average peak ratios and their standard deviations for replicate runs, and automates the creation of a series of graphs that may be used as a summary of the comparison results.

Utilizing data from several different gasoline samples, including multiple runs of individual gasolines, and weathered samples from known gasolines, data from the list of potentially useful target compounds was examined. Peak-pair ratios were eliminated if they were not reproducible within multiple runs of a single sample, or if they were not reproducible within a set of evaporated samples (up to 50%) from a single source. This step was necessary in order to insure that the comparison method would not falsely exclude samples having a common origin based solely on differences in states of evaporation or due to inconsistent integration of poorly resolved peaks. The list of potentially useful target compound peak-pairs was then further reduced based on their ability to distinguish gasolines from different sources. A final set of 20 peak pairs was selected for use in the comparison method.

Gasoline samples from greater than 30 different sources were run through this method, and compared to one another. In addition, 11 of these 30 samples were evaporated to 25% and 50% weathered conditions. Utilizing the instrument's custom reports software in conjunction with user-created spreadsheet templates, data from samples can easily be compared. Using this method, all evaporated samples were correctly matched to their source. In addition, of the 30 gasolines tested, the vast majority could be distinguished from one another and a series of blind samples were correctly matched to their corresponding source gasolines.

The utilization of the autosampler, in conjunction with automatic data processing, makes not only the comparison process easier, but also the process for validating peak selection. By incorporating user-created templates, one can present data graphically and therefore make the process much easier to understand.

Gasoline Comparisons, Arson, GC-MS

B71 A Computer Assisted GC-MS Method for Identifying Flammable Substances in Fire Debris

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The goal of this research project is to present to the fire debris examiner two computer assisted methods for aiding in the interpretation of complex GC-MS data.

GC-MS analysis of fire debris frequently results in confusing chromatograms with hundreds of peaks. In addition to those originating from added flammable liquids, many of the peaks are the result of the pyrolysis

of fabrics, plastics, and other interfering materials. Checking the spectrum of each peak becomes a tedious and time-consuming project for the forensic analyst.

A combination of two computer search programs was used to assist the examiner in identifying the residue of any flammable substances that are present in the debris. The method involves both a pattern recognition and a target compound search using the Agilent Technologies' MSD Productivity Chemstation software (version B.01.00).

The pattern recognition program compares the "fingerprint" generated from the case sample to those in a data set of standard flammable substances. This data set consists of various flammable substances commonly encountered in arson cases. A list is generated of the five most likely substances based on the comparison between the data generated from the case sample and that of the standards in the reference data set. The standards are in both the unweathered state and in known stages of evaporation.

The second search program requires that the gas chromatograph be "retention time locked" (RTL) on a specific qualifying compound – in this case 1,2,4-trimethylbenzene. The screener searches for compounds based on the retention time and ion abundance ratios of peaks in the case sample and compares them to compounds in the custom library. The compounds loaded into this library are the target compounds expected to be present in the various classes of ignitable liquids.

These two search programs provide the analyst with valuable preliminary information from which to begin the evaluation of the GC-MS data generated for a particular fire debris sample.

This poster session will explain how to set-up and utilize these programs and graphically illustrate examples of how they can be used to identify any volatile liquid residue which may be present in the fire debris sample.

Fire Debris Analysis, GC-MS, Flammable Substances

B72 The Use of SPME in the Recognition of Hydrocarbons in Cases of Arson

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The goal of this presentation is to show the advantages of the use of SPME techniques for the analysis of arson evidence.

The analysis of arson residues is a very delicate investigation for the forensic chemist, as it aims at the recognition of some characteristic substances of inflammable liquids within a rather complex matrix. The task is even more difficult when the chemist must analyze the exhibits from a burnt-out car, as in this case, including traces of asphalt, which contain oil derivatives.

Two different methods have been used in preparing and analyzing samples in GC/MS: charcoal extraction and analysis with a quadripolar HP 5970 having a 50m HP-5 MS tube; and, solid phase microextraction (SPME) and analysis with a GC ThermoQuest mod8000 Top, interfaced with a GCQ ionic trap spectrometer having a 26m HP-5MS tube.

The results obtained with the first method were also analyzed with the use of special software, designed and overhauled by staff of the Forensic Science Lab of Parma: this software can produce a "fingerprint" of the hydrocarbons, as it can monitor simultaneously 49 different components belonging to the most common fuels.

The results led to the identification of the type of fuel used in the arson, separating it from the hydrocarbon components of the matrix. While only a few traces were highlighted with the charcoal extraction and were therefore difficult to recognize, thanks to the SPME, the presence of methyl-napthalenes was definitely ascertained.

SPME, Hydrocarbons, Arson

B73 Forensic Identification of Explosive Oxidizers by Electrospray Ionization-Mass Spectrometry (ESI-MS)

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The goal of this research project is to present the forensic community with a novel method for identification of inorganic oxidizers in post-explosion residues.

Inorganic salts have been used extensively as oxidizing agents in various explosive mixtures. Nitrates are used as oxidizers in many commercial explosives, such as dynamite slurries, emulsions and ammonium nitrate-fuel oil (ANFO). Nitrates, chlorates and perchlorates are constituents of a variety of flash powder compositions. Sulphates, carbonates and nitrates are used in black powders. Some of these compounds have been used in improvised explosives as well. Therefore, their unambiguous identification is of major significance in forensic analysis of the post-explosion residues.

Presently, ion chromatography (IC) and X-ray powder diffraction (XRPD) are used for forensic identification of these oxidizers. However, in IC, the positive and negative ions in each oxidizer are analyzed separately on a cation and an anion column, which in some cases makes the identification of the oxidizer as one entity doubtful. X-ray diffraction requires a relatively large amount of material, which in post-explosion residues is not always available.

Being nonvolatile, the inorganic salts are not amenable to the traditional gas chromatography/mass spectrometry. Subsequently, in order to develop an analytical method for the unambiguous identification of these oxidizers in post-explosion residues, we have explored the possibility and feasibility of the electrospray ionization-mass spectrometry (ESI-MS). ESI-MS is a "soft" ionization technique where ions in the liquid phase in the analyte solution are transformed to gas-phase ions by a process of generating highly charged droplets at atmospheric pressure followed by "ion evaporation."

A group of 12 inorganic oxidizers was selected in this study, which included ammonium nitrate, ammonium picrate, ammonium sulfate, potassium sulfate, potassium nitrate, potassium chlorate, potassium perchlorate, ammonium perchlorate, sodium nitrate, sodium chlorate, sodium perchlorate and calcium nitrate.

The mass spectrometric measurements were carried out on a Thermo-Finnigan LCQ_{DUO} LC/MS ion trap mass spectrometer. Standard samples, dissolved in methanol-water (50:50), were introduced into the mass spectrometer through a syringe pump at a flow rate of 5 μ L/min and the full scan mass spectra (mass range 1000–50 amu) were recorded in both positive- and negative-ion modes.

Results showed that for some of the investigated compounds such as ammonium nitrate, the temperature of the heated capillary was a critical parameter. Only at 70–150°C, in the positive-ion mode, could the cluster ions containing the intact molecule be formed. In contrast, other inorganic salts yielded cluster ions in both positive- and negative-ion modes in a wide range of the heated capillary temperatures (70–220°C). In addition, tandem mass spectrometry with collision-induced dissociation (MS/MS–CID) helped further validate the identity of some ions. In some cases, the isotopically labeled compounds were used to confirm the suggested ion compositions.

Cluster ions that provided positive recognition of the presence of the inorganic salts included ions such as $[(\text{NH}_4\text{NO}_3)\text{NH}_4]^+$ of ammonium nitrate, $[(\text{NH}_4\text{HSO}_4)\text{NH}_4]^+$ of ammonium sulphate, $[(\text{K}_2\text{SO}_4)\text{K}]^+$ and $[(\text{K}_2\text{SO}_4)\text{KSO}_4]^+$ of potassium sulphate, $[(\text{KNO}_3)\text{K}]^+$ and $[(\text{KNO}_3)\text{NO}_3]^+$ of potassium nitrate, $[(\text{NH}_4\text{ClO}_4)\text{NH}_4]^+$ and $[(\text{NH}_4\text{ClO}_4)\text{ClO}_4]^+$ of ammonium perchlorate, $[(\text{NaNO}_3)\text{Na}]^+$ and $[(\text{NaNO}_3)\text{NO}_3]^+$ of sodium nitrate, $[(\text{NaClO}_3)\text{Na}]^+$ and $[(\text{NaClO}_3)\text{ClO}_3]^+$ of sodium chlorate, $[(\text{Ca}(\text{NO}_3)_2)(\text{CaNO}_3)]^+$ and $[(\text{Ca}(\text{NO}_3)_2)\text{NO}_3]^+$ of calcium nitrate.

The validity of the method has been demonstrated by analyzing some commercial explosives containing one or more of these oxidizers.

Electrospray ionization-mass spectrometry allows the characterization and identification of the investigated inorganic salts as integral cluster ions. This technique, which is very simple and fast, and needs only a benchtop LC/MS mass spectrometer, can be applied in identifying inorganic oxidizers in the post-blast debris.

Electrospray Ionization-Mass Spectrometry, Oxidizers, Clusters Ions

B74 The Smell of Money

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The goals of this research project are to discuss the detection of large amounts of U.S. currency illicitly moving in commercial shipping channels.

In July of 2000, then Attorney General Janet Reno was briefed by members of the FBI's Financial Crimes Section in the area of money laundering. She was surprised to learn that those laundering money on an "industrial" scale often send whole crates of currency in commerce. She subsequently telephoned Dr. Donald Kerr, then Director of the FBI Laboratory, to inquire as to whether the Bureau laboratory fielded any instrumentation capable of interrogating a container in commerce to ascertain whether it contained a large amount of currency. As such a capability was not among the Bureau's mobile laboratory capabilities, the assignment to pursue this technology was assigned to Special Agent (SA) Jourdan.

In selecting a technical avenue of approach to an investigation of this kind, SA Jourdan considered micro-impulse radar (imaging the inside of the container), magnetic susceptibility (the black ink in U.S. currency contains iron), and volatile organic compound (VOC) identification, settling on the latter, surmising that the "smell of money" was the most likely currency parameter to pursue given a desire to use commercial-off-the-shelf (COTS) technology to as great an extent as possible. Thought was given to the training of canines to alert on money, however, in that: (1) the U.S. has more than 400 ports of entry/exit, and (2) canine/handler teams have finite fatigue/attention spans and duty hours, a portable instrument approach was deemed to be more feasible. The canine approach would of course have been additionally complicated by the fact that people routinely carry at least modest amounts of currency around with them.

Recognizing also that this endeavor was by and large an interdiction task, which is not generally a mission of the Bureau, SA Jourdan contacted the U.S. Customs Service, suggesting a collaborative venture. He was eventually introduced to Dr. Trang Vu of their research laboratory, who interestingly enough had already done some groundbreaking work in the identification of the volatiles associated with U.S. currency. By this time, SA Jourdan had done some remedial work as well, having collected air samples at various stages of the process of printing money at the U.S. Bureau of Engraving and Printing in Washington, D.C., which had then been sent to Professor Donald Blake, of the Rowland/Blake Research Group (specialists in atmospheric chemistry) at the University of California, Irvine. A list of compounds identified had been prepared.

Comparison of the two sets of data in March of this year resulted in the authors' selecting eight VOCs, five aldehydes (hexanal, 2-hexenal, heptanal, 2-heptenal, and octanal), one cyclic ether (2-pentyl furan), one alcohol (1-heptanol), and one carboxylic acid (pentanoic), as potentially being characteristic of new and circulated U.S. currency.

Instrument development is being pursued along two lines. Dr. Brian Eckenrode, of the FBI Laboratory's Research Unit at Quantico, is pursuing solid phase micro-extraction (SPME) coupled with ion mobility spectrometric (IMS) detection using a portable Bruker RAID instrument. At the same time, Dr. Kevin Linker, of the Sandia National Laboratory, is

pursuing the detection of the targeted species using a pre-concentrator of Sandia design, the "Hound," coupled to an ION TRACK Instruments (portable) VaporTracer unit, which employs a variant of the IMS technology.

Envisioning a wider application for the technology in development than just the search for secreted money, two additional compounds, acetic acid and methylbenzoate, breakdown products of heroin and cocaine respectively, round out the suite of VOCs targeted in this project. Substantial progress has been made on this project and the primary logistic hurdle remaining at this point is the mechanics of the acquisition of the sample to be analyzed, i.e., piercing the shipping container and making the sample collection.

As the readers are aware, U.S. Customs does not require a search warrant to examine a shipment crossing a U.S. border. Given that the reasonable suspicion legal requirement does not apply to their selection of a particular container to be sampled, the concept of false positives is not as important an issue to them as it is for the Bureau, which is subject to this legal requirement. The false positive rate associated with this developing screening technology is of course a concern in that all of the VOCs targeted in this project have legitimate uses. This issue is presently being addressed by requiring, as a starting point, that 5 of the 8 VOCs associated with U.S. currency be present in order for the system to alarm for U.S. currency.

Money Laundering, Interdiction, U.S. Currency

B75 The Suspect Who Gave Me the Slip

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The goals of this research project are to teach attendees a new method of sample preparation/sample introduction for time-of-flight mass spectrometry and of its first application to evidence in a forensic science case.

This presentation logically falls into three parts. In the first a new method of sample preparation/sample introduction for time-of-flight mass spectrometry (TOF-MS) having potential application for some types of forensic science-related samples will be introduced. Desorption Ionization on Silicon (DIOS)¹-MS is a matrix-free method of introducing relatively low molecular weight (<5000 Daltons) samples as intact, singly-charged ions into a TOF mass spectrometer. Because of the absence of interfering matrix ions, minimum levels of detection are impressive, and the method is tolerant of the typically dirty samples encountered in forensic science.

The second part of the presentation narrates a case history of the first application of DIOS-MS in a forensic science case. It is a sexual assault case where it is alleged that an adult coerced a child into having sex with him. It is alleged that the adult gave the child a commercial contraceptive product, Encare®. Encare® vaginal inserts are shaped like a suppository and have a paraffin-like consistency. They are composed of a matrix of polyethylene glycol (PEG), which contains the spermicide, nonoxynol-9, plus some inorganic salts designed to produce foaming. Examination by DIOS-MS identified traces of PEG from extracts of vaginal swabs from the victim, and also from an extract of a swab of the suspect's penis (glans and shaft).

In the third and final part of the presentation the story takes a strange twist when the suspect (through his attorneys) provides as an alleged alternative explanation for the PEG traces, a bottle of Slip® Extra personal lubricant. An examination by DIOS-MS (as well as FTIR) shows low levels of PEG. However, the manufacturer of Slip® Extra says that no PEG has ever been used in any of their products. DIOS-MS fails to detect PEG in a sealed Slip® Extra bottle provided by the manufacturer. At the trial, the defendant's attorneys agree to stipulate that their client added some of the Encare® vaginal insert to the bottle of Slip® Extra that he provided to them.

Sexual Assault, Mass Spectrometry, Polyethylene Glycol PEG

B76 Reconstructing Violent Crimes in New York City: The Medical Examiner Scientific Assessment and Training Team (MESATT)

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The goal of this research project is to describe the formation of a team within the Medical Examiner's Office established to reconstruct the events of violent crime.

The face of forensic science has changed dramatically over the last century with many of the transformations occurring recently. Advances in DNA techniques have changed the significance of biological evidence. Computer technology has elevated databases from simple card catalogs to incredibly complex digital systems capable of innumerable classification and search parameters. Physical evidence including fingerprints, DNA profiles, and tool marks on projectiles and shell casings are entered into rapidly expanding databases every day. Increasingly, laboratories are changing their role in the investigative process. Initially forensic science was only useful when a suspect had been identified. Now crime laboratories are becoming indispensable in providing the police and prosecutors with important investigative leads.

It is common sense that every crime scene is unique. Clearly, the most important step in the investigative process begins at the scene of the crime. When probative scene evidence is recognized, documented, and collected properly, these advances in forensic science are applied to the fullest potential. Further, while some cases do bear similarities to others, each is as unique as a fingerprint. If crime scene investigators categorize cases and process them all in the same manner, valuable evidence may be overlooked and destroyed. Dr. Paul Kirk recognized this problem almost half a century ago. He stated, "*more laboratory failures are due to inadequate collection of the existing evidence than to the failure of the laboratory to examine evidence properly.*" Surprisingly, little has changed. Recent advances in forensic science may have even had a negative effect by promoting specialization. While, specialization helps to advance the field, it also poses a limitation. Specialists, adept in one or two areas, often lack the knowledge and training to view a crime scene from different vantage points. Now, more than ever, there is a growing need for "generalists" to be involved at the crime scene. "Generalists" are criminalists with a fundamental knowledge of the many sub-specialties in forensic science.

The generalist approaches a crime scene with an eye toward reconstructing the events of the crime as completely as possible. In nearly every case, a complete reconstruction is impossible, although it may be feasible to determine some of the singular events that were a part of the overall incident. The generalist will rigorously employ the scientific method to enhance the recovery of additional evidence and formulate hypotheses regarding the event. The analyses of bloodstain patterns, projectile trajectories, biological and trace evidence, autopsy findings, and other information are used in the reconstruction process.

For more than ten years criminalists in the Department of Forensic Biology at the Office of Chief Medical Examiner (OCME) have responded to requests from prosecutors, police personnel, and medical examiners to assist in the reconstruction of violent crimes. In January 2000 the Medical Examiner Scientific Assessment and Training Team (MESATT) was established. The backbone of MESATT was formed using a handful of criminalists possessing a strong generalist background. Within a few months MESATT had expanded considerably using the assets of the Forensic Biology laboratory. Core members of MESATT were augmented with other laboratory personnel on an "as-needed" basis. The part-time personnel are subdivided into Adjuncts and Trainees based on knowledge, experience, and the ability to perform forensic analyses. The team possesses a wide array of capabilities including criminalistics, anthropology and reconstruction both in and out of the field.

The team has two broad-based objectives. The first objective is the scientific assessment of crime scenes. Currently in New York City, the Police Department's Crime Scene Unit (CSU) is tasked with the initial response to the scenes of violent crimes in the city. Their primary responsibilities are crime scene documentation and evidence collection. The NYPD CSU reports are procedural, recording the services that were performed at the scene. Rarely do they get involved in the reconstruction aspects of a case. Therefore, it is common for MESATT to respond after the CSU. Advantages to a secondary response team include access to information not available during the initial crime scene processing (e.g., autopsy findings, statements from victims, suspects, and witnesses, etc.). There are disadvantages, however, resulting from the alteration of the scene such as the movement of people and inanimate objects, creation of artefactual evidence, and contamination. Upon review of all the information on a case, MESATT will generate scientific reports and provide expert testimony as needed. Several case examples will be discussed.

The team's second objective is training. To keep law enforcement current with new technology, MESATT provides training in the areas of biological evidence collection, forensic photography, bloodstain pattern analysis, and general criminalistics. Training sessions range from short lectures to five-day bloodstain pattern analysis workshops. The team has trained personnel from city law enforcement agencies and other jurisdictions including the Federal Bureau of Investigation.

As a whole, the team has been successful through the years. In nearly 150 cases examined, expert testimony has been provided in over 20% of them. Future goals of the team include the ability to interact more closely with the NYPD CSU, as well as to provide a more immediate response with the initial investigators.

Reconstruction, Crime Scene, Bloodstain Pattern Analysis

B77 LISA3 – A Comprehensive Enterprise Wide Laboratory Information Management System

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The goals of this research project are to present to the forensic community a custom relational database management system (RDBMS) for case management and laboratory processing (mtDNA and STR) for both forensic and database specimens.

Given the advances in new and emerging technologies and considering the raw volume of electronic data both administrative and scientific that even a small forensic laboratory can produce, a need for a Laboratory Information Management System (LIMS) has become a necessity. The Armed Forces DNA Identification Laboratory (AFDIL) has developed a management system to track, manage and organize specimens and forensic DNA casework. The first and second generations of the application to go into production at AFDIL consisted of 2 main modules, System Administration and DNA2000. The System Administration module manages user accounts and grants users privileges to specific functionality within the system. The DNA2000 module is an automated case processing application which tracks specimens/cases from arrival until testing is completed. This module also contains functionality for SOP and form maintenance with administrative review of laboratory processes.

While this system was ideal for tracking case specimens within the laboratory, it was limited by the fact that it did not provide a total case management solution. Automated consultation report generation, management reporting (number of specimens processed, type, etc.), mtDNA/NucDNA profile management and inventory management still

needed to be addressed. The system was further hampered by the fact that it was designed to process individual cases and did not have a high-throughput capability (i.e., barcode driven processes and sample processing in 96/384 well format).

The solution was to build on the functionality and robustness of DNA2000 in order to develop a comprehensive management system. In this paper I will discuss the development and functionality of AFDIL's 3rd generation Laboratory Information System Applications (LISA³). LISA³ is a robust RDBMS which tracks and manages forensic DNA casework from case receipt to final reporting. The concept was to develop a common graphical user interface (GUI) to manage a laboratory or enterprise wide management system. LISA³ functions as a common portal through which any AFDIL user can gain access to their approved modules within the management system. The main areas of added functionality are the addition of barcode tracking, integration of digital imaging of evidence and agarose gels, an inventory management system for supplies/procurement, a high-throughput lab processing module for database and/or known samples, integration of robotic instrumentation, an STR population statistics application, a combined STR and mtDNA profile comparison application, consultation report generation and an AdHoc reporting tool, and a Mass Fatality Incident Management System (MFIMS).

These topics, as well as new functionality to include a web-based application to allow consultative clients to get online status of casework being processed by AFDIL, will be presented in detail.

The opinions and assertions expressed herein are solely those of the authors and are not to be construed as official or as the views of the United States Department of Defense or the United States Department of the Army.

LIMS, Automation, Database

B78 The Development of an RNA-Based Assay System for Body Fluid Stain Identification

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The goal of this research project is to inform the forensic community about a novel means of body fluid stains identification.

In theory, RNA expression patterns, including the presence and relative abundance of particular mRNA species, provide cell and tissue specific information that could be of use to forensic scientists. For example, an mRNA-based approach could allow the facile identification of the tissue components present in a body fluid stain and conceivably could completely supplant the battery of serological and biochemical tests currently employed in the forensic serology laboratory. Some of the potential advantages include greater test specificity, and the ability to perform simultaneous analysis using a common assay format for the presence of all body fluids of forensic interest. The latter is expected to improve the timeliness of serological analysis due to method automation and decrease sample consumption. Eventually semi-automation of tissue identification in bio-molecular forensics could be achieved through microarrays or real-time PCR assays. We have previously investigated the recovery and stability of total RNA in blood, saliva, and semen stains. Using sensitive RT-PCR assays we detected the presence of mRNA molecules from housekeeping genes in these stains. As a first step in developing a comprehensive body fluid identification system, we identified a number of candidate tissue specific genes that may be used to positively identify saliva. In the present work, we have investigated a number of candidate genes that could be used to identify blood, semen and skin.

RNA was extracted with guanidine isothiocyanate-phenol:chloroform and precipitated with isopropanol. After DNase I pre-treatment, total RNA recoverable from the tissue sample was quantitated using a sensitive fluorescence assay based upon the binding of the unsymmetrical cyanine dye RiboGreen®. To determine whether mRNA sequences were

present in the total RNA extracts from the tissues a reverse transcriptase-polymerase chain reaction (RT-PCR) detection strategy was employed. All RT-PCR products were separated on 2.5% Agarose gels and stained with SYBR® Gold Nucleic Acid Gel Stain. cDNA was synthesized from RNA using an oligo-dT primer designed to anneal to the poly-A tail at the 3' end of mRNA. Three constitutively expressed housekeeping genes, S15, GAPDH, and β -actin, were detected in all tissues. Negative controls, to which no reverse transcriptase (RT) was added, were run in parallel to each reaction to ensure that mRNA was the source of the RT-PCR amplicons and not contaminating genomic DNA. In addition, pretreatment of the RNA extracts with RNase-free DNase I removed contaminating DNA and ensured that only mRNA was detected with RT-PCR.

It is important to know how much total RNA yields sufficient mRNA for detection by the RT-PCR technique. The amount of input total RNA required to detect both housekeeping genes and tissue-specific mRNA's using the RT-PCR technique was studied. Depending upon the gene and tissue, 1-10 ng of input total RNA is sufficient for analysis. This is equivalent to approximately 250-2500 cells or 30-300 pg of mRNA.

RNA stability studies have been conducted. Significant quantities of total RNA were recoverable from all tissues or stains stored at room temperature for at least 10 weeks. As expected, however, an inverse relationship between the amount of total RNA recoverable in the stains and time was observed. However, evidence for partial mRNA degradation was obtained in two-week old stains. Significantly, the use of an oligo-dT primer for first strand cDNA synthesis resulted in significant loss of signal, which was abrogated when random primers were used instead. This result provides evidence for the degradation of mRNA in stains occurring via the loss of the polyA tail. The use of random primers allowed for the facile identification of mRNA in several-month old stains.

We have demonstrated tissue specific gene expression with five genes of the salivary gland. The genes statherin (STATH), histatin 3 (HTN3), proline-rich protein BstNI subfamily 1 (PRB1), proline-rich protein BstNI subfamily 2 (PRB2), and proline-rich protein BstNI subfamily 3 (PRB3) were found to be expressed in saliva but were undetectable in blood and semen. Details will be provided on the identity and functions of the candidate genes that we have developed to identify blood, semen and skin.

RNA, Body Fluid Stain Identification, Tissue Specific Gene Expression

B79 Digging for Causes of Total Homozygosity: Complete Hydatidiform Mole

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The goals of this research project are to present participants with two separate forensic paternity case studies describing DNA patterns of complete homozygosity in products of conception. In both cases, the diagnosis of a complete hydatidiform mole was made. Participants will be informed of the genetic characteristics common to these moles and a suggested course of action to confirm this diagnosis. Furthermore, the implications of such a diagnosis on a laboratory's ability to draw conclusions will also be discussed.

This report describes two unusual forensic paternity case studies with no apparent maternal contribution to the DNA obtained from the products of conception (POC). In both cases, the observation of complete homozygosity and maternal exclusion prompted us to further investigate the cause of these unusual profiles at the time of each original analysis. Our investigation ultimately led us to the conclusion that the tissue tested in the first case was actually that of a complete hydatidiform mole and, several years later, to the same conclusion in a second completely unrelated case

A complete hydatidiform mole occurs when an ovum lacking a maternal complement of chromosomes is fertilized by a haploid sperm, usually containing an X chromosome. Duplication of this chromosome set yields a 46, XX karyotype that is paternally derived. Patients will present with symptoms of pregnancy, although no viable fetus will develop. These complete moles are usually characterized by an abnormal placenta consisting of a mass of tissue with grape-like swollen villi. In both cases described in this report, gross examination of the POCs revealed these characteristics and no fetal parts.

The first case consisted of POC to be compared with standards from the mother and the alleged father. These samples were analyzed by RFLP analysis using the restriction enzyme *HinfI*. This analysis resulted in a completely homozygous RFLP pattern for the tissue sample where none of the alleles matched the mother or the alleged father. Upon observing this result, the submitting agency was contacted to confirm chain of custody and to inquire about any possible existing pathology reports related to the POC. Chain was verified and no pathology reports existed. A pathology screen was then initiated and the diagnosis of a complete hydatidiform mole was confirmed.

A second unrelated case, submitted to us one to two years later, consisted of paraffin-embedded tissue to be compared to standards from the mother and the alleged father. These samples were analyzed using the 13 STR CODIS loci. This analysis resulted in a DNA profile consisting of a primary pattern of complete homozygosity across all loci and a minor secondary pattern consistent with maternal origins, likely to be from cross-contamination of maternal tissue from the collection procedure. In this case, each of the primary homozygous alleles matched one of the alleles from the alleged father at each locus. With the knowledge gained from the previous RFLP case, a complete hydatidiform mole was suspected. Upon inquiring with the submitting agency, we discovered that a pathology report confirming this diagnosis already existed.

Despite this kind of genetic abnormality, the testing of such moles may still be of value in a forensic case. In the two cases described herein, we were able to draw conclusions related to paternity. In the first case, the alleged father was excluded as the donor of the paternal alleles. In the latter case, the alleged father was not excluded as the donor of the paternal alleles and statistics were provided. As unusual as these cases may seem, the frequency of hydatidiform moles is relatively high (1 in 1000 in the US) and, therefore, special attention and follow-up questioning should be pursued in cases of complete homozygosity in POCs. If a complete hydatidiform mole is suspected, it is very important that it is confirmed by pathological examination for a couple of reasons. First, patients diagnosed with a POC that is a complete hydatidiform mole can later develop choriocarcinoma. Thus, it is critical that the female patient be notified that she has this condition so that she may receive the proper medical treatment to prevent the onset of cancer. Second, a diagnosis can prove that the maternal exclusion does not result from a chain of custody problem. Therefore, we highly recommend that when you see possible evidence of a mole, keep digging.

DNA Analysis, Complete Hydatidiform Mole, Paternity

B80 Forensic Biometrics: The Determination of Individual Physical Characteristics by DNA Typing

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The goal of this research project is to inform the forensic community about the possible determination of a person's phenotype by genotyping a body fluid stain left at a crime scene.

It is now a matter of routine for the forensic scientist to obtain the genetic profile of an individual from DNA recovered from a biological stain deposited at the crime scene. Potential contributors of the stain must either be known to investigators (i.e., a developed suspect) or the questioned profile must be searched against a database of DNA profiles. However, in the absence of appropriate comparison reference samples, the DNA profile *per se* presently provides no meaningful information to investigators, with the notable exception of gender determination. A number of other physically recognizable characteristics of an individual are at least partly inherited and these include skin-, hair- and eye- color, stature (height and weight) and facial morphology. Theoretically at least, and given sufficient knowledge of the genetics of complex polygenic traits, a DNA analysis on a crime scene sample could provide investigators with information akin to eyewitness identification. Since, with few exceptions, our understanding of the genetics of these complex traits is somewhat rudimentary, development of significant forensic applications awaits further advances in our knowledge in this area.

Notwithstanding the above, the genetics of skin and hair pigmentation has proved to be amenable to molecular genetic analysis. This project involves the determination of hair color by molecular analysis of the melanocortin-1 receptor locus (MC1R). Certain mutations in the coding regions of this receptor have been shown to be correlated with the red hair color phenotype in humans. Additional mutations in the MC1R have been reported to be (weakly) correlated with blonde hair.

We have sequenced the MC1R coding region of a number of red- and non-red haired individuals to verify this connection and to develop a proof-of-concept test for forensic use. In a sample of thirteen individuals chosen to represent variation in hair color and skin type, we have identified seven mutations in the MC1R coding region. Certain of these mutations appear to be correlated with the red-hair phenotype. Interestingly blonde-hair individuals also possess mutations within this locus. Since these mutations are essentially biallelic single nucleotide polymorphisms (SNPs), we have developed simplified assays to detect these variants. The SNP assays are based upon amplification of the ~300 bp locus followed by minisequencing using dideoxy single nucleotide extension of an unlabeled oligonucleotide primer. Detection of the primer extension products is carried out on the 310 genetic Analyzer capillary electrophoresis system. In order for the minisequencing system to be useful in forensic testing it should be available in a multiplex format. Accordingly, we have developed a multiplex minisequencing strategy for this locus. Details of the developed multiplex minisequencing system will be presented.

We realize that hair phenotype is also likely to be determined by other regulatory regions of the MC1R gene, such as the promoter and the 5' and 3' untranslated regions of the transcript and other interacting genes, such as proopiomelanocortin (POMC), alpha-melanocyte stimulating hormone (*α*-MSH) and agouti related protein (ARP). We are in the process of extending our sequencing analysis to include some of these regions with a view ascertaining the presence of any polymorphism and whether alleles detected are correlated with hair color.

DNA Biometrics, MC1R, Hair Color

B81 Molecular Forensic Botany: DNA Analysis of a Mixture of Plant Particulates Associated With Trace Evidence

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The goals of this research project are to teach the audience about DNA methods used to analyze and identify plant material associated with dust and other particulate material associated with trace evidence. These methods will enable the analysis of a mixture of dried plant material so

that the individual plants contained in the mixture can be identified to the species level. The methods presented include extraction of DNA from dried plant mixtures, cloning techniques, amplification of relevant plant loci, DNA sequence analysis, and algorithms used in molecular plant systematics.

Botanical material found associated with crime scene evidence has potential for providing investigative leads relevant to kidnapping, terrorism, distribution of drugs, and murder. Historically, botanical trace evidence has been analyzed by the morphological and histological characteristics of the plant material. However, many plant materials found in trace evidence cannot be identified to the species level based on their morphological features. We have utilized molecular techniques to identify trace amounts of plant materials to the family, genus and species level. The ribulose 1-5' biphosphate carboxylase gene (rbcL) and the Internal Transcribed Spacer (ITS) region of ribosomal DNA are moderately conserved sequences that are used to identify plants at the family, genus and species level. We have used the DNA sequence variation of these two loci to identify the individual plant components extracted from particulate material associated with trace evidence.

The methods used to analyze the trace evidence involve the following steps:

- Extract the DNA from the trace evidence sample with a variety of methods. Removal of the secondary plant metabolites that can inhibit PCR is particularly important.
- Amplify the plant DNA at two loci (rbcL and ITS) developed by molecular systematists for plant identification purposes.
- Clone the amplified DNA into appropriate hosts for storage and screening purposes.
- Screen the clones using restriction enzyme patterns to identify different plant clones.
- DNA sequence the amplified products associated with the plant clones.
- Identify the plant using the NCBI BLAST search algorithm and the PAUP alignment software.

Using these molecular techniques, plants have been identified from as little as a 1-mm punch of dried plant tissue or from 5 grains of pollen. A minimum of 10 picograms of DNA has been used to identify plant material. These procedures have been developed to identify plant materials in a heterogeneous mixture associated with trace evidence from a variety of environments. Consistently identifying individual plants contained in a defined mixture of eight plants has validated the procedure. Using these methods, we have identified plants from trace materials collected from clothing, video tapes, road side debris, and packaging materials. Two mock-case examples will be presented where the DNA identification of plant particulate material associated with clothing was used to infer the geographic origin of the evidence.

Forensic Botany, Non-Human DNA Typing , Trace Evidence

B82 Validation of the AFLP Technique for the Individualization of Marijuana (*C. sativa L.*) Samples

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The goal of this research project is to demonstrate the results of validation experiments for AFLP analysis of marijuana samples.

Individual identification using genetic analysis is an important contribution to many forensic investigations. The Connecticut State

Forensic Science Laboratory has been validating the amplified fragment length polymorphism (AFLP) analysis method (Plant Mapping Kit; Applied Biosystems, Inc.) for use with marijuana samples. Currently, enormous resources go into drug eradication efforts to locate and destroy fields of marijuana but only rarely can they be linked back to an individual. Marijuana can be grown clonally or by seed. Clonal propagation is simple to perform: a leaf cutting is taken from a high-THC content "mother" plant and rooted directly in the soil. This form of propagation results in large numbers of marijuana plants with identical DNA analogous to identical twins. AFLP analysis could be useful for linking distributors to a common clonal marijuana source. Seed propagated marijuana plants have their own unique DNA analogous to unrelated individuals within a population. In this situation, AFLP analysis could allow investigators to link a leaf found in a suspect's vehicle back to a plant from a small grow operation in an apartment.

Validation studies are critical to the implementation of new genetic profiling systems in the forensic community. Experiments were performed to determine optimal template DNA concentration, effects of degradation on template DNA, determination of the most informative PCR primer sets for selective amplification and verification of genetic clones by AFLP analysis. Ten nanograms of input marijuana DNA for AFLP analysis were optimal for reproducible profile results. DNase enzymatic treatments significantly affected AFLP profiles while freeze-thaw treatments of the input DNA had no effect on AFLP profiles. Sixty-four possible PCR primer sets are available in the Plant Mapping Kit for the selective PCR step during AFLP analysis. For our marijuana samples, we determined the following six PCR primer sets to be optimal: 1) EcoR1-AAG Joe and Mse1-CAA, 2) EcoR1-ACT Fam and Mse1-CAA, 3) EcoR1-ACT Fam and Mse1-CAT, 4) EcoR1-AAG Joe and Mse1-CAT, 5) EcoR1-AGC Ned and Mse1-CAA and 6) EcoR1-AAG Joe and Mse1-CTA. Our criteria for selecting these primer sets were as follows: a high complexity of peak profiles, an even spread of bands from top to bottom of gel image, an even balance of fluorescence band intensities across the profile, an absence of concatamers in the 150-200 basepair size range and significant peak differences between different samples.

Our collaborator (Dr. Gary Shutler, Royal Canadian Mounted Police / Winnipeg) has generated multiple generations of clones from "known" marijuana varieties for our AFLP validation efforts. To test the AFLP method, we typed "mother" plants and first- and second-generation clones with all of the possible sixty-four PCR primer combinations available in the Plant Mapping Kit. In all cases, "mother" plants and the subsequent clones had identical AFLP profiles. Genetically unrelated marijuana varieties could be distinguished from each other, usually with a single PCR primer set.

To make the AFLP method useful for casework, we anticipate the need to construct AFLP databases for marijuana to determine how often we would expect to observe two unrelated (nonclonal) marijuana samples to share the same AFLP profile. AFLP profiles can be individually compared by overlaying one profile on the other in GeneScan software. However, to manage larger numbers of AFLP profiles, we are using Genotyper software macros to assign binary code to peak profiles. By using a binary code format, we hope to generate an easily searchable database that can identify candidate sample matches for an analyst to verify by GeneScan overlay. In addition to building a database of samples for comparative purposes, we are tracking geographic sources and varieties when that information is available to determine if certain marijuana varieties are genetically more closely related than others. We are also tracking the geographic source of the marijuana to see if marijuana seized from a common region of the state or country appears to be genetically related.

Forensic Botany, Non-Human DNA, Marijuana

B83 Prosecuting Drug Facilitated Sexual Assault Cases: Problems Encountered/ Technical Fallibilities

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The goals of this research project are: (1) to identify drugs used to facilitate sexual assaults; (2) to become familiar with technical procedures utilized to analyze biological specimens when a drug facilitated sexual assault is suspected; (3) to recognize problems inherent in the interpretation of results of analysis for some drugs used in these types of assaults; and, (4) to demonstrate direct and cross examination of analysts and the presentation of technical testimony in drug facilitated sexual assault cases.

The prosecution of drug facilitated sexual assault cases is made difficult because of the inherent properties of the drugs utilized to commit such crimes. The drugs, MDMA, rohypnol and ketamine, commonly referred to as "date-rape drugs," are popular at what has become known as Raves, all night drug parties frequented by teenagers and young adults. But rave parties are not the only place that an individual may become a victim of these drugs. Any social event where drinking is taking place, i.e., parties, bars, etc., presents the opportunity for victimization as these drugs are often slipped into the drinks of an unsuspecting victim.

The properties inherent in these drugs which cause difficulties in prosecution include the fact that they have a sedating effect which renders their victim unconscious. The effects can last from 24-48 hours. Additionally, some cause substantial memory loss or amnesia. The victim often awakens in a strange place and cannot remember when or how he/she arrived there or what happened prior to that point in time. Further complicating the prosecution is the fact that by the time the victim regains consciousness and realizes that he or she may have been sexually assaulted, the drug has rapidly metabolized and cleared his/her system. Thus, rarely is blood the specimen of choice in such cases. And, detecting the drug or its metabolite in urine requires careful interpretation.

Further, the analysis itself for drugs used to facilitate a sexual assault requires the use of procedures, techniques and instrumentation which generally may not be included in the protocols of the forensic laboratory to which the sample is submitted, nor in its instrumental inventory. Because these drugs are often used in combination with ethanol, creating a synergistic effect, they may be present in very low concentrations in specimens submitted thus requiring that sensitive methodologies be used.

Gamma-hydroxy butyrate, GHB, presents its own unique testimonial challenge in that it is found naturally in the body. Thus, simply detecting this drug in a biological sample cannot automatically be interpreted to mean that a drug induced sexual assault has taken place.

Moreover, rohypnol, a benzodiazepine, is not the only drug of its class that may be used in the commission of this type of crime. Because other benzodiazepines can cause an individual to forget events that happen after they have been consumed, they too have the potential of being used as date rape drugs.

Successful prosecution of drug facilitated sexual assault cases therefore requires collection of the proper specimen, specific technical procedures, and knowledgeable interpretation of results. Defendant Joe Smith a/k/a *Go Get' Em Joe* is counting on his persuasive talents and skills with the ladies, his sleight of hands technique, and, his presumption that due to forensic laboratory funding shortages for personnel, equipment, training and research, evidence submitted with respect to any complaint against him will be meaningless or go undetected. He is accused of drug facilitated sexual assault in addition to possession of controlled dangerous substances. He has pled *Not Guilty* to all charges. Will the prosecution be able to meet its burden of proof? Or, is Defendant Smith's assessment correct?

Expert Testimony, Date Rape Drugs, Drug Facilitated Sexual Assault

B84 Studies on the Response of Short Tandem Repeat Systems to Changing Temperature and Sizing Methods

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The goal of this presentation is to present the importance of both temperature and the operator-chosen sizing method on STR analysis using capillary electrophoresis.

Changing run conditions such as temperature can result in variations in the size determination of an allele. These effects are caused by secondary structure differences that can occur between the amplified sample and the internal standard. To minimize these effects an elevated pH can be used. The type of method chosen to generate the sizing curve in STR analysis can also influence the relationship between estimated size and temperature.

Two fluorescently labeled allelic ladders, CTTv and Y-PLEX 6 were analyzed using the ABI Prism 310 Genetic Analyzer. CTTv includes the forensic loci vWA, TH01, TPOX, and CSF1PO while Y-PLEX 6 contains Y-chromosomal specific STR loci, DYS 393, DYS 19, DYS 389, DYS 390, DYS 391, and DYS 385. The selected alleles include fragments ranging in length from 116 to 385 bases, allowing investigation of the entire calibration curve produced by the ROX 500 internal size standard. Electrophoresis was conducted at 35-70°C using the commercially available POP4 buffer, which consists of 4% poly(dimethylacrylamide) at pH 8. The fragments were detected using multichannel laser-induced fluorescence and data was analyzed with GeneScan software. From the fragment migration times of the internal lane standard, the software generates a sizing curve using an operator-chosen sizing method. The manufacturer's standard protocol calls for an electrophoresis temperature of 60°C and a Local Southern method of sizing. Two sizing methods were compared in this research, Global Southern and Local Southern. While the Global method generates the best-fit curve from all matched fragments in the size standard, the local method produces the best-fit curve from only nearby internal lane standard data points. The slopes of the regression line between estimated allele size and temperature, using either Global or Local sizing, were measured in order to demonstrate the temperature sensitivity of migration time. Another area of this research was to determine how buffers at elevated pH would affect the temperature response. This type of system should minimize DNA secondary structure effects and result in more precise sizing. For this work a POP4 buffer at pH 11 was used.

Three different analyses of the response of the size estimate with respect to temperature were completed for the CTTv ladder. The estimates of the slope of the temperature response were fairly precise with standard deviations of 0.002-0.02 bases/°C even though the runs were taken at dif-

ferent times over a period of a few months and on different capillaries. Using the Global Southern sizing method the slopes varied consistently for the different alleles within each of the four loci. For example, the slopes for TPOX alleles 6, 10, and 12 were -0.094 , -0.100 , and -0.104 , respectively. However, there was a differential response in slope between loci. For example, the slope for allele 7 in CSF1PO was -0.052 while allele 10 in TPOX had a slope of -0.100 . In contrast to this, when the Local Southern sizing method was used, the slopes varied both between and within loci. For example, while the slope of allele 7 in CSF1PO was -0.027 , the slope of allele 14 within the same locus was -0.156 . Furthermore, many of the slopes were significantly larger than those determined using the Global Southern sizing method. The largest slope measured using Global methods was -0.104 , but a slope of -0.156 was measured with the Local technique.

The Y-PLEX 6 ladder produced significantly different results than CTTv. The slopes of the temperature response for all of the alleles in the CTTv ladder were negative. However, while many of the Y-PLEX 6 slopes were also negative, some were positive and one was even curved. For example, allele 10 in DYS 385 had a slope of 0.0842 , while the slope of allele 8 in DYS 385 was curved each time it was measured. In agreement with the CTTv ladder, the slopes were not consistent among alleles within each locus when local southern sizing methods were used.

In order to characterize the effect of alkaline pH, the temperature dependence of the DNA size estimates using the commercially available POP4 system will be compared to the results obtained using POP4 at pH 11. In previous work using the Profiler + system at the elevated pH, the slopes were nearly flat unlike most of the slopes obtained for the alleles under standard POP 4 conditions, which were $-0.05^{\circ}\text{C}/\text{base}$ or greater. These results indicate that a stabilizing effect on DNA temperature response is occurring, increasing the precision of size estimates obtained.

DNA, Capillary Electrophoresis, Short Tandem Repeats

B85 The Reliability and Validity of Scientific Techniques: The Shaping of Scientific and Legal Communities After Frye

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The goal of this research project is to address the critical issue of communication between the legal and scientific communities when dealing with the reliability and validity of new techniques in the area of forensic DNA examination.

Each year the evolution of the United States of America's judicial system and scientific knowledge becomes more apparent. Through new legal decisions and through scientific advances, each of us has visualized this change. When two constantly changing bodies intersect, as do law and science in the combined field of Forensic Science, the inevitable result is a disruption in the working harmony and a need for adaptation. With the 1993 landmark Supreme Court decision in *Daubert v. Merrell Dow Pharmaceutical, Inc.* and its rejection of the *Frye* Rule, novel standards of reliability and validity concerning new scientific advances had to be adopted, ultimately leading to confusion and concern within the legal and scientific communities.

The Federal Rules of Evidence, which are standardized and binding on all United States District courts, are applied to offers of evidence to ensure that the fact finder hears and ultimately considers only admissible material and relevant evidence when deciding issues in a court of law. When two sovereign fields overlap, such as the spheres of science and law, it is imperative that communication and understanding exist between the two bodies in order to successfully negotiate and determine a common ground. As both of these bodies are in pursuit of truth, when a new scientific technique is presented to the court, it is up to them to find this common ground: determining whether it is admissible and rel-

evant evidence. The *Daubert* decision provided the basic tools for the Court to determine whether evidence or testimony is scientific knowledge and ultimately reliable. *Daubert* addresses the admittance of evidence more liberally than its predecessor, the *Frye* Rule. These four guidelines have included: whether the technique or method has been tested (thus revealing its fallibility or validity), whether the known error rate of the technique is acceptable, whether the technique or method has been subjected to peer review, and whether the scientific community generally accepts the technique. Each new scientific technique presented to the court must undergo scrutiny under these rules. Once the technique is accepted, it is deemed worthy as evidence in other court cases. The Supreme Court, on remand, explained that these four factors were not necessarily relevant in every circumstance and that it was ultimately up to the judge to act as a gatekeeper to determine whether evidence or testimony is reliable.

Due to the rapid advances being made in DNA technologies, there is no guarantee that a technique used today won't be replaced by a new one tomorrow. Such was the case with Short Tandem Repeat (STR) analysis replacing that of Restriction Fragment Length Polymorphism (RFLP) analysis. The Forensic Science community has been taking steps to establish internal standards and guidelines to fit with those set by *Daubert*, making the transition to new techniques easier. Organizations such as the Scientific Working Group on DNA Analytical Methods (SWGAM), the American Society of Crime Laboratory Directors (ASCLD), and others were established in hopes of bridging the gap between judicial and forensic science standards of reliability and validity. In addition, the National Institute of Standards and Technologies (NIST) provides tests for laboratory competency by supplying DNA standards to ensure quality assurance and quality control. These standardized tests help to determine whether the overall work being done by a laboratory, including their DNA analysis methods, conforms to criteria specified by the established guidelines.

In an ideal world one would follow all of the rules and obtain the truth as intended. However, the ultimate use and significance of any valid scientific evidence presented for legal means may be affected by unexpected nonscience or nonlegal variables. Representatives for the legal and scientific communities need to continue to work together with the ultimate goal of a smooth transition from the laboratory into the courtroom.

DNA, Daubert, Quality Assurance and Quality Control

B86 Chemical Analysis of Organic Material on the Surface of Human Scalp Hair as a Basis of Forensic Comparisons

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The goal of this research project is to present the results of a feasibility and optimization study for the chemical analysis of human hair using various extraction techniques and gas chromatography/mass spectrometry.

Currently, methods for the forensic analysis of human hair rely upon microscopic examination or DNA comparisons. Chemical techniques, on the other hand, have focussed on extracting and identifying drugs of abuse. Recent work in our laboratory has shown that organic material on the surface of hair is easily accessible using conventional extraction techniques and solvents, readily analyzed using gas chromatography/mass spectrometry (GC/MS), and provides qualitative and quantitative information that may be effective for forensic identifications or comparisons.

In this work, various extraction methods such as ultrasound, Soxhlet, pressurized solvent, and supercritical fluid extraction have been evaluated for their efficiency and selectivity. Using these procedures, the organic fraction of hair samples was isolated in methanol, acetone,

dichloromethane, hexane, and supercritical carbon dioxide. Gravimetric studies of the liquid solvent techniques resulted in yields from hair samples of 0.9 – 1.8% (w/w) for ultrasonic extraction, 1.1 – 4.1% for Soxhlet extraction, and 2.5 – 3.6% for pressurized solvent extraction. Of the liquid solvent extraction techniques, pressurized fluid extraction was the most convenient and amenable to samples as small as 50 mg. In general, yields for all techniques decreased as solvent polarity decreased.

The most successful method to date is on-line supercritical fluid extraction where unmodified carbon dioxide is used in static and dynamic modes. The pressure, temperature, and time of extraction have been optimized in order to maximize efficiency and hence sensitivity. As a result, samples as small as ~150 mg (representing approximately a 2 cm strand of hair) have been successfully analyzed. In this method, a restrictor is used to deposit the solutes directly onto the stationary phase of the chromatographic column. Subsequent analysis time is on the order of 90 minutes. Characterization of the dichloromethane and supercritical carbon dioxide hair extracts has revealed a complex mixture of components ranging in carbon number from C₁₄ to C₃₃. This surface material largely consists of sebaceous excretions such as fatty alcohols, acids, esters, and other lipids including squalene and cholesterol. In some cases, anthropogenic material from consumer products was also found.

Analysis of head hair from 20 subjects varying in age and gender has shown that these chromatograms are suitably complex to provide some degree of individualization to a particular hair sample. Furthermore, there appears to be systematically higher levels of cholesterol in pre-pubescent versus post-pubescent individuals. Literature data suggests that further systematic differences in lipid composition according to gender and/or race may exist that would further increase the evidentiary value of chemical analysis. Finally, the chromatographic profiles obtained using this technique have proven to be stable under normal storage conditions and are reproducible for a single scalp location on an individual.

Future work in this area will include evaluating other extraction techniques such as solid phase microextraction. Plans are also underway to correlate results with demographic data from subjects such as age, race, and gender. An expanded sampling study is also needed to determine the amount of variation in the chromatographic profile of a single individual over time and scalp location. Lastly, chemometric pattern recognition algorithms will be used to quantitatively compare chromatographic profiles.

Hair, Gas Chromatography, Mass Spectrometry

B87 The Development of an ELISA Technique for the Detection of Salivary Amylase

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The goal of this research project is to introduce the participant to a newly developed technique for the specific identification of salivary amylase.

An ELISA technique for the detection of salivary amylase has been developed. Confirmation of salivary amylase by this method offers greater specificity for the detection of saliva than existing methods.

There are two forms of amylase found in body fluids: pancreatic and salivary. Pancreatic amylase is found in many body fluids and is the predominant form of amylase in feces. Salivary amylase is predominantly found in saliva but can also be found in other fluids. High levels of amylase in non-fecal stains by existing methods is usually presumed to be salivary in origin. At lower levels of activity, however, the source of the amylase cannot be discerned. Traditional methods, such as the Phadebas test and radial diffusion in a starch-agarose gel, do not discriminate between the two types of amylase. In addition, the possibility of the

presence of bacterial amylase in the vaginal cavity (as well as amylase that is pancreatic in origin) can lead to positive amylase results on vaginal swabs taken from sexual assault victims. These results may lead to the conclusion that oral sodomy may have occurred.

The developed ELISA is an indirect assay using a monoclonal anti-salivary amylase antisera (BiosPacific) bound to a microtiter plate. Validation studies determining the proper dilution of all antisera employed in the assay were conducted. A detection mechanism employing an alkaline phosphatase conjugate using *p*-nitrophenol phosphate as a substrate was used. Measurements were made at 405nm and quantitative results were obtained from a standard curve.

Tests were conducted on dilutions of commercially prepared salivary amylase to determine the range of linearity and sensitivity. After controlling for background absorbance (including microtiter plate absorbance) and non-specific binding, the lower limit of salivary amylase detection was 0.002 units. Beer's law was observed from 0.2 units down to 0.002 units. Cross reactivity with pancreatic amylase was not observed in this range. Standard samples containing 2 units of commercially prepared pancreatic amylase did show cross reactivity.

Unit concentrations of salivary amylase within the linear range were chosen as standards for subsequent experiments on body fluid stains. Tested body fluid stains from laboratory members included blood, saliva, urine, semen, vaginal fluid, fecal matter, and perspiration. With the exception of saliva, no other body fluid stains showed positive results in the linear range of the standard curve.

Vaginal swabs from forensic casework samples which previously tested positive for amylase by radial diffusion in a starch-agarose gel were tested with the ELISA method. In every sample but one, results did not reach the linear range of the standard curve indicating the presence of saliva.

Future research includes the incorporation of selective inhibitors to distinguish between pancreatic and salivary amylase in concentrations above and below the linear range of the standard curve.

Saliva, Amylase, ELISA

B88 Comparison of Methods to Collect Epithelial Cells on Clothing

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The goal of this research project is to introduce a new method of collecting epithelial cells from crime scene evidence for DNA analysis.

According to Stouder *et al*, "trace evidence debris may contain sufficient cellular material to permit identification of the wearer of that item through DNA analysis." The authors took tee-shirts and hosiery worn by laboratory personnel for a period of time and then scraped for trace evidence. Subsequent DNA typing gave promising results. To further investigate the applicability of this "scraping" method for the collection of epithelial cells on clothing, a study was designed to compare different collection methods and evaluate success rates for the different methods using various types of items.

Epithelial cells can be a sufficient source of typable amounts of nuclear DNA using PCR techniques. They are deposited from the skin onto everything it comes into contact. This has been seen in casework with non-porous items such as knife handles, steering wheels and carpenter-hammers. Epithelial cells are not shed solely from the hands of a person but from the entire body, therefore, it should be possible to find these cells on articles of clothing with which a person has come into direct contact. The best collection process has to be determined to utilize this source of nuclear DNA to its capacity.

In the past, the most general method of collection of epithelial cells on a non-porous surface was swabbing the surface with a cotton swab moistened with distilled water and on a porous surface by cutting out a

small portion of the substrate. These methods often failed to yield viable results due to the lack of epithelial cells collected to perform DNA analysis. This study incorporated the cutting and swabbing methods as well as the new method where an article of clothing was scraped with a razor blade and the resulting debris was used for DNA extraction. Scraping the article in question and collecting the resulting debris concentrates the epithelial cells to be collected and increases the chances of obtaining a DNA profile. Tee-shirts and facial tissues were a reliable source of DNA while latex gloves and various personal items yielded lower numbers of usable DNA profiles.

Nine laboratory volunteers were asked to wear their own tee-shirts, pairs of socks, baseball caps and pairs of latex gloves. Each participant also used three tissues on his or her face and donated some personal items such as eye glasses or jewelry. Each of the clothing articles (tee-shirt, socks, and baseball hat) was subjected to the same order and method of collection: first the cutting, next the swabbing and finally the scraping. Each of the samples taken was subjected to the same procedures such as DNA extraction using a modified chelex method, quantified using Quantiblot (ABI), and typed with the AmpF ℓ STR $\text{\textcircled{R}}$ Profiler Plus TM Amplification Kit (ABI) and the 377 automated sequencer (ABI). Results were categorized in three groups: negative (or inconclusive), mixtures, or clean (or interpretable). A result was considered negative or inconclusive when no or only a partial profile with less than 4 loci was detected. A mixture result occurred when more than two peaks were present at multiple loci and no major component matching the known donor could be determined. A result was determined to be clean or interpretable when either a clean profile or major component consisting of more than four loci could be generated that matched the known donor.

From the study, three different comparisons could be made from the results: a comparison of the methods of collection, of the items used, and of the research volunteers. The scraping method showed a clear advantage by producing interpretable results almost 60% of the time; whereas, the cutting and swabbing methods only produced interpretable results 21% and 13% of the time, respectively. The higher success rate can be explained by the larger surface area that is used for the collection. Interestingly, the percentage of mixtures did not increase with the increase of the surface area. For all three collection methods, the mixture rate was about 15%.

The "most desirable" piece of evidence in the study was determined to be the tee-shirts, which produced the highest success rate, followed closely by the facial tissues. The socks and baseball hats produced usable results at rates similar to each other. DNA typing of the latex gloves worked less than 5% of the time.

Finally, there was a definite distinction between the nine volunteers of the study showing interpersonal variability. One of the volunteers had over 90% negative results (average 65%) and samples from another individual showed greater than 50% mixtures (average 14%).

Overall, the scraping method can be recommended for the collection of epithelial cells found on articles of clothing.

Epithelial Cells, Scraping, DNA

B89 Determination of Heroin Metabolites in Human Urine by Capillary Electrophoresis With β -cyclodextrin and Native Fluorescence Detection

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The goal of this research project is to present a new method for determination of heroin metabolites in human urine by capillary electrophoresis with native fluorescence.

A method has been developed for the detection of a mixture of mor-

phine, codeine, 6-acetyl morphine (6-AM) and normorphine using capillary zone electrophoresis (CZE) with native fluorescence. The method utilized urinary 6-AM as a diagnostic indicator of heroin abuse because it is not a product of either morphine or codeine metabolism. The electrophoretic separation was achieved using an uncoated (53 mm I.D.) fused-silica capillary, 77 cm long, and containing the detector window 10.0 cm from the outlet end. Samples were injected electrically (5 KV) for 10s using Chromabeam 1050. The system was run at 25 $^{\circ}$ C at a constant voltage of 20 KV. The cathode was located on the detector side. The running buffer (pH 6.0) contained 50 mM sodium phosphate and 0.015 M β -cyclodextrins (β -CD). The capillary was washed sequentially with 0.1M NaOH and distilled water (1 min of high pressure, rinsing each), followed by reconditioning with running buffer (3 min of high pressure, rinsing) between runs. The fluorescence detector (FL 750B) was operated at 225nm excitation wavelength using a band pass filter with emission above 300 nm and data were analyzed with Chrom Perfect software. The internal standard was nalorphine. It has been found that β -CD can improve the separation efficiency due to the hydrophobic cavity of the CDs. The effect of the concentration of β -CD and pH was also evaluated. Increasing the concentration of β -CD led to an increase in the separation efficiency and resolution. The optimum concentration was found to be above 0.015 M as judged by the separation efficiency.

The extraction method utilized a mixed-mode solid-phase extraction procedure. A 200 mg CLEAN SCREEN $\text{\textcircled{R}}$ SPE column was used for the extraction. The SPE columns were conditioned by the sequential passage of 3 mL of methanol, 3 mL of distilled water, and 1 mL of 0.1M phosphate buffer (pH 6.0). The supernatant layers from the samples were applied to the SPE columns. The columns were washed with 3 mL of distilled water, 2 mL of 0.1 M acetate buffer (pH 4.5), and 3 mL of methanol. The drugs were eluted with a solution consisting of dichloromethane/ isopropanol/ ammonium hydroxide (78/20/2) and collected in glass tubes. The limit of detection was 5 ng/ml for codeine and normorphine and 10 ng/ml for morphine and 6-AM. The calibration graphs were linear up to 1000 ng/ml. The method had good reproducibility, precision, accuracy, and high recovery.

The above method was compared with UV detection and fluorescence derivatization. The P/ACE 5000 SERIES was used with UV absorbance detector (the absorption wavelength 210 nm, other conditions as above). The derivative is based on the selective reaction of morphine with benzylamine in neutral media in the presence of potassium hexacyanoferrate (III). In this case, the fluorescence detector was operated at an excitation wavelength of 350 nm and with using a band pass filter with emission above 450 nm. It can be concluded that CZE with fluorescence detection is a rapid, simple, sensitive and useful screening technique for the detection of heroin metabolites in urine.

Heroin, Capillary Electrophoresis, Native Fluorescence

B90 The Detection of Inorganic Ions in Smokeless Powder Residue

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The goal of this research project is to demonstrate the applicability of capillary electrophoresis (CE) and the ion chromatography (IC) in the analysis of inorganic ions in explosive residue.

Ion chromatographic and capillary electrophoretic methods have been developed for the analysis of inorganic anions and cations in post-blast debris from smokeless powders. In this procedure, a small amount of the smokeless powder is burned on a clean watch glass to simulate the resultant pipe bomb residue. This material is next extracted using 18.2 m Ω distilled water in order to dissolve the inorganic salts. The extract is drawn into a plastic syringe where it is filtered through a Gelman IC syringe filter and prepared for analysis.

The ion chromatography analysis consisted of two types of detection:

uv absorbance and conductivity. The uv detector utilized a Spectra-Physics SP8800 ternary HPLC pump, a Spectra-Physics SP8800 autosampler and a Spectra flow 773 variable-wavelength detector. The column was a Nucleosil Anion II anion-exchange column. The eluent used was 1 mmol of DCTA dissolved in 18.2 mΩ distilled water and adjusted to pH of 5.2 using 0.05M LiOH. The conductivity detection instrument included a Spectra-Physics SP8800 ternary HPLC pump, a Rheodyne 6 port manual injector, a Shimadzu CTO-6A column oven and a Shimadzu CDD-6A conductivity detector. The column was a Nucleosil Anion II anion-exchange and a PRP-X200® cation-exchange column. The run time was 12 minutes. The capillary electrophoresis analysis was obtained via indirect photometric detection. The instrument was a Beckman Pace System 2050. Ions were separated using a chromate buffer consisting of borate, dichromate, DETA, and boric acid.¹ The run time was 6 minutes. Cation analysis was also performed using capillary electrophoresis with a buffer consisting of hydroxyisobutylic acid, imiazole and 18 crown 6.²

It is important to look at the ions present in differing burned powders in order to determine whether IC and CE are inclusive for these specific ions. The IC analysis method was capable of simultaneously detecting anions and divalent cations present in the residue, including nitrate, sulfate, calcium and magnesium. The CE analysis was utilized as a confirmatory step in the analysis of smokeless powder residue and was capable of detecting a wide range of inorganic anions. Together, the methods described above can be utilized in the detection of inorganic ions in common improvised explosive devices such as pipe bombs. We were interested in determining if these same procedures could be utilized in the analysis of residue from smokeless powders.

The results show the methods are clearly able to distinguish different ions present in black powder, Pyrodex, and smokeless powder. While smokeless powders generally contain organic components such as nitrocellulose, nitroglycerin, and various stabilizers and plasticizers, inorganic materials such as KNO₃, K₂SO₄, NaCl are added during processing. The presence of these materials can be used to further distinguish different types of smokeless powder residues. In this presentation we will illustrate the application of CE and IC.

Explosive Residue Detection, Ion Chromatography, Capillary Electrophoresis

B91 Forensic Analysis of Petroleum Products by FT-ICR Mass Spectrometry

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The goal of this research project is to demonstrate how FT-ICR mass spectrometry can be used for complex mixture analyses in forensic science.

Forensic analyses that involve petroleum-derived samples (such as arson and environmental forensics) are difficult for a number of reasons. First, compositional analysis of crude oil and petroleum distillates is complicated given the large number of compounds that comprise the starting material and consequently, the products. The complexity of the sample precludes individual component identification by current analytical techniques due to a lack of chromatographic resolution (in traditional techniques such as GC and LC) and known compounds for retention comparison. Secondly, when "heavier" petroleum fractions are analyzed, typical ionization methods commonly used prior to mass spectrometric analysis suffer from a number of important limitations. Ionization techniques such as electron impact, field ionization, and chemical ionization

require that the sample first be volatilized before analysis. This presents a significant problem because the high-boiling nature of heavy petroleum renders traditional vaporization methods ineffective. Finally, once exposed to the environment, the petroleum product of interest will undergo biotic and abiotic modifications that further complicate an already complex mixture. Isolation of the sample is difficult and commonly includes many matrix species from the material the sample was isolated (soil, carpet, etc.). The matrix species introduced during sample isolation can further complicate analysis if those species are made from petroleum-derived materials (such as carpet and adhesives). They can co-elute from a chromatographic column (either GC or LC) and prevent compound identification. FT-ICR MS benefits from ultra-high mass resolving power (greater than one million), high mass accuracy (less than 1 ppm) and rapid analysis which make it an attractive alternative for the analysis of petroleum products that range from crude oil to gasoline.

First, we report two environmental forensic applications of FT-ICR mass spectrometric analyses in the initial site characterization of a U.S Air Force jet fuel (JP-8) spill site and the initial results from forensic typing of crude oils. High resolution mass spectra of electron-ionized jet fuel samples are obtained from as little as a one microliter septum injection into the AGHIS. Molecular formulas (elemental compositions) are assigned from accurate mass measurement alone. From a compositional analysis of the unweathered standard, components are identified and monitored as a function of weathering. Identifying the leachable and volatile components present in such a complex mixture is useful in fate and risk assessment and environmental impact studies. JP-8 contaminated soil samples were obtained from Eglin Air Force Base, Soxhlet extracted, and analyzed for compositional similarities to weathered standards. Crude oil standards were provided by ExxonMobil and analyzed by ESI FT-ICR mass spectrometry. Each crude consisted of thousands of peaks and hundreds of compound classes. Three crudes were analyzed in an effort to differentiate the crudes from one another based on their compositions provided from the FT-ICR MS analysis.

Finally, we report the first forensic application of FT-ICR mass spectrometric analysis for discrimination between unweathered/weathered arson accelerants and for identification of those accelerants in fire debris by use of a homebuilt 6.0 T FTICR mass spectrometer. As discussed earlier, pyrolysis products and matrix volatile organics (often of petroleum origin themselves, i.e., plastics) can complicate the gas chromatogram and/or mass spectrum. This complexity, compounded with GC and GC/MS's limitations in chromatographic or mass spectral resolution, can, in some instances, make detection and subsequent identification of suspected arson accelerants difficult to impossible. Furthermore, the present method of comparison for ignitable liquid identification is based simply on presence or absence of reference compounds in an unknown analyte mixture. It does not rely on relative abundances of those components, and thus may be more robust than "pattern-recognition" methods. After prolonged burning, the mass spectra of ignitable liquids resemble those of "weathered" (partly evaporated) analogs. We therefore created a mass spectral library (peak list with elemental compositions for all above-threshold peaks) for unweathered, 25%, 50% and 75% weathered #2 diesel fuel, kerosene, gasoline, mineral spirits (two commercial brands), bulk lighter fluid, turpatine, and paint thinner to aid in the identification of suspected accelerants in arson-related fires. To test our new method of "fingerprint" matching, we collected fire debris samples from a series of controlled burns separately accelerated with either a simple (lighter fluid) or complex (turpatine) ignitable liquid that were collectively treated as "unknowns." Samples were Soxhlet extracted and subsequently analyzed by low-energy (<20 eV) EI-FT-ICR MS. Matching of fire debris samples to the spectral library was successful. For example, 45 of 56 lighter fluid constituents and 126 of 133 turpatine constituents (not counting ¹³C-containing species) were identified in burned couch samples when matched with their 85% weathered analogs. There was good agreement between the arson extract and library standard for the turpatine-accelerated control burn. The high resolution and high mass accuracy provided by FT-

ICR MS allow for matching even when multiple peaks are present at nominal mass (e.g., matrix or pyrolysis products). The present technique was also able to differentiate between two brands of mineral spirits—results that open the possibility of identifying an ignitable liquid (even after severe weathering) within a commercial petroleum class. This work was supported by NSF (CHE-99-09502), Florida State University, and the National High Magnetic Field Laboratory in Tallahassee, Florida.

Mass Spectrometry, Environmental, Arson

B92 3-D Spectrofluorometric Fingerprinting of Automobile Petroleum Products

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The goal of this research project is to have an understanding of the complexities associated with analysis of petroleum products from automobile chassis using fluorescence spectrophotometry for characterization and comparison.

Automobile chassis residues often consist of complex petroleum mixtures which may provide crucial investigative and adjudicative information in a hit-and-run case. Spectrofluorometry is recognized as one of the more sensitive instrumental techniques and has particular application to forensic science. It is particularly useful in trace evidence analysis since a technique with high sensitivity most often has associated with it a low detection limit. Also associated with high sensitivity is the ability to reliably measure small changes in signal. This work presents the principles of the technique as applied to forensic petroleum analysis and discusses its usefulness in investigations and court presentations.

Experimental: The 3-D fluorescence spectra of chassis petroleum residue samples were collected using a Varian, Inc., Cary Eclipse™ Fluorescence Spectrofluorometer (Walnut Creek, CA). The Cary Eclipse utilizes a high intensity Xenon flash lamp, Czerny-Turner monochromators, and highly sensitive photomultiplier tube detectors. Instrument validation and the optimum collection method were determined using known fluorescence standards. Spectral data were collected using instrument software provided with the Cary Eclipse. Data normalization was then performed with Excel spreadsheet software. Three-dimension spectral processing was performed using Grams 3-D software provided with the instrument. Five automobile displays were selected for comparison and samples were collected from five different areas on each automobile. Each sample was successively fractionated using n-pentane, pyridine, and toluene to separate, respectively, the oil, pre-asphaltenes, and asphaltenes. Multiple sample analysis was performed to demonstrate reproducibility.

Results and Discussion: The results to be presented will show clearly identifiable fluorescence spectra can be readily obtained for characterization and comparison. The data indicate that samples can be readily differentiated and identified when comparison samples are available (i.e., from a suspect automobile). This presentation will illustrate data substantiating the ability to characterize automobile chassis petroleum products using 3-D spectrofluorometric fingerprinting and will identify the vehicle source.

3-D Fluorescence Spectrophotometry, Petroleum, Trace Evidence

C1 A Comparison of the Microstructures of Surface Melted Cu-Wire

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The goal of this research project is to investigate the cause of a fire by discrimination primary arc marks from molten Cu-wire.

We already presented "Microstructure and Composition Changes of Cu-Wire According to Heat Source" at last year's meeting (2001 Annual Meeting) by analyzing primary arc marks and secondary arc marks created in the laboratory. We have named each as "Primary arc marks" (electrical heating before the fire); "secondary arc marks" (electrical heating after the fire), and "Molten marks" (external heat; flames). In this presentation we hope to discriminate primary arc marks from melted cu-wire collecting at a fire scene as suspicious cause of ignition.

To discriminate two cases, we collected three denominated cu-wires at a fire scene, a short circuit wire (primary arc marks) identifying it as the cause of a fire by many other evidences; another thing (secondary arc marks), identifying it as the of burning of insulating cover, the other being not clear (or melted marks), etc.

For that purpose we have made the use of a scientific instrument like stereomicroscopy. This method is currently used for investigation of the cause of fire but has limits for concrete results by itself.

Then we have optical microscope and microstructure of the melted area. This method results in differences in grain growth of arc marks and molten marks surely but not of primary arc marks and secondary arc marks. So we need to perform analytical methods for critical results quantitatively. And we have analyzed the composition of cu-wires by using XRD and TEM and have intended to characterize microstructure at surfaces of melted cu-wire.

The microstructure of surface melted cu-wire has been characterized using transmission electron microscopy, energy dispersive X-ray spectroscopy, and convergent beam electron diffraction for identification and distribution of Cu Phase. We observed many voids and they are Cu₂O particles. Through performing XRD experiment, we found out those voids exist at specific angles (2) and could discriminate between arc marks and molten marks.

These data are similar to the results of the samples, created in the laboratory, that were conducted in the last paper.

As a result of the experiment, we could understand the methodology and hope to discriminate between primary arc marks and secondary arc marks by those experiments or help in the investigation of a fire cause. Therefore we will perform experiments under more various and precise conditions to gain critical value, especially for collecting of evidence at a fire scene. Additionally, we have need to discriminate the variety of primary arc marks

Fire, Cu-Wire, Arc Marks

C2 Novel Software Architecture for Surveillance Video Processing

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The goal of this research project is to present to the forensic community the architecture design of a software environment for surveillance video processing.

This describes the organization and capabilities of the Video Tool for Aiding Law Enforcement (VITAL). Included in the presentation will be a

demonstration of the VITAL software. VITAL is a software program that can be used for restoring and enhancing surveillance video. It was developed by the Image Science and Machine Vision (ISMV) Group at Oak Ridge National Laboratory (ORNL) to offer video analysts a new work environment as well as new algorithms for processing video. VITAL is organized in a novel architecture that makes the video analyst's task easier and offers several unique capabilities, making it a model application for surveillance video restoration.

In the VITAL environment, cases are handled as application projects. Entering case and investigator information and then selecting a sequence of video that has been previously digitized outside the VITAL environment initiate projects. The sequence is then pre-processed to handle any formatting issues associated with the video's storage protocol. At that point, the project's data can be restored or enhanced using a number of video and image processing algorithms made available in the VITAL environment.

The interface and processing is completely oriented toward the handling of video sequences. This differs from many basic image processing applications that handle individual images one at a time. In the user interface, video sequences are displayed using a combination of an Animator window and a Browser window. The Animator window displays the sequence as a movie in which the speed can be varied or one frame can be viewed at a time. The Browser window displays the video similar to a filmstrip in which thumbnails of many sequential frames can be viewed at once. The Animator and Browser windows are always together for viewing a particular sequence; and, the frame that is active in the Animator is highlighted in the Browser, so they are always synchronized as well. Although one image is highlighted as the current frame, any processing operation that is chosen from VITAL drop-down menus will be automatically performed on all frames within the sequence. In some cases, there is a preview mode in which the current frame is used for iterative selection of processing parameters, and then once the parameters are chosen the sequence is processed in its entirety.

While the VITAL environment is very structured and is able to track all operations performed on a sequence, it still allows and encourages experimentation by the analyst. Once a video sequence is brought into the environment, a number of different analysis sets can be made from part or all of the video sequence frames. In fact, a processing chain can be separated into multiple branches at any time. This allows the analyst to try different approaches in parallel and disregard the results from less successful branches. Each analysis set has a current video sequence that is displayed through the Animator and Browser window pair. These windows can be used to view multiple analysis sets at once, or the analyst can hide sets that aren't currently being considered. After a processing step has been performed on an analysis set of video, the analyst is presented with an Animator and Browser window pair for both the before and after video sequences so they can be viewed at the same time. Then the user is asked whether or not to replace the current video with the new results.

During processing, the steps and parameters are automatically recorded by the software, making it easy for the analyst to document and later repeat any processing steps. Also during processing, the analyst is able to enter any comments to clarify analysis objectives or record observations. Once the processing of a case is complete, the analyst can command VITAL to write a HyperText Markup Language (HTML) document that will contain all case information, notes, and processing parameters. The document can also contain original, intermediate, and final imagery. The benefit to creating a report in this fashion is that the entire report can be written to digital media, such as a compact disc, that can then be copied for documentation or delivery to law enforcement and court personnel. This reduces costs, simplifies procedures, and ensures a high-quality representation of resulting imagery.

Surveillance Video Processing, Video Restoration, Video Enhancement, VITAL

C3 Investigation of the Skid Force After a Vehicle Collision

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The goal of this research project is to present to the forensic community several published references to aid in a traffic accident reconstruction.

Knowing the length of skid marks, L, and using the dynamic coefficient of friction for the roadway surface, we can determine the amount of kinetic energy converted to work during the skidding process on a level roadway. And, tire marks after a vehicle's collision are being used in the same way as skid marks in a traffic accident reconstruction, too.

But, it guesses the skid force when vehicles have big action three-dimensionally different from the skid force in the two-dimensional action. So, I investigated the skid force by using the acceleration data in the vehicle's collision experiment.

The condition data of the vehicles collision experiment are shown in Table 1. I took pictures of the image of the vehicle's collision experiment with a high-speed video camera; the acceleration meter measured the vehicle's acceleration. The rotation angle of the vehicles based on the ground was measured from the high-speed video image. Then, acceleration data were changed into the ground coordinate by using the rotation angle of the vehicles.

Using the changed acceleration data, the following two investigations were done: (1) The mass of the vehicles was put on the acceleration and the force added to the vehicle was investigated. Most of the force to act on the vehicle was force, which acted on the vehicles mutuality during the collision as that result. (2) The force that acted on each vehicle was subtracted. It confirmed that there was time when a dynamic coefficient of friction for the roadway surface got over 1 when that value is supposed to be the skid force. It guesses that it influences the vehicle's action, such as the rotation, though there are a few influences to exert on the decrease speed because the action time of the big skid force is short.

The easiness of the vehicle's action analysis by the image analysis and high precision data by the acceleration meter were used, and the force that acted on the vehicles during the collision could be investigated by this research. But, only short time could be analyzed with the influence of the photography range of the high-speed video camera after the collision. When the reason why the vehicles received the big skid force after the collision was researched, it became clear that acceleration in the up-down direction had close relations with the slide power. In other words, it was proved when the weight ratio of the vehicles was big, and when the center of gravity was high, the big skid force was often received. It confirmed that the big slide power didn't occur in the same type sedans' collision conversely.

Table 1 Experiment data

No.	Vehicles type	Collision form	Collision position	Road condition	Collision speed (km/h)	Vehicles size (m)		Vehicles weight (Kg)
						Length	Width	
1	Compact sedan Sedan	Side collision	Left side	DRY	64.9	3.195	1.395	802
			Front		64.9	4.69	1.69	1587
2	Compact 1box Sedan	Side collision	Left side	DRY	56.4	3.195	1.395	845
			Front		56.4	4.69	1.69	1435
3	Sedan Sedan	Offset collision [50%]	Front of right	DRY	64.5	4.69	1.69	1434
			Front of right		64.5	4.69	1.69	1442
4	RV Sedan	Offset collision [50%]	Front of right	DRY	64.4	4.12	1.65	1876
			Front of right		64.4	4.69	1.69	1437

Skid Force, Collision, Acceleration

C4 Physical Defects and Human Factors Omissions Lead to Electrocution

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The goals of this research project are to expose the series of factors which led to the electrocution of a worker and identify the physical defects and lack of systems approach which were causes.

V.P. had worked for some years in a plant that manufactured prefabricated wood trusses using nail plates. He was not an electrician and had little, if any, electrical training. An assembly table had a moving power press that automatically pressed the nail plates to join the wood members. Three-phase 480-volt electric power for the press was delivered by four semi-sheathed conductors that ran underneath the assembly table supported from flat bar brackets bolted to the concrete floor. The electrical conductors were formed of sheet steel into a figure eight and were then surrounded with insulation excepting for a groove on the underside where the brush made contact with the conductor.

The brush arms were supported by a bar and spring assembly which was eccentrically supported by a vertical angle iron bolted to the press frame. This torsionally weak structure deflected so that the brushes became misaligned with the opening in the plastic cover of the conductors. Periodically, one or more of the copper brushes would ride on the plastic and lose contact with the conductor, and the press would stop.

When this happened, the fused disconnect switch located in a nearby shed was turned off and the switch on the moving power press control panel was turned off and the brushes would then be resealed.

On the day of the accident, the above procedure was followed: A co-employee turned the fused disconnect switch to "off." The indicator light on the power press panel was off when V.P.'s supervisor told him to go underneath the table and check the brushes. A few moments later V.P. indicated that indeed there was a problem with one of the brushes. A scream was then heard. V.P. had been electrocuted.

Subsequently, it was determined that the fused disconnect switch, which was operated by a front-mounted handle had failed to break the circuit when the handle was rotated to a position which was marked "off." The "on" position of the switch lever was horizontal and when it was rotated counterclockwise downward there was an abrupt reduction in the force required to operate the lever giving the tactile sense that the switch had opened. However, the switch was still closed when the lever was vertical and aligned with the middle F of OFF. It was found that had the lever been rotated 5° further the switch would have opened. Examination of the circuitry showed that the indicator light on the moving power press control panel could be off when one conductor was interrupted and the other two legs and ground were still conducting. The "Power switch" on the moving power press control panel did not disconnect electric power to the conductors running underneath the press table.

There were several human factors issues. The co-employee who rotated the manual disconnect lever to the right towards the off position did not rotate it far enough to break the circuit, though he believed he had. Human factors considerations include the location of the controls legend which was obscured by the operator's hand, changes in control resistance with lever rotation, and other sources of feedback as to the position of the lever.

In addition, consideration was given to whether the electrical conductors provided adequate guarding in terms of both proximity to the operators (guarding through location) and the dimensions of the gap in the insulation.

Another human factor issue concerned the status of the indicator light on the power press's control panel. V.P.'s supervisor maintained that he had turned off the power press and that the indicator light was dark. However, the conductors could still be hot even if the indicator light on the power press indicated that no power was being delivered to the machine.

An interactive computer model was constructed to model the operation of the disconnect switch. The model permitted manipulation of the brush contact with the conductors for the three phases. The graphics showed, for example, if the middle brush was not making contact with the conductor, the power indicator light on the power press would correctly indicate that the power was still being delivered (provided the main disconnect switch was not rotated all the way to the right).

However, if under the same conditions, the brush on the far right did not make contact with the conductor, the indicator light on the power press failed to remain on. Therefore, this accident could not be solely attributed to the defects in the main power disconnect switch. However, it illustrates the importance of adopting a systems approach to identifying what can go wrong in equipment operation.

Causal factors of this electrical fatality included:

1. Positioning of electrical conductors in which energized surfaces were within reach of persons at the floor level;
2. A conductor support system which was flexible contributing to the propensity for misalignment of the brushes and the conductors;
3. A flexible electrical shoe support system which was torsionally flexible leading to misalignment of the brushes and the conductors;
4. An absence of adequate means of guiding the shoes to maintain conductor contact when there was angular misalignment of the shoes and conductors;
5. Absence of dependable indicators as to whether each of the conductors was energized;
6. A fused disconnect switch which did not function as normally expected;
7. Failure to replace the defective switch, and,
8. Absence of a systems approach to potential failure.

Electrocution, Human Factors, Press

C5 Performance Characteristics of Smoke Detectors

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The goal of this research project is to familiarize the audience with the operation of smoke detectors, the differences in design, and how these differences manifest themselves in performance.

Smoke detectors have markedly improved since the scam of 25 years ago, whereby wind-up heat detectors were sold as life safety devices. The predominant technologies of today and the last 20 years have relied on light scattering detection (photoelectric technologies) and ionic particle detection (ionization detectors). Each of these detectors operates differently, and as a result, there are varying differences in performance.

The photoelectric detector pulses a light source, typically an infrared LED, for a short time every several seconds. Smoke particles, if present, will cause the light to reflect on a PN type material that is responsive to infrared energy. The change in conductivity of this PN junction is sensed, and after appropriate signal processing, an alarm is sounded. The ionization detector uses an ion chamber, along with a radioisotope, to develop a base level current. Changes in current occur when ions (from combustion) are present, and this current level change is sensed and an alarm is sounded.

The authors performed repeated testing under various fire scenarios, and the results of this testing will be outlined. We note that detector performance, particularly with ionization detectors, is very dependent on the distance from the flame / fire, as well as the type of combustion event that is occurring. For some fires, we note that the ionization detector is of little to no value. Because of economic reasons, the ionization detector is the detector most frequently installed in homes; it is also the detector most frequently sold at home improvement stores.

The technology and costs associated with these two types of detectors will be outlined. In particular, contrasts will be made between commercial types and dual technology detectors. The engineering that is associated with many of these detectors will be exposed for what it is – cookbook – with a manufacturer selecting integrated circuits and using the IC manufacturer's design.

Both detectors are subject to non-performance if power problems develop, and the authors will explain the various types of power sources and their benefits: 10 year battery, battery, AC, AC with battery backup.

The authors have also tested PIR (Passive Infrared Receivers) as a means of detecting smoke and fires. We believe that these PIRs can be used for smoke and heat detection and that they work reliably. The testing carried out will be detailed and will show PIRs are useful in non life safety situations in closed spaces (after hours in a business). Because they also react from human body heat, for which they were originally designed, they are not suitable for use where personnel are present.

Smoke Detectors, Ionization Detectors, Photoelectric Detectors

C6 Point Source Electrocution in Swimming Pools and Spas

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The goals of this research project are to describe a technique for mapping voltage and current in a pool or spa in order to ascertain the energy distribution in the water. The paper also discusses some of the variables that impact on the distribution of energy in the pool or spa.

Serious injury and death continue to occur in swimming pools and spas due to electrical energy leakage into the water. Electrical energy dispersion through the water from the source is often misunderstood and as a result inaccurate conclusions can be formulated in regard to the evaluation of an incident.

Fundamental electrical circuit equations are not appropriate for calculations when evaluating energy flow in pools and spas since the flow of energy is a function of the electric field distribution in a given geometry. Maxwell's equations are appropriate as well as field mapping in order to determine the voltage and current density in a given scenario.

Five different experiments were carried out in order to ascertain the voltage distribution in a typical swimming pool when energized at 110 volts ac. Further, various grounding techniques were utilized in order to evaluate the impact of energy flow regardless of grounding.

The evaluation of the data clearly indicates that the energy flow is governed by field equations and that the degree of grounding has a direct impact on the total energy flow into the medium.

Voltage Distribution, Electrical Field, Mapping

C7 Electrostatic Hazards in Rotary-Screw Compressors

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Oil-flooded twin-screw air compressors discharge a pressurized oil-air mixture into a tank-oil sump where most of the oil is separated from the compressed air. Residual oil in the air stream is carried over as a fine mist to an oil-separator tank where all but a few parts per million are removed.

Electrically insulated metal parts in the gas stream become electrostatically charged when fine-particle laden gas flows over them. When the vapor/particle - air mixture is of a flammable composition discharging the accumulated electrostatic charge across a spark gap can ignite it. Since the production and flow of oil mist are part of the process

of producing compressed air, the build up of electrostatic charges must be eliminated. Charge build up can be prevented by securely bonding all metal component parts in the air/oil mist stream to a very low resistance ground.^[1]

Described in this paper is the explosion of a Sullair twin-screw air compressor, Series 32, 450-horse power. That compressor supplied 125 psi air to various steel foundry operations. It exploded one afternoon without warning and witnesses reported they heard two loud reports each one following the other in rapid succession.

A post-explosion inspection revealed that about one third of the air exit end of the 30-inch diameter steel tank-oil sump had blown out. The four-inch diameter steel discharge pipe was pivoted through about 130 degrees during the explosion and hurled some 20 feet to the rear of the compressor unit. The discharge pipe had also been expelled from a four inch Flextran coupling which attached it to the oil-separator tank. The only other material damage to the compressor unit was a blown copper gasket in the oil-separator outlet pipe flange and a twisted, as well as partly collapsed, double walled steel filter element.

Upon completion of the first inspection, the theory was advanced that the fillet weld, which attached the four-inch discharge pipe to the tank-oil sump, was a bad weld and it was of insufficient strength to withstand the working air pressure. Subsequent light optical examination, three years after the event, in my laboratory, revealed that the weld had not been defective; in fact, the unit had been in service for six years before the explosion. The weld fracture had resulted from a bending-stress overload, with the bending axis running vertically through the weld.

In order for the maximum bending stress (M_b) to have been applied across the weld annulus and at 90 degrees to the tank-oil sump axis, a force of at least equal in magnitude to M_b had to have been applied at 90 degrees to the exit end opening in the discharge pipe.

The maximum bending strength of the weld annulus was calculated,

$$\begin{aligned} M_b &= \text{yield strength} \times \text{moment of inertia} / \text{max. radius} \\ &= 205802 \text{ lb in,} \end{aligned}$$

or a stress loading of 25329 lb @ 8.125 inch from weld. Now,

$$\begin{aligned} 25329 &= \text{working air pressure} + \text{dynamic gas loading (DGL)} + \\ &\quad \text{frictional resistance in separator pipe union} \\ &= 1590 \text{ lb} + \text{DGL} + 3800 \text{ lb, therefore,} \\ \text{DGL} &= 19939 \text{ lb (approximately 20000 lb).} \end{aligned}$$

The average pressure rise for an explosion of various carbonaceous particles and dusts in air is given in the literature^[2] as 3400 +/- 1970 lb/in²/sec. Thus, the pressure-spike loading at the mouth of the four-inch pipe would have added an additional load of 3400 x 12.73 = 43282 lb/sec - almost double the loading required to surpass the maximum bending strength of the weld annulus.

Inspection of the deformed double screen oil separator found no grounding staples attached to the inner metal screen; the correct separator would have had three grounding staples. Thus, the installed separator at the time of the explosion only had the outside metal screen securely grounded.

Another source of electrostatic charge generation was the Flexmaster coupling, which joined the outlet pipe to the oil-separator tank. The coupling consisted of a steel sleeve, flared at both ends and with rubberized, self-restrained, gaskets squeezed onto the four-inch pipe ends with coupling clamps. That type of coupling left the steel sleeve electrically isolated from the pipe ends, and the two pipes electrically isolated from each other, except through torturous paths to electrical ground at the compressor base.

Either the inadequately grounded coupling, or the double-screen oil separator could have generated the spark which ignited the oil-mist/air mixture. That explosion was of sufficient intensity to expel the discharge

pipe from the inlet end of the Flexmaster coupling and to tear it away from the tank-oil sump.

The much greater second explosion occurred when the very large volume of oil-mist laden air escaped from the opened up end of the oil-tank sump and it was ignited by an electric light bulb, which was hanging a few feet above the compressor unit. The bulb's glass envelope fractured when it was blasted with escaping gas.

1. Protection Against Ignitions arising Out of Static, Lightning, and Stray Currents, American Petroleum Institute Recommended Practice 2003, Fourth Edition, March 1982.

2. Explosive Characteristics of Various Dusts, Mark's Standard Handbook for Mechanical Engineers, Ninth Edition, 1986, p 7-30.

Rotary-Screw Compressors, Electrostatic Charge, Oil-Mist Explosion

C8 Unsupervised Youth Electrician

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The goals of this research project are to illustrate diversity of things that can go wrong.

A renovation project involved the addition of 3 KA electrical capacity to a 25 year old 480 volt 4 KA installation. A new cabinet was to be added to a set of six already containing a number of large breakers and one with instrumentation. Without any investigation, it was decided to cable the new 4 KA breaker cabinet to the old cabinet buses. After delivery and installation was started, adequate termination space for the 32 cables, each about an inch in diameter, was only in the adjacent cabinet used for the instrumentation. The utility and not the property owner owned that cabinet. There was no clear labeling of the cabinets concerning ownership or who had permission to open them.

The 19 years old electrician (with five years' experience working with his father) climbed into the instrumentation cabinet to begin terminating the cables. The utility was requested in writing to de-energize the cabinets and had racked out the main breaker leaving the feed bus hot. He had been advised as to which bus was still hot. He had been specifically instructed not to enter the cabinet. Autopsy showed he had been using cocaine recently.

As the young man was maneuvering his arm around to connect a cable, he made contact with a hot bus. Even though it was after midnight, the temperature in the room was well above 90 degrees. He died before the two men in the room could get him out of the cabinet. Survivors filed suit against the property owner, three architect firms involved, the engineering firm, the general contractor, the utility, the equipment manufacturer, and the man's employer, the electrical sub-contractor. Allegations against the manufacturer included lack of warnings about installation, lack of drawings of connecting to existing system, design flaws, manufacturing flaws, misrepresentations by the manufacturer's representative.

The writer was engaged by the equipment manufacturer to ascertain what part they had played in the death. Study of the situation revealed an installation more than 25 years old, no as-built prints, no records of modifications, additions, or even the original job. The manufacturer had been contacted about a breaker to install in the original cabinets. Of course, a breaker to fit that age cabinet had not been made in many years. A new cabinet and breaker were acquired and were being installed by the sub-contractor.

Installed in a very small room there was not enough room between the rear of the cabinets and the wall to let the cabinet door open completely. The engineering specifications capabilities but not the make nor the method of connection to the old equipment. Cabling termination procedure and location was left up to the electrical sub-contractor. This contractor made no prior effort to determine how or where the terminations could be made.

Forensic analysis of the situation showed the ownership and legal accessibility to the cabinets were not readily discernable, front in or back

of the cabinets. The “engineering” work had been done by a non-engineer designer in the engineering firm. The specifications had been approved by the architects and the general contractor. Plaintiffs demanded “as-built” drawings of the original work and for the new delivered equipment connection to existing units from the manufacturer.

The forensic report to counsel included the lack of proper supervision, permitting a man to work under the influence of drugs, lack of any contractual obligation concerning cabling or cabling terminations, lack of a request from anyone for help from the manufacturer, failure of the utility to kill the area, lack of proper labeling of the work area, victim’s lack of following instructions, and lack of study of installation problem before proceeding with the installation. After consideration of the report and other arguments, the plaintiff let the manufacturer out of the case.

Contract Problems, Project Management, Electrical Hazard

C9 Limitations of the Auger Analysis of Electrical Arc Beads

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Auger analysis has been used since approximately 1985 to analyze the melted copper beads, which are associated with short-circuits of electrical wiring. The limitations of the analysis were explored utilizing two case studies.

A short-circuit of electrical wiring is an electrical malfunction where the flow of electrical current takes a shortcut across wiring instead of continuing to a load such as an appliance or light. The shortcut taken by the electrical current causes a sudden increase in the current magnitude. The current magnitude is basically limited by the resistance of the wire. The metal utilized for electrical wiring is selected for its low resistance to the flow of electrical current. Subsequently, the current can increase to 40 times the circuit’s rating. The large overcurrent causes the wires at the point of short-circuiting to melt and form round beads at their ends. The short-circuit beads or arc beads are the items which are tested using Auger analysis. The purpose of the analysis is to determine if the wires short-circuited before the occurrence of a fire. The ultimate benefit is that the results of the analysis might verify the cause of a fire. The technique utilized for the analysis was developed by Robert N. Anderson, Ph.D. and published in the (*Journal of Forensic Sciences*), JFSCA, Vol.34, No.3, May, 1989, pp.633-637.

Case Study #1 - This case involved a fire which originated in a child’s bedroom of a residential home. An investigator of the fire reported finding the remains of a lamp and beading in the area of fire origin. Subsequently, the investigator brought me a bead in an envelope and the remains of a lamp. The envelope was opened and a bead was found inside. However, the bead was not attached to electrical wiring. It did not appear to have been caused by melting. The bead did not even appear to be metal. The bead appeared to be made of ceramic materials from the lamp or another item from the bedroom. Auger analysis of the bead would not have yielded any useful information about the cause of the fire. Next, the remains of the lamp were examined. Evidence of short-circuiting was found on the power cord of the lamp. The short-circuiting occurred at the end of the cord normally attached to the lamp’s bulb socket. Beads of copper were found on the ends of the wiring. The shiniest bead was selected for Auger analysis since the reflectivity of the bead is an indication of the amount of material contaminating its surface. Normally, the brighter bead has less surface contamination and it can be analyzed in less time. The bead was cut from the wiring and taken to a laboratory. The Auger surface analysis protocol of Dr. Anderson was applied to the bead at a laboratory. The tests determined that the short-circuit occurred in an environment which did not contain combustion products. Consequently, the short-circuit most probably caused this fire.

Case Study #2 - The second case study involved a fire which originated in the closet of a residential building. The burn patterns in the closet

indicated that the fire originated at floor level. Fire investigators removed the carpet from the closet and retained it as evidence. Subsequently, litigation was initiated in regard to the cause of the fire. The closet carpet was brought to this engineer by an attorney for a non-destructive visual examination. Preliminary inspection of the carpet revealed that an electrical extension cord was fused to the surface of the carpet. Evidence of short-circuiting was noticed upon the wires of the extension cord and copper beads were present. This engineer informed the attorney that the short-circuit or copper beads could have been caused by the fire. If another ignition source started the fire in the closet, the fire could have burned the insulation off the extension cord. Without insulation, the extension cord’s wiring could short-circuit and produce copper beads. Consequentially, I suggested Auger analysis of the beads to determine the environment in which they were formed. The attorney was hesitant to perform the analysis and left with the carpet. After further consideration, the attorney decided to have the beads analyzed. At this point, I told the attorney that destructive examination of the carpet was required to separate the extension cord from the carpet. The extension cord had to be examined from one end to the other, to obtain the most downstream short-circuit and to verify that molten metal had not fallen onto the cord. While separating the cord from the carpet, additional short-circuits were found along with copper beads. No foreign metal was found fused to the extension cord. Two copper beads were found further downstream along the cord than the beads noticed during the preliminary inspection. These beads were selected for laboratory Auger analysis. The beads were located approximately a quarter inch apart along the cord. The upstream bead was shinier than the downstream bead. Subsequently, the upstream bead was tested first. Auger surface analysis indicated that the bead was formed when combustion products were present. Therefore, the second bead was tested. The second bead was covered with surface contamination but a valley was found in the contamination. Auger analysis was performed in the valley and it indicated that the bead was formed when combustion products were not present. Consequently, the short-circuit found furthest downstream caused this fire.

In conclusion, Auger analysis has limitations when applied to fire investigation. It cannot independently determine where a fire originated or its cause. A thorough analysis of burn patterns is required to determine the area of fire origin. If electrical wiring is found in the area of origin, an electrical expert knowledgeable about the protocol of Auger surface analysis must examine it. Beads cannot be sent to a laboratory for analysis. They must be taken to a laboratory where instructions are given to the laboratory technician operating the test equipment. Furthermore, the analysis will only verify a fire cause if the investigator is lucky enough to find the bead which formed before combustion products were present. Quite frequently, the short-circuit or copper bead which ignited the fire is lost by fire fighting and overhaul procedures at the fire scene.

Auger, Short-Circuit, Fires

C10 The Breakdown of Electrical Insulation at High and Medium Voltage

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The goals of this research project are to establish a scientific basis for the interpretation of the electrical breakdown of dielectrics.

The premature breakdown of electrical insulation is frequently cited as a cause for the initiation of electrical failures at medium voltage although the details of the mechanisms involved have not been subjected to very much scrutiny. In failures involving large power systems, the condition of the insulation can often be brought into question even though there is rarely very much supporting evidence because the formation of

ionized gasses will often lead to the destruction of all but ceramic insulators. Nevertheless, even when there is little forensic evidence from which to deduce the exact cause of an electrical arcing, polymeric insulation is often cited as being responsible for initiating failures in medium voltage installations based upon comparisons to precursory deterioration which is observed at much higher voltages. This may be an appropriate comparison in ionic materials where the deterioration processes are known to involve very small ionization energies and hence an electrical breakdown can be set in motion by quite small fields. This may not, however, be true for many of the covalent materials that are in common use, and, a review of the literature indicates that there is very little that has been published about the early stages in the deterioration of polymeric and composite insulators at medium voltage. What we do know however is that the onset of the electrical failure of an insulator at any voltage is associated with a dielectric breakdown, which is in turn is determined by the gradient of the internal electric field. In different materials this can be associated with a variety of parallel mechanisms. These include recoverable electronic processes as well as permanent degradation reactions which are associated with processes such as ionic transport defect formation, as well as oxidation or reduction reactions that are stimulated by the presence of the electric field. Experiments with silicate glasses in vacuum, for example, indicate the preferential migration of alkali metal ions that produce an associated loss in electrical resistivity with the accompanying formation of color centers. Such process are seen to occur at extremely low voltage, and so, in this instance, in the absence of any other breakdown mechanism, the deterioration of these materials can be expected to simply be slowed by the presence of the shallower field gradients. In situations where the reactions are associated with much higher activation energies, the magnitude of the electric field becomes more significant and this will be particularly marked if the chemical reactions are dependent upon the dielectric breakdown as a precursor.

One of the reactions of particular interest is the reduction of carbon, both from the air and from the organic materials, which is the basis of many common insulators. The activation energies for these processes and the consequences to the stability of some common insulators are not well known and so the question as to whether or not the necessary conditions for dielectric breakdown can be met by the particular geometry and configuration of the insulation involved is rarely considered. In the case of insulating structures having to do with medium voltage (<500 Volts), however, it may well be possible to say something about the likelihood of such a fault, particularly when it is presumed that the mechanisms follow the same characteristics of breakdown and disintegration that are seen in high voltage systems. This can firstly be done by taking either the dimensions involved or the field strengths present into account when analyzing the behavior of a particular type of insulation. This can be particularly valuable when such deterioration has been observed and established at higher voltage. There, is however, the complication that some of the most obvious precursory breakdown mechanisms which occur at high voltage, such as surface tracking and discoloration, likely involve reduction reactions that have to do with the surface reactions of the insulation. Since reactions of this type could also be rate limited by the presence of external contaminants, it is worthwhile to determine the voltage and rate dependence of these mechanisms in different types of insulation.

We will present the results of a series of ongoing experiments that compare and contrast the consequences of resistivity losses in different types of insulation, as well as the determination of the characteristic voltage at which the onset of different mechanisms is observed.

References:

- 1) T. M. Walker and D. G. Howitt, *Scanning* 11-5-11.
- 2) D. L. Medlin and D. G. Howitt, *Phil. Mag. Letters* 64(3): 133-141.
- 3) P. Rez, J.K. Weiss, D.L. Medlin and D.G. Howitt, *Microscopy, Microanalysis Microstructures*, 6 (4) 433-440.

Electrical Arcing, Electrical Insulation, Failure Analysis

C11 Lightning Phenomenon and Detection—Part I

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The mechanics of lightning phenomenon, lightning detection systems for North America and How the network may aid the forensic scientist during a lightning accident investigation.

The purpose of this presentation is to provide an overview of lightning phenomenon and detection systems. The presentation is divided into two sections. Section A deals with a brief overview on lightning phenomenon and characteristics (lightning formation hypothesis, flash and stroke durations, and the three components of the electro-magnetic field). Section B will discuss the existing Lightning detection systems in place for North America.

Section A – Lightning Phenomena:

Lightning is one of the most spectacular natural phenomena that occurs on the earth. Two centuries ago Benjamin Franklin first demonstrated that the lightning bolt is a gigantic electrical discharge; since then the quest for scientific understanding of lightning has been an elusive adventure. The physical processes that take place in and around a thundercloud occur at the micro-particle level, and a much grander scale that involves the entire earth as an electrical circuit. Lightning events also span a wide temporal scale, since the charge separation process takes a relatively long time in relation to the fast incident of the streamer, leader, and return stroke(s) of a lightning occurrence.

Since Franklin's initial discovery of charge separation between clouds and the earth, a couple of hypotheses have been formulated to further explain the phenomena of charge separation. The two common charge separation models are the precipitation model, and the convection model. The presentation will briefly cover the dynamics of these phenomena.

Lightning strikes the earth approximately 100 times per second (eight million times per day)! A tall freestanding structure such as the CN (Canadian National) Tower in Toronto is struck many tens of times during a lightning season. Each flash that hits the tower may include multiple strokes (stroke multiplicity), and up to as many as nineteen strokes have been observed in one flash. This is understood from the 'flickering' pattern of light one sees when observing lightning; the flickering is actually multiple strokes in one flash event. The duration of a stroke (stroke duration) is typically between 100 μ S and 500 μ S, and time between each stroke (interstroke interval) of the same flash is spaced in the order of tens of milliseconds. The duration of a flash (flash duration) is simply the summation of the interstroke intervals and stroke durations from the beginning of the first stroke to the end of last stroke. These characteristics of stroke multiplicity, flash duration, and interstroke interval, all depend on varying environmental factors that will be discussed in the presentation.

Section B - Lightning Detection Systems:

The original demand for having a lightning detection network for North America came from the electric utility industry around 1983. The benefits of locating cloud-to-ground (CG) lightning was realized by industry and led to funding from the utilities through the Electric Power Research Institute (EPRI). Many industries, such as weather networks, insurance companies, forensic firms and others also appreciated the usefulness of such a network and supplied a further catalyst for the full implementation of a commercial data service. At this point, the US Federal Coordinator for meteorological services encouraged and assisted to combine the individual networks into a single National Network. This network began in 1991, is presently operated by Global Atmospheric, Inc., and is referred to as the "U.S. National Lightning Detection Network" (NLDN).

The purpose of this section is to describe the history and operation of the NLDN. Discussion on the brief history of lightning detection systems, current detection systems, NLDN operation and parameters, and a short description of the NLDN performance parameters will all be presented.

Dating back to the 1920s, Watson-Watt and Herd developed a cath-
 eray direction finder (CRDF) that used a pair of orthogonal loop
 antennas tuned to approximately 10kHz. These detected the horizontal
 magnetic field produced by lightning. The azimuth angle to the discharge
 was acquired from displaying the strength of the East-West and North-
 South components of the magnetic field. This was then displayed on an
 oscilloscope and the resulting vector pointed in the direction of the
 lightning discharge. Two or more of these CRDF's would reveal the
 location of the strike from the intersection of the direction vectors. This
 technology was used up until and during World War II in many regions of
 the world.

Presently, improved systems have been developed, namely the
 "Gated Wide-Band Magnetic Direction Finder" (DF), and the "Time-of-
 Arrival" (TOA) sensors. The magnetic DF sensors can locate lightning
 within a range of approximately 500km. They are designed to respond to
 field waveforms that are characteristic of the return strokes in cloud-to-
 ground flashes. The magnetic field is sampled at the time of stroke current
 peak, as is the electric field to give an indication of the stroke polarity.
 TOA sensors operate by receiving the far-field radio pulse emitted from a
 lightning stroke. The stations across North America are temporally syn-
 chronized and use the constant difference in radio pulse arrival times to
 define range hyperbolas. The intersection point of these hyperbolas gives
 the location of the lightning strike.

The NLDN network currently employs 59 TOA, and 47 combined
 DF/TOA sensors. In order to effectively detect lightning in any location,
 these sensors are located in a strategic pattern throughout the U.S.A. The
 NLDN has also employed a real-time data acquisition system that may be
 viewed over the Internet. Although, the real-time data may not be as
 accurate as the stored data which is processed later for any possible cor-
 rections (e.g., recalibration gains, improperly functioning sensors etc.).

The existence of the NLDN enables the Forensic Engineer/Scientist
 to locate the incidence of a lightning strike. This network is an invaluable
 tool to facilitate in a lightning accident investigation.

1 "High Voltage Engineering: The Lightning Discharge". University of Toronto
 masters course. Professors: Dr. W. Janischewskij and Dr. A.M. Hussein.

2 "High Voltage Engineering: The Lightning Discharge". University of Toronto
 masters course. Professors: Dr. W. Janischewskij and Dr. A.M. Hussein.

Lightning, Detection, Phenomenon

C12 Lightning Injuries and Cases-Part II

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The participants will increase their understanding of lightning
 injury pattern recognition and phenomenon.

Despite all that we know about lightning, there are still many myths
 that surround it. Probably the most common belief is that injuries from
 lightning are rare, and, when they occur, are invariably fatal. While the
 incidences of lightning injuries vary by geographical location and the
 topography of the land, they are quite common in most populated areas.
 Each year in the United States about 1,800 people are struck by
 lightning. Of victims seriously injured by lightning, 20% to 30% die and
 up to 75% of the survivors have permanent sequelae. Those that are
 involved, but not struck, may have no sequelae.

Electrical injuries are very complex and can be a potentially devas-
 tating form of trauma. The manifestations and severity of electrical
 trauma encompass a wide spectrum ranging from a transient unpleasant
 sensation, due to a brief contact with low-intensity household current, to
 instantaneous death and massive injury from high-voltage electro-
 cution/lightning injury. Unlike thermal burns, electrical injuries com-
 monly involve multiple body systems with potential to pose difficult
 challenges regarding accurate assessment and proper treatment.

Many people believe that when lightning strikes a victim, he/she is
 severely burned or burned to a crisp because of the lightning's

tremendous energy and violence. Lightning sometimes causes deep
 burns, but usually results in surface damage to the skin and soft tissues.
 This damage may play havoc with the cardiac and neurological systems,
 since it interferes severely with the body's natural electro-chemical
 systems. The amperage, voltage, type of current (AC vs. DC), duration
 of contact, tissue impedance and current pathway through or over the
 body will determine the type and extent of injury. Higher voltage, higher
 current pulse, longer contact, and flow through the heart are all
 associated with greater injury outcome.

There are several ways in which a lightning victim may be injured,
 affected or involved: direct strike, ground current step-potential, voltage
 from touching a struck object, side flashover (splash) from another
 object (e.g., tree or pole), and blunt injury. Direct strikes to humans
 generally occur from the misconception that one cannot be hit if the
 storm has just begun or appears to have terminated. Also, the presence
 of rain is not a requirement for lightning to strike. Furthermore,
 lightning may hit as far as 10 miles ahead of a thunderstorm and most
 people unaware about the hazards of lightning remain outside until rain
 begins to fall. The most common mechanism for lightning injury is
 "splash." In this situation, lightning strikes an object first and then
 jumps to a nearby person of lower surge impedance and resistance. With
 ground current step-potential, the stroke hits the ground and radiates out-
 wards to the victim. Injury is then inversely proportional to the distance
 from the strike. Blunt injury results from the lightning shock wave,
 which leads to acoustic trauma, contusion of internal organs, or from
 being thrown and falling. The violent propulsion of some lightning
 victims is secondary to titanic muscular contraction or the acquisition of
 charge. According to reports and theories, when struck by lightning, the
 victim becomes highly charged and may be strongly attracted to or
 repelled by an adjacent object.

According to the National Lightning Safety Institute (NLSI), sta-
 tistics of location of lightning strikes for the period of 1959-1994 are
 listed in the table below:

Location of Lightning Strikes

40%	Unreported
27%	open fields and recreation areas (not golf)
14%	under trees
8%	water related (boating, fishing, swimming, etc.)
5%	golf-related
3%	heavy equipment and machinery-related
2.4%	telephone-related
.7%	radio, transmitter and antenna-related

Gender of victims	84% male	16% female	
Months of most incidents	June 21%	July 30%	Aug 22%
Days of week of most incidents	Sunday	Wednesday	Saturday
Time of day of most incidents	2:00 p.m.	to 6:00 p.m.	

Many victims of lightning injuries do not take the necessary pre-
 cautions to prevent accidents from occurring. Sports or recreation fields
 are a hazardous target since many organizations do not evacuate the
 fields prior to the first drops of rain. Since lightning may strike as far as
 10 miles ahead of a thunderstorm, it is very unsafe for individuals to
 continue their recreational activities in the event of a thunderstorm.
 Also, water-related activities provide an unsafe situation in the event of
 an electrical storm. Again, many individuals do not realize that lightning
 can strike up to 10 miles ahead of a storm and thus fail to evacuate the
 water in time. Some boaters are too far off-shore to be able to reach the
 shore in time. It is advisable to check the weather forecast and always
 be on the lookout for a possible thunderstorm due to the severity of
 injury that can occur as a result of it.

It should also be understood that lightning injury and death, while
 most common outdoors, can also occur indoors. The mechanisms are the
 induced voltage or side flash. Sometimes the source is the telephone,

although other systems, such as electrical appliances, underground or overhead wires, and water pipes, which connect to substantial metal outside the structure, may be a source of induced voltage or side flash.

In the case of the telephone, a voltage difference is generated between the person and the telephone. There are several ways this can occur: First, the telephone wires outside are directly struck (placing large amounts of charge on the telephone lines with respect to ground potential), leading to flashover from the phone, through the person, – and then into the ground. Second, large voltages on the phone lines are induced by close strikes, or because the potential of earth, power ground, or other grounds attached to the person is raised due to lightning current injection into the person. The resulting voltage difference between the headset and the body causes a spark between the headset and the ear, often burning the ear canal and breaking the eardrum, and sometimes causing death or injury.

According to the National Lightning Safety Institute (NLSI), statistics of lightning strike victim’s sequelae are listed in the table below:

Lightning Strike Victim’s Sequelae (Frequency of 25% or Greater)

Memory Deficits & Loss	52%	Depression	32%
Attention Deficits	41%	Inability to Sit Long	32%
Sleep Disturbance	44%	External Burns	32%
Numbness/Parathesias	36%	Severe Headaches	32%
Dizziness	38%	Fear of Crowds	29%
Easily Fatigued	37%	Storm Phobia	29%
Stiffness in Joints	35%	Inability to Cope	29%
Irritability/Temper Loss	34%	General Weakness	29%
Photophobia	34%	Unable to Work	29%
Loss of Strength/Weakness	34%	Reduced Libido	26%
Muscle Spasms	34%	Confusion	25%
Chronic Fatigue	32%	Coordination Problems	28%
Hearing Loss	25%		

Lightning injury has partly neurological side effects, affecting all three parts of the nervous system: 1) the brain – neurocognitive changes, sleep disturbance, personality change, seizures, learning disability type problems, post-concussive headaches and nausea; 2) autonomic nervous system – regulation of some blood pressure and cardiac response (positive tilt tests, dizziness), sympathetically mediated pain syndromes; 3) peripheral nervous system – chronic pain and sometimes sensory problems. According to medical practitioners, many of these injuries are ongoing and not easy to quantify or treat.

The severity of trauma that can occur during a thunderstorm is alarming when one considers that many occurrences were preventable by taking basic safety measures. There are many myths surrounding thunderstorms and individuals are not informed as to the dangers of lightning. The figures and facts presented in this paper only begin to describe the phenomenon of lightning and the injuries related to lightning. Lightning injury is as elusive and difficult to diagnose and predict as lightning itself. Direct strikes on the body are usually accompanied by “Lichtenberg” arboritic type patterns on the skin.

Engineers and technicians should concern themselves with lightning protection system design, testing, and commissioning, in order to achieve a Faraday cage like design, or other shielding (including sky wires or rods) that protects potential victims and objects. The metal skin of an airplane, automobile, and buildings are common examples of a Faraday cage.

Lightning, Electrical Injury, Patterns

C13 Court Appointed Expert Selection Methodology

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The purpose of this presentation is to suggest methodology for selection of court appointed experts, highlight some of the important attributes a court appointed expert should possess, and propose the use of a multi-dimensional matrix system to determine the most appropriate expert witness.

Scientific and technical issues are playing an increasingly important role in the courts. Experts frequently are utilized by all parties to assist in the understanding of issues necessary to reach a decision. However, the Federal Rules of Evidence also allow the judge to appoint a non-partisan expert to assist in the analysis and understanding of technical issues. That expert may also assist the judge in articulating the rationale for the court’s decision.

Rule 706 of the Federal Rules of Evidence states that a “court may appoint any expert witness agreed upon by the parties, and may appoint expert witnesses of its own selection”.

Text of Rule 706

(a) Appointment

The court may on its own motion or on the motion of any party enter an order to show cause why expert witnesses should not be appointed, and may request the parties to submit nominations. The court may appoint any expert witnesses agreed upon by the parties, and may appoint expert witnesses of its own selection. The court shall not appoint an expert witness unless the witness consents to act. A witness so appointed shall be informed of the witness’ duties by the court in writing, a copy of which shall be filed with the clerk, or at a conference in which the parties shall have opportunity to participate. A witness so appointed shall advise the parties of the witness’ findings, if any; the witness’ deposition may be taken by any party; and the witness may be called to testify by the court of any party. The witness shall be subject to cross-examination by each party, including a party calling the witness.

Authors’ Comments

In an actual case, the judge ordered that the four experts representing the four parties nominate, interview, agree, and recommend a court appointed expert to the federal judge.

(b) Compensation

Expert witnesses so appointed are entitled to reasonable compensation in whatever sum the court may allow. The compensation thus fixed is payable from funds which may be provided by law in criminal cases and civil actions and proceedings involving just compensation under the Fifth Amendment. In other civil actions and proceedings the compensation shall be paid by the parties in such proportion and at such time as the court directs, and thereafter charged in like manner as other costs.

Authors’ Comment

In the example to be discussed, the court ordered that each of the four parties pay one-fourth of the court-appointed experts’ fees. The fees would be divided and sent to each party’s attorney monthly.

(c) Disclosure of Appointment

In the exercise of its discretion, the court may authorize disclosure to the jury of the fact that the court appointed the expert witness.

Expert witnesses must possess appropriate specialized qualifications or experience and their expertise must form part of a body of knowledge or experience, which is sufficiently organized or recognized to be accepted as reliable body of knowledge.

Authors’ Comment

In addition, there are additional attributes that need to be considered and assessed as set out in Table 1.

Methodology for Selection:

The authors suggest that the key attributes are education, training, and experience. In addition, the court may require specific experience that is relevant to the particular issues facing the court. If this attribute is missing, the court may not recognize the individual as qualified to testify as an expert. The criteria for evaluating potential expert witnesses can be appraised based on the following categories: possible conflict of interest, education, practical experience, publications, forensic experience, design experience, application experience, technical issues, safety issues; court experience, available support, and professional affiliations.

The following table created and used by the authors suggests a possible point rating system for assessment of three candidates as a court appointed expert:

TABLE 1

ATTRIBUTES/COMPETENCES	CANDIDATES		
	A	B	C
Conflict of Interest	- ½	---	- ½
Education	+1	---	+1
Field Experience	---	+ ½	+ ½
Forensic Experience	---	+ ½	+1
Design Experience	+1	---	---
Application Experience	All Same	All Same	All Same
Technical Issues	All Same	All Same	All Same
Safety Issues	---	+ ½	+1
Court Experience	---	+ 1	+1
Support Within Co. Size	---	+ ½	+1
Affil. Professional Association	+1	- ½	+1
Internal Library	0	+ ½	1
Points Total	2 ½	3	7

By using the methodology of a multi-dimensional matrix system, it was determined that candidate "C" possesses the most relevant attributes and expertise as a court appointed expert. The identification of a court-appointed expert witness is the process of careful examination of all available attributes to aid the four experts in agreeing to the selection of the court appointed expert, who would then be recommended to the court.

Conclusion:

Table 1 thus provided a logical method to overcome the difficulty faced by opposing experts in being able to agree on an independent court appointed expert. This methodology worked well in a recent case. The selection process for a court appointed expert appears to have many similarities from court to court. In addition, another common feature is that the court expects the expert to obtain the information necessary to the case, and then interpret its meaning. The court appointed expert must prepare a protocol for obtaining the information and then obtain it, using the power of the court. The protocol would describe documents needed, testing needed, and experiments and inspections necessary. In this way, the use of a court appointed expert is both efficient and decisive.

Appointment of an expert will undoubtedly remain a rare and extraordinary event, suited only to the most demanding cases and judges. Regardless, Rule 706 remains an important alternative source of authority to deal with some of the most demanding evidentiary issues that arise in federal courts.

Court Appointed Expert, Witness, Selection

C14 Spray-In Foam Insulation—Energy Efficient and Electric Nightmare

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The goals of this research project are to familiarize the electrical engineer with the hidden dangers of spray-in expanding foam insulation and its extraordinary ability to inhibit heat transfer.

Spray-in expanding foam insulation has recently entered the marketplace for home construction. Inherent in home construction is a lack of coordination among the trades; that is, each of the trades has no idea as to what the other trade is doing and when they are doing it. Also inherent in home construction is the predominant use of type NM for electrical wiring in a house

Expanding foam insulation relies on the injection of small amounts of urethane-based cellular foam into wall cavities and stud spaces, with the urethane then expanding greatly to completely fill the cavity. The R value of such systems is very high, and the foam saves on labor costs typically associated with roll or bat forms of fiberglass. In addition, the foam is presumably less harsh on installers who do not have the worries associated with fiber-induced respiratory problems or forms of contact dermatitis.

When one has a "good" R value for insulation, then, by definition, that insulation system is a poor conductor of thermal energy. For this study, we outline the electrical fire dangers associated with this type of foam. A series of test panels was constructed to simulate 4" and 6" wall stud spaces. Runs of type NM were installed in various configurations, and the stud spaces were filled with the expanding foam, which also coated the wiring. Thermocouples had been placed within the wire runs to measure internal temperatures. The type NM was then energized at constant current levels and maintained until thermal equilibrium was reached

Our testing shows that the foam is excellent at inhibiting heat transfer, which is the worst condition that can be placed on wiring systems - a lack of heat transfer. Twelve AWG copper, while useful at 30 amperes, is limited by Code to 20 amperes for NM usage. Our testing shows that at 20 amperes, the thermal foam insulation is so "good" that the heat cannot escape and the wiring can exceed the limits of its PVC insulation. When multiple runs are present, the type NM will char, degrade, and short circuits will develop.

The testing also demonstrates the fact that there is no effective circuit breaker protection when wire is insulated in this fashion and run at name-plate rating. Per NEMA AB-1, a 20 ampere breaker must trip at 27 amperes (135%) in 1 hour or less. There is no Code requirement that the breaker trip at 1.1 or 1.2 times rated current levels. And yet, at these levels of current flow, the wiring is destroying itself because of the heat trapped by the foam. This mode of operation totally violates the spirit of NEC Article 240, for which the underlying premise is that a breaker will trip before the supply wiring is damaged from overcurrent.

When electricians install the home wiring, they have no knowledge of the insulation system that will be used. Thus, they often group wires together for ease of installation, unaware that the wiring will later be encased with the foam. Further compounding the problem is the foam manufacturer's belief that circuits will never be overloaded; in truth, there is no control over how a circuit is loaded, as long as the breaker does not trip. As earlier demonstrated, the breakers respond to trip levels of 135%, and have no effect in the 110% and 120% levels, which are areas where the wire will destroy itself because of the foam.

The result of this foam system is that the foam has destroyed the factor of safety that is built into the normal electrical system. Wires rated, as an example, at 20 amperes can easily handle 40 amperes under many conditions and not be damaged. The foam, however, takes away this safety factor, and places the wiring at a point where it can create a fire and for which the overcurrent protection will not respond.

Electrical Fires, Overcurrent Protection, Thermal Insulation

C15 Forensic Aspects of Automotive Headlights

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The goals of this presentation are to show the complexities encountered in the compilation of a database on automotive headlights.

This paper describes a project at the National Institute of Standards and Technology (NIST) to compile a database on automotive headlights. The database is intended to serve the forensic community and law-enforcement in investigations to determine the identification of a specific vehicle, such as the year, manufacturer and model, from fragments of headlights left at the scene of hit-and-run crimes.

A major challenge today is that the current market and application of headlights in vehicles is very large and complex. In prior years, headlight parts, such as lens and reflector components, were made from borosilicate-type glass produced principally by three companies. Several lamp makers then assembled the lens and reflector glass parts as single unit sealed-beam headlights. Nearly all of these production and assembly facilities were located in the United States. These sealed-beam headlamps were then installed in passenger-type vehicles in both right and left front locations for road illumination. Of significance is that prior to the 1980's, over a period of twenty years, only a couple of dozen different sealed-beam headlights designs were installed in all sort of vehicles, built mostly in the United States.

Today, there are diversities in materials, many suppliers, and constantly changing designs. Glass, plastics, and glass-plastic hybrids, are used for headlight systems. These headlights are installed in different types of vehicles, such as passenger cars, sport utility vehicles (SUVs), light trucks, and minivans. The number of different vehicle models is significantly greater today than in the past. Design is very important in marketing strategies; changes are made each year and headlights are no exception. In the majority of cases, headlights today are designed specifically for the left and right location in a vehicle, and therefore, cannot be interchanged. For the North American market, which comprises Canada and Mexico, headlights are made and assembled by a large number of companies, many of which are located offshore. Similarly, the U.S. market involves vehicles that are about thirty percent imports. Another complication is that the worldwide market for automotive components is very competitive. Therefore, the automakers and their suppliers consider parts source information and pertinent designs company proprietary. In this situation, the origin, application, the identification details for headlights, along with the associated purchasing and referencing system, are exceedingly intricate. For these reasons, a databank for headlights installed in all vehicles makes and models built in any model year is a massive and very complex task.

This paper discusses current NIST- Industry collaborations that have the purpose to create a database on headlights. These established collaborations include the major automakers, parts suppliers, and the SAE International Committee on Headlights. This partnership is designed to generate and establish a running mechanism for data collection for a database on automotive front lighting systems. The new database encompasses the identification details, visual characteristics, and information of single headlights and front lighting assemblies, for both the right and left positions, from present to future production and application. Covered data include the headlamp, materials, inner and outer lens, park and turn signals, side marker, side reflex, and daylight running lights (DRL). This database is a very difficult task because it involves many headlight designs. However, because each design is specific for a particular year, type, and model of a vehicle, the output of this project will provide an effective diagnostic tool in forensic investigations in which fragments of automotive headlights exhibited as evidence can conclusively be linked to a vehicle involved in a crime.

For glass sealed-beam headlights, material characterization measurements, practices and standards have been developed. Similar method-

ologies are needed for contemporary headlights made of plastics. This paper also discusses insights on measurements and standards needed to characterize present-day headlight systems.

Automotive Headlights, Automotive Classification, Forensic Science

C16 Premature Failure of a Floating Ring Rotary Compressor Incorporating Liquid Lubrication

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The goals of this research project are to illustrate the necessity to pay close attention to the details of kinematics, tribology, and material selection in the design of machines and the analysis of failure.

Rotary compressors employing liquid lubrication used in some refrigerators have prematurely failed due to wear on the outer surface of the floating ring (or rolling piston). The ring wear caused by the sliding contact with the vane which separates the inlet and outlet ports of the cylinder was due to the distinctive motion of the floating ring. A metallurgical analysis of the wear problem was made. Ring/vane pairs from four compressors employing liquid lubrication and a ring/vane pair from another manufacturer's compressor, which incorporates a graphite/metal vane, were examined.

Conceptualization of the Motion and Relative Wear Problems: The basic components of the compressor are a cylinder; an eccentric circular shaft with its axis of rotation coincident with the axis of the cylinder; a floating, a constant thickness ring fitted on the eccentric shaft; and, a spring-loaded vane that moves in a slot in the cylinder wall along a radius of the cylinder so as to fill the gap between the cylinder and the ring. The sum of the ring outside radius and the eccentricity of the shaft are effectively equal to the radius of the cylinder ($R=r_0+e$), so that as the shaft rotates, a single line of contact exists between the ring and the cylinder wall which sweeps around the circumference of the cylinder.

If the ring were locked to the eccentric shaft, the sliding speed between the outside of the ring and the cylinder at their line of contact would be the rotational speed of the shaft times the radius of the cylinder. The sliding speed between the ring and the vane would vary between that speed, when the vane is fully retracted from the cylinder, and the rotational speed of the shaft times the radius of the ring less the shaft eccentricity when the vane is fully extended into the cylinder.

If the ring was prevented from turning relative to the cylinder by having the vane end seated in a notch in the ring, the sliding velocity of the ring and cylinder will be zero. The effect would be pure rolling contact between the ring and cylinder. The sliding velocity between the ring and vane will also be essentially zero, but there will be a relative angular motion between the radius of the ring and the axis of the vane. There will be a sliding velocity between the shaft and the inside of the ring that varies around the inside of the ring.

The Range of Solutions and Their Trade-offs: Locking the ring and shaft together produces high sliding velocities at the cylinder wall and vane, generating high temperatures. The high temperatures would compromise the film of lubrication. Preventing the ring from rotating relative to the cylinder would solve that problem. It would shift the high sliding velocities to the shaft/ring interface, but because of the smaller radius the sliding velocity would be much less. Also, the lubrication of that interface is more positive and controllable than the lubrication of the outer surface of the ring. The main problem for this configuration would be the oscillating load on the vane caused by the relative angular motion between it and the ring radius and lubrication of the notch/vane interface. We know of no such designs in use, so the magnitudes of the problems are not known.

This design takes a middle ground: the ring is allowed to float relative to the shaft and the cylinder/vane. An equilibrium condition develops where the rotational velocity of the ring cycles between zero and about 10% of the shaft speed. This reduces the sliding velocities at the shaft/ring inner surface interface and produces moderate, maximum sliding velocities at the ring/cylinder and ring/vane interfaces.

The inherent problem with this general design is that the sliding velocities between the vane and the ring go to zero twice per revolution. When liquid lubrication is used, there must be sufficient relative motion between surfaces to produce the hydrodynamic forces necessary to hold them far enough apart that the surface irregularities of each do not make contact (elasto-hydrodynamic lubrication or EHL). Because the relative velocities between the vane and ring and between the cylinder and ring periodically go to zero, at each occurrence there will be distances along the circumference of the ring that are not lubricated because the velocity is too low to produce the necessary hydrodynamic forces. The wear at the vane/ring interface will be pronounced.

Required Corrective Measures: When EHL is no longer effective due to insufficient sliding speed, boundary lubrication or solid lubrication must be used to decrease the friction coefficient and material wear rates. Boundary lubricants are typically long chain molecules that are absorbed into the sliding surfaces creating thin interacting surface layers, or lubricant additives, whose molecules react with the sliding surface at the transient high temperatures and pressures of marginal EHL films, forming low shear strength surface films. Since there are problems in supplying adequate lubricating films to the outer ring surface at the vane interface in the rotary compressors, a solid lubricant system would appear to be the obvious solution. One component of the sliding pair could be made of a composite containing a solid lubricant such as graphite dispersed in a metal matrix. The vane would be the component best suited to fabrication from the solid lubricant material. Other rotary compressor manufacturers use such components. One such ring/vane combination was examined and found to fulfill the requirements for solid lubrication.

Rotary Compressors, Machine Design, Tribology

C17 Dust Explosion Produced by Lightning Storm

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Participants will learn the severity of dust explosions. The forces produced by dust explosions are some of the most powerful and destructive as characterized by the explosive event. Participants will learn to properly classify explosions.

There are two major types of accidental explosions: mechanical and combustion. Explosions are characterized by the sudden conversion of potential energy into kinetic energy with the release of a gas under pressure. The release of the high-pressure gas subsequently does mechanical work by deforming moving, shattering, or generally changing nearby materials. The primary result of an explosion is the generation and subsequent release of a pressurized gas and not the loud noise that is produced. The noise is simply the by-product of the expanding gas envelope in the air medium.

Combustion type explosions can be classified as

1. Flammable gases,
2. Ignitable vapors,
3. Dusts,
4. Low explosions,
5. High explosions, and,
6. Smoke and flammable by-products of incomplete combustion.

The last type of explosion is commonly known as a back-draft explosion and was portrayed in a movie by the same name. The explosion

in this case was not a mechanical explosion because there was no high-pressure gas confined within a vessel. A mechanical explosion consists of the rupturing of a vessel that has been subject to high pressure. Similarly, there were no ignitable vapors, explosives, or back-draft conditions that may have produced the explosion. The only two possible scenarios were the ignition of a flammable gas or dust within the confines of the environment. This explosion occurred at a plant that manufactures fuel pellets for fireplaces and heating chambers. The raw product for this process is discarded wood chips from logging and milling operations. The wood remnants are not suitable for the manufacture of particleboard or oriented strand board and contain a significant amount of sawdust. The raw material is stored outside and is subject to significant moisture infusion in addition to its green condition. Therefore, the material must first be passed through a dryer in order to reduce the moisture content of the material to a working level. The dryer is powered by natural gas, which could have produced an explosive environment within the dryer. Inspection of the dryer indicated that this scenario was not the case for three reasons: 1) the explosion epicenter was located away from the air heater at the transition between the dryer drum (referred to as the tail) and the ductwork leading to the main cyclone; 2) the system was purged of gas; and 3) A flammable gas type explosion would have produced more flame spread.

Dust Explosion, Explosion Classification, Tensile Strength

C18 The Diving Hypothesis

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The goal of this presentation is to evaluate the hypothesis that serious injuries in rollover collisions are due to “diving” into the roof.

In the 1970’s, safety belt usage rates were 10 to 20 percent. At that time, publications and “scientific” papers generally concluded that most rollover injuries would be prevented if vehicle occupants wore their seat belts. The papers hypothesized that rollover injuries were primarily ejection related, while injuries occurring to contained occupants were a result of “diving” into the roof. In the majority of the papers, it was suggested that roof crush and injury were not causally related, since the diving velocity was assumed to be independent of roof deformation. For these hypotheses to be true, several key parameters would have to be established:

- a. Ejection portals must exist independent of roof deformation.
- b. Centripetal and inertial forces acting on contained occupants are negligible.
- c. The “diving” velocity of the occupant exceeds the threshold velocity for serious injury.
- d. Safety belt restraints will prevent ejection and minimize or eliminate the “diving” injury risk.
- e. Rollover collisions are likely to be benign for belted occupants.

Today, safety belt usage rates are approaching 80 percent. Safety belted occupants in rollovers are being seriously injured, ejected and killed. It is obvious that one or more of the key parameters must not be true.

Effect of Roof Deformation on Ejection Portals:

Reinforcing the roof structure reduces glazing failure and minimizes risk of partial or complete ejection. In all of the rollover tests reviewed, vehicles with deformed roofs had more glass failure.

Inertial and Centripetal Forces:

The frictional forces and belt loads will resist movement of the out-board occupant’s torso towards the roof, since the roll velocity often results in centripetal accelerations exceeding three g.

Velocity Tolerance:

a) Based on Falling and Diving:

- i) Cervical spinal injuries with the potential of paralysis rarely occur in head first accidental falls of less than three meters. (9.6 feet) The impact velocity exceeds 7.5 m/sec (17 MPH).

- ii) Cervical spinal injuries in sport and recreational diving generally are consistent with head to pool bottom contact velocities of more than 4.5 m/sec (10 MPH).
- b) Based on Intact Cadaver and Test Dummy Impacts:**
 - i) Intact cadaver neck failures occur at similar impulse/energy values independent of dynamic loading methodology.
 - ii) The likelihood of clinically relevant cervical fracture when a cadaver is dropped head-first less than a meter (3.3 feet) is extremely low. That velocity exceeds 4.5 m/sec (10 MPH).
- c) Based on Isolated Cervical Spine Tests**
 - i) The isolated spine failure energy is much less than that required to fracture the cervical spine of intact cadavers.
- d) Based on Human Volunteer Testing**
 - i) Restrained human volunteers have been drop-tested in reinforced production vehicles 91 cm (3 ft.), and have survived measured head loads of 1400 N (315 lb.) without injury.
 - ii) A 91 cm drop equates to an impact velocity of 4.4 m/sec (9.5 mph).
- e) Based on Windshield Impacts**
 - i) Occupants fracture HPR windshields in frontal collisions.
 - ii) Windshield fracture occurs at impact speeds greater than 6 m/sec (13.5 mph).
 - iii) At speeds below 6 m/sec, neither the windshield nor the cervical spine fractures.
 - iv) Either head injuries or facial lacerations generally occur when the windshield fractures, alerting researchers to these impacts.

Conclusion:

The equivalent roof damage to that seen in typical rollovers can be generated in a 0.3 to 0.5 meter (12 to 19 inch) drop test. That drop height is one third to one half the minimum drop required to cause a cervical fracture to an elderly cadaver. The test data and the engineering and medical literature cannot support several of the key parameters on which the “diving” theory depends, since a head impact without roof deformation doesn’t cause injury. In fact, similar injuries to those present in rollover collisions occur when moving vehicles strike relatively lightweight falling objects that deform the roof structures. In those collisions, “diving” is impossible, since there is virtually no vehicle center of gravity vertical movement.

Cadaver Testing, Rollover, Neck Injury

C19 Speed From “Scuffs” on a Grassy Field: A Case for Dr. Daubert?

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The goals of this research project are to provide a critical examination of the abuses of critical-speed scuff analysis under the *Daubert* standard, and to provide further insight on the admissibility of scientific evidence, as well as methods for preventing sub-standard evidence from being admitted.

At what point does the unorthodoxy of a technique proffered as “scientific” evidence become excludable under *Daubert*? How is a judge to know when measurements bearing a first-order resemblance to ones generally accepted in the relevant technical community (and thus in compliance with the *Frye* test, which is one of the *Daubert* factors) become so lacking in scientific basis that they should be barred from the courtroom? Once again, the critical speed scuff mark (CSSM) technique provides a point of discussion of this question. The recent experience of one of the authors in confronting this question is presented below, along with some suggestions of how to deal with a *Daubert* hearing relating to unorthodox CSSM applications proffered as scientific evidence. In particular, the question of how an expert witness is to deal with the old “where in the literature does it say you *can't* do this?” line will be discussed. Also,

the debate about how candid one should be in preparing writings prepared in anticipation of testimony will be re-visited.

Largely as a result of experimental studies carried out over the past 15 years, the CSSM technique, introduced at least 50 years ago, has been shown to give the “right” answer provided that certain conditions prevailed during the creation of the “scuff mark” (better stated, “cornering mark”) on which the method is based, and provided that care is taken in the measurements made on that mark. In particular, if the cornering mark has an effective radius of curvature R and the sliding coefficient of friction (COF) between the tires and the road surface is μ , then the equation

$$S = [g\mu R]^{1/2} \quad (1)$$

gives a useful value for the cornering vehicle’s speed, S , provided that several conditions are met, such as that there is not significant braking of the vehicle by its operator during the creation of the mark. The statement about the usefulness of the speed calculated from Eq. (1) is based on the published and unpublished results of hundreds of tests over the past 15 years. By “usefulness,” it is meant that the calculated speed is acceptable for purposes of conservatively assigning culpability when the vehicle operator is a potential defendant following a motor vehicle crash. That in turn means that the calculated speed must be on the low side of the actual speed. A common misconception about the CSSM technique is that the calculated speed is the “minimum” speed of the vehicle. In cases of criminal prosecution, this false assertion will often be brought out in the form of a statement such as, “The defendant must have been driving at least X miles-per-hour in order for his vehicle to leave these marks.” The truth about the CSSM technique is that it provides a calculated speed that is close to, and usually slightly less than, the actual speed.

All of the referenced tests have been carried out on hard surfaces that presented a single value for μ . More particularly, they have all been carried out on paved roads or surfaces that could serve as paved roads. Furthermore, it seems clear that all of the theoretical discussions of the technique going all the way back to J. Stannard Baker’s envision such paved surfaces. What then is a crash analyst to do when presented with speed calculations based on curved tire tracks on a grassy field full of hillocks? It seems clear that if asked to evaluate them by the prosecutor wishing to use them, he/she should say that it is inappropriate to do so, that it is an unacceptable application of the CSSM technique. In the criminal prosecution forming the point of departure of this discussion, that is exactly what the physicist/crash-expert consulted by the DA did. Concurrent with receiving that evaluation from his own expert the DA received the defense expert’s report, which stated exactly the same conclusion. Furthermore, the DA correctly opined that the two evaluations were done independently of one another. Nevertheless, the DA steamed ahead, prepared to present his CSSM in grass based on his police reconstructionist’s testimony. He also provided the defense attorney with his own expert’s report invalidating that expected testimony — as he was obliged to do because it was potentially exculpatory for the defendant. The DA also made a motion *in limine* to exclude all mention of his own expert’s opinion. This set the stage for the defense expert to convince the judge that the grassy CSSM should be excluded. In this he failed. This failure probably can be attributed to an experiment with the CSSM on grass that the police, working on behalf of the prosecution in anticipation of the trial, carried out in the wake of the DA’s receiving the two referenced reports criticizing the grassy CSSM.

The experiment was set up with some attention to proper control of the test subject, the police officer who had done the CSSM calculations following the crash leading to the prosecution. In particular, five sets of tire marks were laid down by a vehicle traveling at approximately 30 mph on a grassy surface having some bumps, but arguably smoother than the field on which the marks were laid down in the crash. The police officer was present only after these marks had been made, and he determined that three of the five sets of marks were consistent with CSSM. From these three sets of marks, he made three calculations of speed for the test vehicle.

During what was effectively a *Daubert* hearing, the defense expert listed the six *Daubert* factors that are regarded as indicia of scientific validity. Briefly, these are: 1) widespread acceptance, 2) peer review, 3) publication, 4) testing, 5) rates of error, and 6) the existence of standards. While no particular one of these standards is essential for scientific evidence to qualify under *Daubert*, the police experiment that was presented as evidence at this hearing clearly did not meet a single one of these criteria, being an unpublished, unreviewed test of a novel methodology (calculating speed from CSSM on grass) without any known rate of error. Nonetheless, admitted into evidence was the police officer's CSSM calculation of the original vehicle crash. As was predicted by one of the authors of the present paper in a paper co-presented to the AAFS in 1994, the *Daubert* standard failed to halt the admission of unqualified "scientific" evidence. Indeed, as this particular case demonstrates, the *Daubert* standard has opened new opportunities for untested methodology to enter the courts when lay judges (who, understandably, most often have little training in science) rule on a method's scientific appearance, rather than its scientific substance. This is not to say that the presented case was a lost cause for the defense from the outset. Rather, as with any hearing where non-*Daubert* qualifying evidence is being considered for admission, an expert can be successful in pointing out to the judge the shortcomings of the evidence, and with that in mind, the authors propose some pointers on how an expert may effectively criticize sub-standard scientific evidence.

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2. Lofgren, M.J. *Handbook for the Accident Reconstructionist*, 3rd Ed. University of North Florida: Institute of Police Technology and Management, 1985. p. 36.
3. Baker, J.S. *Traffic Accident Reconstruction Manual*. Evanston, IL: Northwestern University Traffic Institute, 1975. pp. 217-221.
4. In the state where the trial occurred the evaluation enunciated in *Daubert* had been accepted for many years as the proper test to apply.
5. Also, the judge granted the motion *in limine* to exclude the report elicited by the DA from his own expert.
6. Bohan, T.L. and Heels, E.J. "The Case Against Daubert: The New Scientific Evidence 'Standard' and the Standards of the Several States," *Journal of Forensic Sciences*, JFSCA, Vol. 40, No. 6, November 1995, pp. 1030-1044.

Forensic Engineering, Critical Speed, *Daubert*

C20 Motion of a Vehicle in a Plane— Mathematical Validation of the Critical Speed Equation

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The attendees will learn that the critical speed equation is valid if appropriately utilized in accident reconstructions. Validation is proven through standard mathematical techniques.

Recent arguments concerning the validity of the critical speed equation in engineering reconstructions of vehicular accidents have emerged. At the past two annual meetings, papers have been presented covering refutation and validation of the critical speed equation,

$$v = \sqrt{\mu g R}$$

In this paper we will present the mathematical validity of the critical speed equation as derived in a general case. The general case includes both normal and tangential components of acceleration that must be overcome in order for the vehicle to lose control.

The arguments against the use of the critical speed equation are as follows: An automobile does not behave like a rock on a string. Opponents maintain that while a vehicle is negotiating a turn and going into a yaw, part of the available road friction is drag and part keeps the vehicle from turning over. Thus, both tangential and normal components of acceleration need to be considered. In contrast, opponents reason that a rock on a string

uses all available force to keep moving in a circle so that the only acceleration for this model is the normal component. Furthermore, opponents state that since the critical speed method is derived from a rock on string, the critical speed determination is flawed and improper. A corollary argument deals with the proper choice of the coefficient of friction that is used in the analysis. They reason that since coefficients of friction, drag factors, or obtained from skid tests, they are improperly applied in critical speed calculations. The opponents of the critical speed equation argue that tire road interaction during braking is different than tire road interaction in a yaw. Consequently, they reason that utilizing frictional coefficients from skid tests are improper. These arguments, some valid and some erroneous, are clarified by a complete derivation of the motion of a vehicle in a plane. As the derivation will show, the proper coefficient of friction has both a normal and tangential component.

Generally, road curves are complex, including sections of spirals, circles, and straight lines. However, over the trajectory of a vehicle that loses control in a curve, a mean radius for the vehicle path with respect to its center of mass can be determined. Alternatively, the mean path of each vehicle tire can be determined so that the relative velocity of each tire can be computed with respect to a reference point. However, since we are interested in the vehicle velocity, the proper reference on the vehicle is its center of mass and not its individual wheels. Keep in mind that we assume the vehicle remains together during the loss of control.

The theoretical development starts from the motion in polar coordinates to a more generalized solution in normal and tangential components as described in Figure 1.

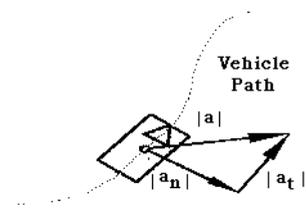


Figure 1 Motion of a Vehicle in a Plane

The loss of control criteria are governed by the inequality

$$\left(\frac{v^2}{R}\right) + \left(\frac{dv}{dt}\right)^2 \geq (\mu g)^2 \quad (2)$$

The solution over the limits of integration yields

$$|v_{CRIT}| = 0.967 \sqrt{\mu g R} \quad (3)$$

Considering both normal and tangential components of acceleration validates the critical speed equation. The coefficient of friction and radius must be appropriately chosen. Specifically, the coefficient of friction has both a normal and tangential component. The radius is that determined by the mean path of the center of mass of the vehicle.

Critical Speed, Normal and Tangential Acceleration, Path Radius

C21 Analyzing Crash Data to Verify Vehicle Spacing and Velocity in a Multiple-Impact Crash Event

Holly A. Adams, BS, and William Rosenbluth, MS, Automotive Systems Analysis, Inc., 12015 Center Lane, Reston, VA*

The goals of this research project are to analyze data retrieved from an event data recorder (EDR) to form a more valid and higher resolution crash scenario and time history. The data from the EDR can then be used to validate the accident scenario put forth by an accident reconstructionist.

Theory of the Analysis:

As many of the participants in this session are aware, EDR EEPROM data has been an important tool with respect to analysis of accident causation. Data containing information regarding the Delta V of a recorded event have been available as early as the 1994 MY on GM products. Even though this velocity information is only Delta V, where the actual pre-impact speed is not known, these milliseconds of data, combined with the recorded timing information, create a window of plausible pre-impact vehicle velocities which can validate, or discredit, an accident reconstruction.

An analysis is presented which describes the conditions from which data can be retrieved, the limitations of the EEPROM data, and the unique velocity pattern that provided a higher resolution work product with high engineering confidence. This work product included a timeline that not only validated a dual crash impact, but also provided the timing necessary to create an upper velocity limit for the impacting vehicle.

Discussion:

The feasibility of recording data parameters describing the dynamic characteristics of a crash impact started when the multiple electro-mechanical switches previously used for crash sensing were replaced by a solid state analog accelerometer and a computer algorithm integrated in an ECU which then evaluated crash severity in order to determine if air bags should be deployed. These systems could also record the status of the seat belts (buckled or unbuckled) for both deployment and near deployment events. Lastly, certain newer (1998+ MY) vehicles have the added capability to record vehicle data parameters for 5 seconds prior to an impact. These data parameters are vehicle speed, engine RPM, throttle percent, and the brake switch on/off status.



In this case example, a mid-sized passenger vehicle was impacted from behind by a tractor-trailer. This impact propelled the mid-sized vehicle into a large passenger 4x4. As the mid-sized passenger vehicle was impacting the 4x4, the tractor-trailer rear-ended it again, causing a re-acceleration of the mid-sized vehicle. As a result of the multiple impacts, the mid-sized vehicle experienced a fuel fed fire that burned the vehicle to its frame rails.

Of the vehicles involved in the accident, the mid-sized vehicle was the only one that had the potential to have saved critical crash data. However, because of the post-accident fire, the survival of the data was questioned. After many legal motions, the vehicle was inspected, and the SDM was found in the charred remains. Although it took very careful removal, the SDM was found to still contain the valuable crash data needed to support the accident reconstruction.

Analysis and interpretation of the SDM's EEPROM data confirmed that the mid-sized vehicle had been impacted twice from behind, and that in between those rear impacts, it had decelerated from a frontal impact. The velocities and timing associated within the crash and near deployment records bounded the possible entrance and exit velocities of the mid-sized vehicle, and consequently the impacting tractor-trailer velocity, allowing the reconstructionist to state with more certainty that the impacting tractor trailer did not hit the mid-sized vehicle at an excessive speed from which the fuel system should not have been expected to remain intact.

The use of the vehicle's own stored data to validate the reconstructionist's crash scenario greatly enhances the credibility of that reconstruction because the data being relied upon came from the vehicle, which does not bias the data with opinions or perceptions. It simply records what it experiences.

Black Box Analysis, Air Bag, EEPROM

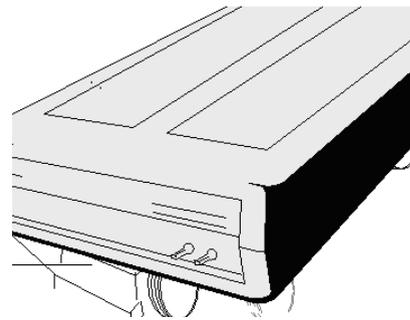
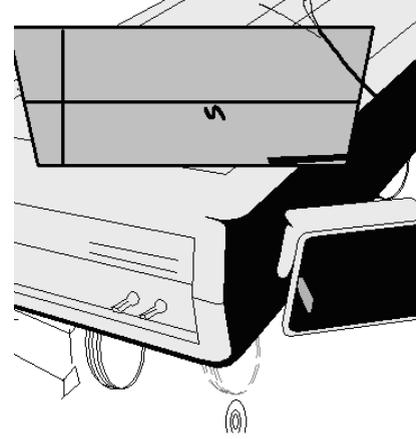
C22 Identifying Black Box Data Interrogation Codes on a Vehicle Area Network^[1]

William Rosenbluth, MS*, Automotive Systems Analysis, Inc., 12015 Canter Lane, Reston, VA

This paper will show the participant a methodology of extracting black box data for use in assisting with crash investigation assignments.

Theory Of The Analysis:

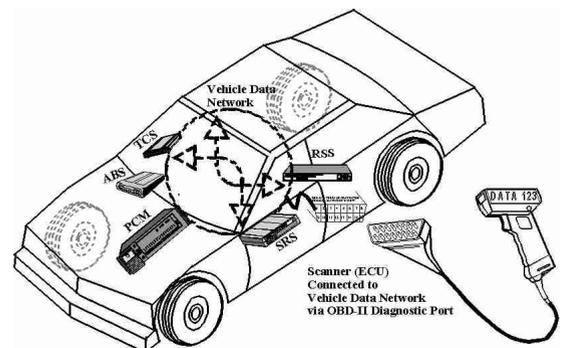
Most contemporary vehicles contain Electronic Control Units (ECUs) which are used for diagnostics and control in one or more vehicle systems. Many of these ECUs contain diagnostic trouble codes (DTCs), saved in non-volatile memory, to assist technicians in diagnosing intermittent malfunctions. In many cases, to further assist in intermittent malfunction diagnosis, certain vehicle operating parameters associated with the time of the DTC detection are also saved in nonvolatile memory. These are called freeze frame data. If the detected DTC is associated with a crash event, the associated freeze frame parameters can assist with accident investigation. Since such data were not originally intended for crash investigation use, it can be called *ancillary* crash event data. Systems containing ancillary crash related data can include:



- A. ABS controllers (EBCM, etc.),
- B. Engine/powertrain controllers (PCM, etc.),
- C. Transmission controllers, and
- D. Suspension controllers (RSS, etc.).

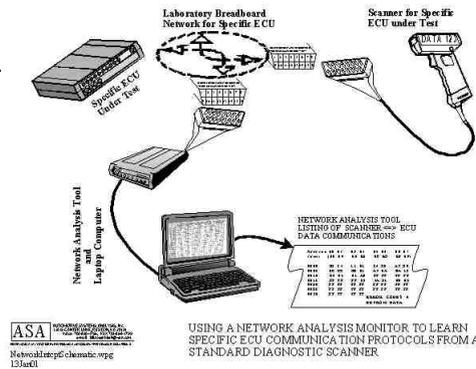
In addition to ancillary crash event data, certain systems are specifically designed to respond to a crash pulse, (air bags, seat belt pretensioners, roll bar deployment, etc.). These systems are designed to save crash related data in their nonvolatile memory. Such systems can include:

- a. SRS controllers (DERM/SDM/SRSU/ABDM, etc.)
- b. Event Data Recorders (EDR) and/or Trip Data Recorders (TDR, etc.)
- c. Rollover rollbar controllers
- d. Occupant position detection controllers
- e. Collision detection and warning controllers

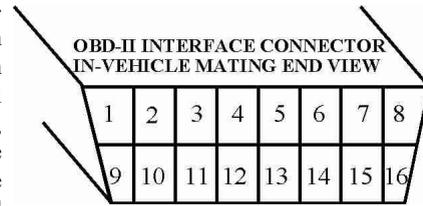


The electronic control units (ECUs) in many of these systems contain electronic memory which retains electronic data without battery power. Such memory is known as electrically erasable programmable read-only memory (EEPROM) or flash memory and it is this memory in which residual DTCs and freeze frame parameters are stored. In general, vehicle manufacturers provide their dealers and service technicians diagnostic tools sufficient to identify and isolate malfunctioning units on a vehicle area network. However, such service tools and procedures may or may not provide crash-event data such as desired by post-crash investigators. Such crash-event data are normally found only in special manufacturer scan tool equipment (or in specially formatted versions of service technician level scan tools).

In most 1996 and later passenger vehicles, most of the on-board ECUs are accessed via a vehicle network. There is no limit on design variations of scanners (Diagnostic ECUs) that can comply with the ISO 9141 / SAE J1850 / SAE J1979/SAE J2178 specifications, but they must all physically connect to the same SAE J1962 connector.



replicate the original commercial scanner input. In this manner, we can turn our network analysis tool into a substitute scanner, and hopefully incorporate the additional knowledge gained from our decrypted network message patterns, for known (simulated) vehicle input conditions. In this manner, we are establishing additional interrogation capabilities for that specific ECU.^[1]



Network Analysis, Vehicle Crash Data, Scanner Analysis

C23 Correlation Between Vehicle Damage and Impact Speed in Low to Moderate Speed Rear-End Crash Tests

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The goals of this research project are to review the limitation on the use of vehicle damage as a forensic tool and predictor of occupant injuries in low and moderate speed rear-end vehicle collisions.

A principal purpose of the staged crash tests described in this report was to explore the apparent disparity between published crash test results and injury observations gleaned from actual collisions. Forensic reconstruction of rear-end automobile collisions is complicated by the fact that staged crash tests have shown that it is possible for one vehicle to strike the rear of a second stopped vehicle at speeds up to 20 m.p.h. and leave no significant damage to the striking/struck vehicle. Obviously, significant forces can be imposed on the occupants of both vehicles. Data collected from the National Accident Sampling System (NASS) reveals that collision with a change in velocity of under 10 m.p.h. account for approximately 60% of neck injuries in rear impacts. Other studies have demonstrated that test subjects reported symptoms in collisions that had no damage, even when conditions were safety optimized. Thus, injury potential cannot be judged solely by damage to a vehicle.

During these crash tests we have experimentally determined damage profiles associated with vehicle-to-vehicle rear-impact collisions at speeds up to 12.6 m.p.h. Three crash test vehicles were employed: 1) A 1985 Ford Thunderbird, 2) A 1979 Honda Accord LX, 3) A 1986 Oldsmobile Calais Supreme. The vehicles were pushed to attain the desired speeds. The push vehicle was disengaged shortly before impact. Vehicle speeds were measured by timing the vehicle's passage between two light beams. Three sets of 3-axis microaccelerometers were mounted on the windshield, bumper, and center of mass of each target vehicle. Accelerometer data was captured at 10ms intervals. Accelerometers were factory calibrated to an accuracy of 1%. Although these are older vehicles, their "sisters" span a significant number of years. Newer vehicles have better designed bumper systems, which would produce less damage, at the same collision speed, but impose larger forces on the vehicle occupants. Bumper isolator compression was measured. It was observed that usually the isolators were fully stroked by the collision impact. In a few cases it was discovered that the isolator had been frozen until after the first collision. The vehicles were photographed and inspected before and after each collision to document the damage that occurred. In these tests, the front of each vehicle served as a bullet while the rear of each vehicle served as a target. The front and rear of each vehicle was used repeatedly, until damage became evident. The vehicle damage resulting from each crash test is summarized in Table 1.

On a network, each of the ECUs on a network have individual addresses, and each also has individual communication mode commands to enable interrogation of its EEPROM. None of these are published, but there is a way to determine the initial access to an ECU. OBD-II data consists of two parts, both acquired from the vehicle network by a serial access protocol.

All of the ECUs on an automotive network are autonomous. That means that any two or more ECUs, properly connected, will form a valid network. The standard means of interrogating any ECU on a network is with an approved manufacturer or aftermarket commercial scan tool (scanner). Once it is properly connected, the scanner acts just like another ECU on the network; however, its command and communication set is solely oriented to interrogating (or controlling) a target ECU. This configuration is shown in the above Figure or to the left.

Another tool that is available in the industry is a network analysis tool. These tools, normally used with a laptop computer, also connect to a network, and they have features that display and save network message traffic (in hexadecimal format). Thus, with such a tool one can see the exact format of communications between any two other ECUs on a network.

If we create a special network as shown,^[1] we can isolate a specific ECU and the commercial scanner that is interrogating it. If we then use a network analysis tool to monitor the communications between the specific ECU and the commercial scanner which is interrogating it, we can record that network message traffic (in hexadecimal format) occurring on the 3-ECU special network. We can then learn the physical addresses and a subset of proper command modes which cause an ECU response.

We can learn this because we know the commercial scanner input commands we initiated to cause any particular interrogation, and we can repeat these indefinitely. In our laboratory breadboard, we can also force certain DTCs to be detected at known (simulated) freeze frame conditions (e.g., wheel speeds, throttle position, brake status, etc.).

We can then begin to associate known repetitive input commands with repetitive hexadecimal-encoded network message patterns for known (simulated) vehicle input conditions, and soon we can remove the commercial scanner to create a 2-ECU special network, and interrogate that ECU with the learned hexadecimal-encoded network message pattern and

Table 1 Summary of Induced Vehicle Damage

Run No.	Bullet Speed (m.p.h.)	Bullet Vehicle	Target Vehicle
1	3.6	Ford No new visible damage (ND)	Honda No new visible damage (ND)
2	4.9	ND	ND
3	6.1	ND	Rear bumper indented ¼ inch, horn button popped off
4	6.1	ND	Dome light cover popped off
5	8.0	ND	Rear bumper indented ½ inch
6	9.6	Slight scuff on bumper pad	Rear bumper indented 1 inch over a length of 12 inches
7	10.5	Slight scuff on bumper pad	Minor left rear quarter panel deformation, bumper indented 1 ¾ in.
8	11.9	Slight scuff on bumper pad	Left rear quarter panel dented ½ inch, right rear quarter panel dented 1 ½ in.
9	4.3	Ford ND	Oldsmobile Slight bulge in right side bumper skirt
10	5.8	ND	3/8 inch indentation in bumper trim
11	7.3	ND	Bumper fascia indented 1 inch
12	11.3	Some misalignment of right front fender	Bumper center indented 1 ¾ inches over a length of 2 inches
13	12	Slightly greater misalignment of right front fender	Left rear fender dented 1 ½ inch; bumper indented 2 inches
14	3.9	Oldsmobile ND	Ford ND
15	12.6*	Right front bumper & parking lamp smashed	Little visible damage to rear bumper
16	11.3*	Right side of bumper smashed	Left rear quarter panel dented and bowed; left rear bumper indented 2 inches on outer edge
17	~6	ND	ND

* This collision involved an impact offset to the left on the target vehicle.

Table 2 presents the data relating to peak speed and acceleration levels of the target vehicles. Coefficients of restitution calculated from the data are also found in Table 2.

Table 2 Summary of Data

Run No.	Bullet Speed (m.p.h.)	Measured Target Speed = DV (m.p.h.)	Peak Target Acceleration (G)	Coefficient of Restitution
1	Honda Approx. 3	2.4	0.84	0.37
2	4.9	3.7	1.5	0.31
3	6.1	4.7	1.7	0.35
4	6.1	5.7	2.0	0.61
5	8	7.1	2.3	0.55
6	9.6	7.3	2.5	0.28
7	10.5	8.9	3.0	0.43
8	11.9	9.9	4.0	0.40
9	Oldsmobile 4.3	3.0	1.1	0.34
10	5.8	4.6	1.6	0.53
11	7.3	6.3	2.2	0.66
12	11.3	8.1	3.4	0.34
13	12	8.7	3.1	0.35
14	Ford 3.9	2.7	0.9	0.46
15	12.6	6.1	—	—
16	11.3	6.9	2.5	0.33
17	6	4.8	1.7	0.67

The data at 12.6 m.p.h. for calculating coefficient of restitution, was erroneous.

Correlation of Test Results and Actual Collisions

The collisions resulted in changes in velocity approaching 10 m.p.h. with little, or no, visible damage. It is noted that the minimal damage that was visible during the physical inspection of the vehicles would have been difficult, or impossible, to observe in the type of photographs often used in collision reconstruction. However, the changes in velocity recorded are in the range where injuries occur in actual traffic collisions. Injuries that are documented in rear impact cases where we have performed reconstructions include lumbar injuries, thoracic injuries, extremity injuries, brain injuries and injury to the TM joint. One study based on the National Accident Sampling System (NASS), using 2914 subjects revealed that approximately 60% of the cervical injuries in rear impacts occur in collisions with a change in velocity of 10 m.p.h. or less.

The existence of injuries in rear impacts, coupled with the difficulty in detecting damage to vehicles, has generated a problem for the forensic investigator. If an attempt is made to compare the calculated change in velocity with the reported injuries, the use of damage alone is invalidated by the fact that injuries are possible with little or no visible damage to the vehicles.

Application of Biomechanics to Injury Correlation

The failure of the use of vehicle damage alone to prove or refute injuries in a rear impact focuses the investigator on the correlation of the applied forces to the diagnosed injuries. As an example, the lumbar region is differentially loaded during rear impact. The presence of lumbar injuries has been established in rear impacts. Therefore, the forensic investigator may conclude that a diagnosed lumbar injury is consistent with the applied forces in the subject rear impact. A discussion of injury correlation logically lends itself to consideration of injury thresholds. There does not appear to be an adequate study available of actual collisions to establish a reliable value for thresholds in rear impact collisions. Under ideal conditions, some investigators have attempted to establish a threshold for cervical injuries at a change in velocity of 5 m.p.h. However, data from NASS establishes that cervical injuries occur in actual collisions at much lower changes in velocity. Similarly, the motion studies often referenced in the discussion of injury thresholds rarely report lumbar injuries, even though they are documented to occur in actual collisions.

Energy Transfer in Bumper-to-Bumper Rear Impact Collisions

These tests reveal that it is possible to transfer sufficient energy to a struck vehicle to injure the occupants, without damaging the vehicle. The tests also indicate that vehicle damage can only be used to determine the minimum amount of energy transferred to the struck vehicle, not the maximum amount. The tests show that considerable kinetic energy is transferred before the onset of damage.

Conclusions

As a result of these tests, it was concluded that:

- Repeated impacts in excess of 10 m.p.h. often resulted in only minimal damage to the vehicles.
- In some impacts, one vehicle showed significant damage while the other vehicle showed no obvious damage.
- The angled nature of some collisions caused induced damage, which was not observed in on-axis collisions.
- The threshold for vehicle damage appears to be higher than the threshold for injury.

Accident Reconstruction, Vehicle Damage, Injury Potential

C24 Need for an Expeditious Emergency Release Capacity in Safety Belt Buckles: Test Methods to Document Seat Belt Buckle Responses to Webbing Load

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This paper will show the participant the investigation and test techniques used on various standard production restraint systems to perform an analysis on the forces required to release a seat belt buckle latchplate with the press button while a webbing load is being applied in the opposite direction to latch plate insertion.

The equipment used includes the synchronized use of two seat belt sensor load cells, data acquisition, and videography. Forces have been measured on the lap and shoulder belts while the test vehicle was inverted with various height and weight occupants in the restraint system. Aside from the test techniques, the participant will learn about the push button release forces with no load on the webbing, view patents that make reference to this problem, and review alternative designs that can prevent this type of failure.

Theory of the Analysis:

With the new laws of mandatory seat belt use in the United States and in Europe, the fear that an occupant may not be able to release his or her seat belt buckle in an emergency is well known. It is desirable for an occupant to be able to release the latch plate (tongue) from the buckle when under great stress or tension, such as may occur at the time of an accident. These belts must be able to be released by the occupants or by emergency personnel particularly in case of fire or sinking in water. The type of buckle in question in this paper is design code "4-A," commonly called the *R.C.F.67* buckle with a side release button, patented June 29, 1971 by Robert Cripps Fisher, U.S. Patent 4,388,746.



However, we have shown that when a 240 lb. surrogate male is placed in the test fixture and inverted, he is unable to produce adequate force on the press button to release himself from the restraint system. This phenomenon has been reliably reproduced using the test fixture shown here. Additionally, the test buckles used in these tests came from documented production vehicles and had not been modified.

Discussion:

Given that we reliably demonstrated that the *R.C.F.67* buckle can fail to open when subjected to this real world test, additional efforts were undertaken to create a database of alternative design seat belt buckles that were in production during or before this particular *R.C.F.67* (1990) model year. A total of 21 buckles were tested comprising of side and end release types, and all of the alternative design production seat belt buckles have been tested with webbing loads ranging from zero to 250 lbs. with appropriate documentation. Additionally, alternative design production seat belt buckle patents have been collected and reviewed. Out of these 21 buckles, one was selected that disengaged at a much lower push button release force. This buckle came from a 1987 Pontiac Firebird, design code 5-E end release type buckle.

There were two test fixtures used to characterize the seat belt buckles. The first fixture consisted of a hydraulic ram with a load cell that applied a force to the latch plate; and, the second test fixture consisted of a portion of a production vehicle (1986 GMC Jimmy) that was fabricated onto a frame that would allow it to rotate 360 degrees.

A comprehensive collection of production seat belt buckles is being collected to perform these tests in an effort to study the forces required to release these systems. We have also collected eighteen patents covering a time span of 29 years that make reference to this phenomenon. Currently, we have a personal library of over one thousand seat belt buckle patents collected to date.

Expeditious Emergency Release, Push Button Forces, Entrapment

C25 Diagnosis and Concomitant Physics of Sacroiliac Joint Injury

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The purpose of this paper is to highlight major differences between injury profiles specific to a multiple-collision motor vehicle accident and those that would have been caused if each collision in the accident had occurred separately.

Injury to the sacroiliac joint is known to be underreported because it is often quite difficult to detect, as illustrated by the review of data in a trauma registry at a regional medical center, which revealed only three sacroiliac joint injuries over a five-year period when the appropriate ICD-9 codes^[1] were searched. One reason for these injuries being missed is that they frequently occur in conjunction with some other injury, such as a fracture in the pelvis or the lower extremity, which is more noticeable and therefore tends to draw attention away from what might be overlooked as a lesser lesion, if any, to the joint.^{[2],[3]} When no such injury to a different part of the body is present, the potential for injury to the sacroiliac joint can be aggravated because there is no mechanism for energy to be managed away from the joint.⁴ Another reason is that an inaccurate description of a multiple-collision motor vehicle accident can lead to a mischaracterization of vehicle occupant kinematics and a possible misinterpretation of symptoms. Any incomplete or delayed diagnosis arising from this can then result in less than optimum treatment. The research presented here shows how multiple impacts should be evaluated to identify a potential for injury that might not be expected from the corresponding single impacts.

Approximately 300 patients in rear-only, rear-then-front, and front-only impacts of similar magnitude were considered in this study. The accident data were collected over a five-year period, not contemporary with the above trauma registry. Conventional clinical examinations were conducted for all patients and accident reconstructions were performed to determine vehicle dynamics. Special attention was paid to ascertain the time of separation between the two collisions in rear-then-front impacts. The occupant kinematics of each patient were then calculated with the Articulated Total Body, or ATB, package of computer programs. The package was originally developed as the Crash Victim Simulation, or CVS, by the United States Department of Transportation, and its main program has the capability of finding the response of a multi-segmented human surrogate to an insult in complex geometrical surroundings. Validation of CVS/ATB during the past four decades or so has made it a commonly accepted model of occupant kinematics. Other programs in the package include one that provides pictorial images and another that enables one to generate customized surrogates. The latter was employed extensively in this study because the values for height and weight did not normally coincide with standard percentiles. An especially noteworthy feature of the dynamic analysis with CVS/ATB was the rigorous adherence to the strictest standards for the equilibrium configuration of the model at the initial time $t = 0$. This was found to be crucial because invalid results are known to be obtained with subjects that are not stationary before the impact event begins.

Forces on different parts of the body of each patient in rear-then-front impacts were compared with the forces in the constituent rear-only and front-only impacts in the following manner: (a) head, neck, chest, and low back: lower in multiple impacts than in one or both of the separate impacts; (b) left side of pelvis: comparable, but slightly lower except in isolated cases; and (c) right side of pelvis: nearly always higher, including instances where it was more than doubled. This last outcome was accompanied in some circumstances by injury to the right sacroiliac joint. The mechanism for this injury was found to be loading on the right foot by the brake pedal during the second impact, which was transmitted rearward through the right leg at the same time as the patient was rebounding forward from the seat after the first impact. When these events were synchronized by a specific time separation, injury was produced in the right sacroiliac joint when neither of the single impacts would have done so on its own. A shorter separation led to an application of rearward force before the forward rebound motion reached a critical point; whereas, a longer separation allowed dissipation of forward rebound motion before the rearward force could be an influence. The distance associated with this critical time separation coincided with typical vehicle-to-vehicle distances for traffic in many city locations.

Multiple impacts are not generally simple sums of separate impacts, and careful effort is sometimes necessary to establish the entire effect of each part in the sequence of events. A proper understanding of injury causation in multiple impacts can enhance the detection of injury and facilitate correct diagnosis, which contributes to effective treatment and thereby promotes healing and recovery.

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Diagnosis of Injury, Injury Mechanisms, Multiple Impacts

C26 Cervical Disc Protrusions in Frontal Automobile Collisions

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This paper examines the circumstances that can lead to cervical disc protrusion to seat belted occupants in frontal collisions and seeks to explain the appropriate injury mechanism. While seat belts prevent many injuries and should be worn by all occupants, there are specific circumstances where they may not be of any influence in injury elimination. Therefore, it is imperative that each motor vehicle accident and injuries be analyzed individually and on its own merits.

The victim, a 41-year-old male was the driver of Car 1 that was approaching an intersection. Car 2, traveling in the opposite direction and approaching the same intersection from ahead, made a left turn in front of car 1 across his path, seeing which he started braking. Car 1 laid skid marks on the asphalt before the impact and the collision damaged the front portion of the car, more on the left side, and pushed the front bumper area rearwards. The driver indicated that he was wearing the three-point seat belt equipped with a single webbing, single retractor of the emergency locking type; the seat belt also had a “window shade” or comfort feature

along with a cinching latch plate that goes with this type of seat belt system. In these seat belt systems, the occupant can intentionally introduce a slack of a desired amount on the shoulder belt portion, to prevent the belt from being too tight or otherwise uncomfortable (and hence the name comfort feature). However, the disadvantage with this system is that the occupant may inadvertently introduce an excessive slack on the shoulder portion of the belt, thereby losing the protection of the seat belt without the occupant realizing it. This situation may or may not have existed in this accident. During post-accident vehicle examination, the retractor was found to lock up and the seat belt system was found to function properly. There were no impact marks or cracks or any other damage on the windshield, steering wheel, or the dashboard area. The seatbelt system also did not show any witness marks for loading on the webbing or any of its other components. The interior occupant compartment was spatially uncompromised and undamaged except for minor cosmetic damages such as a broken car radio knob and a slightly damaged air vent in the right center area of the instrument panel. In a static study of the belted driver in this vehicle, when the retractor was manually locked up, he was still able to strain forward and impact the upper surface of the steering column with the upper portion of his forehead.

The driver complained primarily of neck pain at the scene and was transported to the hospital, diagnosed with a neck strain in the emergency department, and released. The patient also had contusions on the forehead, just below the hairline and also in the left shoulder area and minor abrasions to the volar aspect of the right hand. Subsequently, the patient complained of persistent bilateral neck and arm pain and a cervical spine MRI performed one month after the accident identified a broad based disc protrusion at C5-C6, mainly left paracentral, effacing the subarachnoid space and causing slight flattening of the cervical cord and mild narrowing of the left neural foramen. Minimal annular disc bulges were observed at C4-C5 and C6-C7 levels.

It should also be noted that eight months previously, the driver of Car 1 had been involved in a low speed three-car rear impact, his car being the frontmost and hence the last one struck in the rear, in this chain of collisions. He complained of right sided neck pain and was prescribed physical therapy sessions after which the problem had subsided. It is noteworthy that he did not report any arm pain or numbness, which were observed in the second collision.

Disc prolapse can occur suddenly in a traumatic situation or gradually in a chronic fashion, according to researchers^[1]. In sudden disc prolapses, a specific injury mechanism has been identified in the laboratory^[2]. Cadaveric vertebral specimens were somewhat laterally bent and flexed while a sudden compressive load was applied to the specimen. This produced a disc prolapse in the posteriolateral aspect of the annulus that was under tension, which was on the side opposite the side of the lateral bend. This injury mechanism was used in explaining lumbar disc herniations under specific traumatic situations^[1]. This same injury mechanism exists in frontal automobile collisions under certain conditions and has been specifically identified by the authors in this collision. The forward flexion of the neck, the compressive component of the sudden impact on the frontal head coupled with a lateral bending of the neck, provides the injury mechanism in this case that led to a left lateral disc protrusion in the cervical spine. It should be noted that this injury mechanism may also be present in head impacts on the steering wheel, windshield, A-pillar, and other appropriate structures in an automobile collision; and, biomechanical engineers should be able to explain the disc herniations if found in such circumstances using the analysis discussed here.

The change in velocity for Car 1 was determined to be in the range of 15 to 20 mph. It was also determined that the occupant was wearing the seat belt at the time of the impact. The low delta-V, the “window shade” feature in the shoulder belt, on left shoulder area and the static study of the occupant in the accident vehicle all pointed to this conclusion, despite the lack of loading witness marks in the seat belt system. However, this injury mechanism for producing a cervical disc prolapse may be present in belted as well as unbelted occupants, depending on the specifics of the accident.

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Cervical Disc Herniation, Cervical Disc Injury, Disc Injury Mechanism

C27 Aggravation of Injury From Non-Standard Postures: II. Lumbosacral Spine

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The purpose of this paper is to show the forces generated in the low back during automotive insults can be significantly increased by departures from conventional seated postures and how these forces exacerbate injury.

There has been much debate in recent years over the extent of injury, if any, produced to vehicle occupants during low-severity impacts. On the one hand, it is claimed that little or no property damage should lead to little or no injury; whereas, on the other hand, it is argued that significant injury can arise even when the change in speed is accepted as being minor, which typically means less than ten miles per hour. Both viewpoints tend to use selective data, ranging from tests with human volunteers to subjective patient histories. The former can be particularly problematic because it usually employs subjects who are prepared for the impact event, in complete contrast to the unaware condition of many occupants in actual motor vehicle accidents. Other shortcomings include differences in age, health, and physique, all of which lead to the methodology being reduced to merely an exercise in comparing apples with oranges.

The above impasse was resolved in this research by an independent approach that applied the scientific and medical information from some 500 motor-vehicle occupants over a five-year period.^{[1],[2]} A comprehensive range of values for parameters related to the occupant (height, weight, sex), impact (magnitude, direction), and low back itself (local vector, anatomical level) was provided by the exceptional size of the population. The good quality of these data allowed the force produced in the lumbosacral spine to be calculated with the Articulated Total Body, or ATB, package of computer programs. The package was originally developed as the Crash Victim Simulation, or CVS, by the United States Department of Transportation, and its main program has the capability of finding the response of a multi-segmented human surrogate to an insult in complex geometrical surroundings. Validation of CVS/ATB during the past four decades or so has made it a commonly accepted model of occupant kinematics.

Other programs in the package include one that provides pictorial images and another that enables one to generate customized surrogates. The latter was employed extensively in this study because the values for height and weight did not normally coincide with standard percentiles. An especially noteworthy feature of the dynamic analysis with CVS/ATB was the rigorous adherence to the strictest standards for the equilibrium configuration of the model at the initial time $t = 0$. This was found to be crucial because invalid results are known to be obtained with subjects that are not stationary before the impact event begins. Not one of the parameters listed above produced significant correlation with the low back force; such an outcome suggests that there is no simple relationship for the force within the lumbosacral spine and this, in turn, means that the potential for low back injury has to be evaluated on a case-by-case basis.

A major demarcation from previous work was then effected by making highly detailed assessments of cases, in which the heads of vehicle occupants were turned away from the forward direction in a standard posture when the collision occurred. This body configuration commonly occurs when waiting at an intersection. Quantitative evaluations were

made for the initial rotation of the head at several locations between (a) the forward direction and (b) the position at $\pm 90^\circ$ to this. As the head angle was increased, there was no clear pattern of how the low back force changed; in some cases, the most noticeable increase was in the local lateral vector; whereas, in other cases, it was in the local forward vector or local upward vector. There was a wide range in the ratio of local lateral force in positions (b) and (a), and similar unevenness in increases was obtained for the ratio of the local forward and local upward forces. The lack of any order in these findings contrasts with the loosely uniform values determined for the neck,^[3] which might be explained by there being more rotation at the top of the spine, than at the bottom and this greater rotation affording more opportunity for a trend to emerge. However, an increase in trauma to the lumbosacral spine when the head is rotated at the time of collision, has now been documented by numerical calculation for specific occupants in specific vehicles in specific impacts.

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Low Back Trauma, Injury Mechanisms, Posture

C28 A New High-Fidelity, Extended-Range Color Reversal Film for Forensic Recording

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The goals of this research project are to test and report on a new high-fidelity low-contrast extended-range color reversal film for recording nighttime scenes to a higher level of photometric accuracy than was achievable previously by any other commercially available color reversal film. Attendees will learn how to apply this film to the recording of typical crime and accident scenes under existing low-light-level lighting conditions.

Baker & Fricke, of Northwestern University Traffic Institute, recommended the use of Kodachrome 64 film to produce "a record to explain what a driver or pedestrian could have seen at night with the light available to him at that time." The authors note that a typical nighttime exposure is $f/4$ at 4 seconds and further recommend that the film be processed by Kodak for uniformity.^[1]

Harris & Harris in 1992 suggested the use of a slide duplicating film for recording simulated accident scenes under existing nighttime lighting conditions.^[2] This class of films has lower contrast and better linearity over a greater luminance range than conventional color slide films, such as Kodachrome, which typically produce images that have higher contrast and color saturation than the scenes recorded. The specific film described by Harris & Harris was Kodak Ektachrome SO-366 slide duplicating film, which was originally formulated for electronic flash illumination. Kodak later introduced Ektachrome 5071 slide duplicating film, with almost identical characteristics to Ektachrome SO-366, except it was formulated for tungsten illumination. Both of these films are relatively insensitive to light. More importantly, the film "speed" characteristics of these films have been particularly difficult to control in their manufacture. Variation in ISOs ranging from 12 to 40 is not uncommon. Ektachrome SO-366 and Ektachrome 5071 films are also especially sensitive to minor variations in processing. Latent image fading is also a potential problem with these films, which requires that they be processed as soon as possible following exposure. Processing needs to be done under tightly controlled laboratory conditions to minimize variations in image density and color.

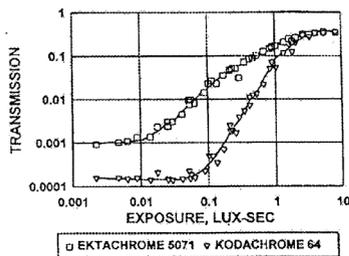


Figure 1

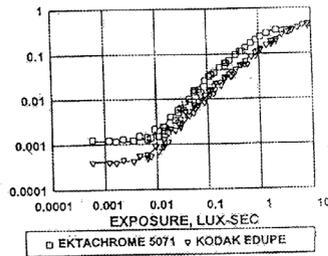


Figure 2

The authors have conducted numerous tests and experiments with Ektachrome SO-366, Ektachrome 5071, Kodachrome 64, and other color and B&W films over the past 20 years (since 1981). Among our objectives is to find a suitable recording medium for studying and demonstrating nighttime visibility (under automobile headlight illumination, for example)^{[3][4]}. This requires a recording medium with the capability of accurately duplicating individual luminance levels in a scene throughout a wide range of nighttime luminances. As a result of these experiments, and owing to the problems noted above, all of the above films failed to meet our requirements when photometric fidelity was considered.

Recently Eastman Kodak Company introduced EDUPE, a new high-fidelity low-contrast color reversal duplicating film, to replace Ektachrome SO-366 and Ektachrome 5071. EDUPE offers superior high-light detail, shadow detail and tone-scale neutrality. Additionally, it is a much more robust film than Ektachrome SO-366 and Ektachrome 5071 with respect to both process sensitivity and latent-image stability. Reciprocity is also significantly improved over an exposure range of 1/100 to 10 seconds.

The characteristic curves of Ektachrome 5071 and Kodachrome 64 are both plotted together in Fig. 1 from the authors' data [5]. The curves for EDUPE and Ektachrome 5071 are plotted in Fig. 2. EDUPE is shown to have a dynamic exposure range of 1000:1 compared to dynamic exposure ranges of 250:1 for Ektachrome 5071 and only 30:1 for Kodachrome 64. Based on an exposure of 8 seconds at $f/1.4$, the minimum scene luminances that can be recorded by these three films are 0.002 cd/m², 0.003 cd/m² and 0.03 cd/m², respectively. In all respects, EDUPE is a vast improvement over Kodachrome 64 and the two extended-range Ektachrome films it is replacing. A typical nighttime exposure for EDUPE is $f/2.8$ at 8 seconds. Its improved characteristics now make it possible to record nighttime scenes to significantly higher levels of photometric fidelity.

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Photographic Film, Accident Reconstruction, Visibility

C29 Photographic Identification of a Native American Artifact Using Visible and Ultraviolet Light

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The goals of this research project are to describe the photographic identification of a hand-woven tray that utilized both visible and ultraviolet light.

This paper will describe the means by which an artifact recovered from a suspect was positively identified based upon a photographic comparison of the artifact with a known photograph, as one stolen from a federal agency. This identification was made despite the suspect's efforts to alter the appearance of the artifact. Examination of the artifact using ultraviolet light proved useful in verifying the alteration.

Examiners in the FBI Laboratory's Forensic Audio, Video, and Image Analysis Unit conduct examinations of questioned photographic evidence, such as film negatives, photographic prints, video tapes, or digital images. The majority of casework involves surveillance images from banks, convenience stores, and other locations. The most common request involves the photographic comparison of people or items depicted in the questioned image with known suspects or objects recovered from suspects. At other times, an object of unknown provenance is submitted for comparison with a photograph that depicts a known object in order to identify or eliminate it as the known object.

During the course of a relocation, a federal agency in Alaska placed a number of Native American artifacts in storage. Upon retrieval, a number of items was found to be missing. Subsequent investigation led authorities to a former agency employee. Several artifacts corresponding to those missing were found in his possession, but since the artifacts contained no identifying marks, tags, or labels, it was not possible to state with certainty that they were the missing items. The only means by which the artifacts might be identified was through comparison with a single photograph in which several of the missing items appeared in a display case. Thus, the photograph and several of the recovered artifacts were forwarded to the FBI Laboratory for comparison.

Among the missing artifacts included a shallow, circular, hand-woven tray made of salt water beach grass. The base of the tray consisted of a reed spiraled around itself and held in place by light-and dark-toned grasses woven together. The dark-toned grasses only occurred in three places as single loops, creating three concentric rings around a central core. The final design elements in the tray were dark, narrow strips of dyed seal gut arranged as twelve triangles pointing toward the center of the tray. The triangles were arrayed at 90-degree intervals within each of the three concentric rings, and each consisted of four strips of seal gut, held in place by the grass weave, with shorter pieces creating the tip of each triangle.

Although the gross characteristics of the tray recovered from the suspect matched those of the missing tray, detailed examination of the triangles revealed multiple apparent differences. Specifically, the tray recovered from the suspect contained triangles in only the outer two rings, and the triangles consisted of only three strips of seal gut, not four. The regions exhibiting differences were inspected under magnification and using alternate light techniques (ultraviolet). Under magnification, the grass weave in the vicinity of the missing gut strips was found to exhibit tearing and other damage that could be associated with the forcible removal of the strips. When inspected under ultraviolet light, the locations at which seal gut was thought to be missing exhibited a marked decrease in tonality relative to their surroundings - a latent impression consistent with the missing seal gut. These characteristics, when combined with additional random variations observed in the tonality of the grasses making up the overall weave of the tray, were sufficient to permit the positive identification of the tray recovered from the suspect as the missing tray.

Photographic Identification, Photographic Comparison, Ultraviolet Light

C30 Photographically Maximizing the Information Recorded in Forensic Images

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The objective of this paper is to present a scientifically based photographic technique for analyzing and enhancing forensic images and to demonstrate, through case studies, how the technique has been applied.

Attendees will better understand the limitations of the photographic process in recording the luminance range of a scene and how to use the photographic process to maximize the information obtained from and about the scene.

A photographic image can be considered a two-dimensional projection of three-dimensional space, recorded at an instant in time. Photographs, then, represent to the viewer the spatial distribution of both luminance and color that existed at the scene photographed, limited by the spatial resolution and spectral sensitivity range of the recording media. The capacity of color photographic negative film to record scene luminance information far exceeds the capacity of photographic print paper to display it. Therefore, since more information exists in the negative than can be displayed in a single print, it is necessary to produce a series of prints to display completely the luminance range of the scene. To quantify this, sensitometric data were experimentally determined for a commonly used color negative film and the color glossy prints produced from it.

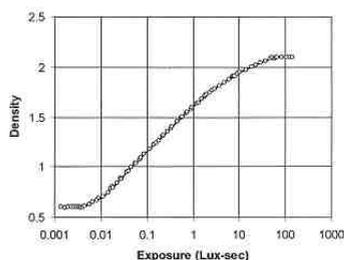


Figure 1: D-Log H Curve for Kodak Gold

the straight line portion of the negative film depicted in Figure 1.

Analysis of Figures 1 and 2 reveal that a typical color negative film (in this case Kodak Gold 200) can record a subject-space luminance range of about 10,000:1 with a linear portion of about 300:1. A glossy color print made from color negative film can record and discriminate a up to a maximum dynamic range of 100:1 with a practical dynamic range of about 80:1 and a linear range of about 4:1. Therefore, to analyze the entire luminance range that exists on the negative, one needs to produce a sequence of prints exposed at a maximum of 2 stop intervals from completely underexposed to completely overexposed.

The minimum number of prints (N) necessary to represent the full range of luminances that were recorded by the negative into the linear portions of the prints can be calculated from: $N = \text{Log}(R_n)/\text{Log}(R_p)$, where R_n and R_p are the dynamic luminance ranges of the negative and print, respectively. For the case of the film studied for this analysis, a minimum of seven prints would be necessary to cover the entire dynamic range of the film.

Since the contrast index of a color photographic print is typically greater than one, as can be seen in Figure 2, objects depicted in color prints will have a contrast that is greater than in the scene depicted and will not appear as they did to an observer at the scene. When print contrast is greater than scene contrast, and if contrast threshold is a visual limiting factor, then some details will be easier to see in prints than in the original scene.

Two case studies will be described to demonstrate how the technique of multiple printing can be effective in extracting useful data from negatives that would otherwise not be detectable from one print. In one case, the area of interest was contained in the toe or shadow region of the D-log H curve for the negative; and, in the other, in the shoulder or highlight region.

Photography, Illumination, Visibility

C31 Forensic Injury Biomechanics: Airbags and Belts

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Attendees will learn to accurately synthesize injury mechanisms for motor vehicle occupants restrained by airbags and seat belts.

Occupant contact with an airbag in an motor vehicle collision, either during or after airbag deployment, oftentimes confounds forensic analysis of: (1) injury causation; (2) whether or not an occupant was belted, let alone properly belted; and (3) initial occupant configuration, relative to the occupant seat and vehicle interior. Difficulties attempting to interpret the forensic findings arise because shoulder belt loads can be reduced significantly when occupant restraint is shared by both seat belts and an airbag, resulting in forensic belt findings that are oftentimes subtle or even absent. In addition, occupants who are in-position to significantly interfere with airbag deployment can sustain huge punch-out, membrane thrust, or rebound forces. These huge air bag-induced loads often result in the generation of additional forensic data that (1) complicate attempts to accurately reconstruct the accident scenario experienced by an occupant, and (2) hinder attempts to derive injury mechanisms that are sound.

Reconstruction of the conditions responsible for occupant injuries in motor vehicle collisions, especially when airbags have deployed, requires acquisition and analysis of a full spectrum of potentially relevant forensic engineering, medical, and bio-mechanical data. Relevant engineering data that must be considered include: (1) the pattern and extent of vehicle exterior damage; (2) vehicle kinematics prior to, during, and following the collision sequence; (3) occupant-induced vehicle interior damage — i.e., occupant “witness marks”; (4) configuration of the occupant’s seat bottom, seat back and head rest, at the time of the collision and post-collision; (5) configuration of the seat belt restraint system, relative to the vehicle interior and the occupant, at the time of the collision; (6) seat belt restraint system forensics induced by occupant loading; (7) airbag forensics induced by occupant loading; and (8) cargo, or other motor vehicle occupants, that may have impacted the occupant during the collision. Relevant medical data that must be compiled and analyzed include: (1) all injuries sustained by occupant and especially every integument lesion sustained; (2) shape and size of an occupant; and (3) age, sex, physical condition, and prior medical condition of the occupant. Biomechanical engineering data that must be considered include: (1) design and performance characteristics of the seat belts, airbag, occupant seat, steering wheel, steering column, and knee bolsters; (2) impact laboratory test results involving anthropomorphic test devices (i.e., ATD’s crash dummies) and human cadavers; (3) performance of motor vehicles and restraint systems in field accidents; (4) human tolerance to impact loading under similar conditions; and (5) performance of alternative occupant restraint systems under similar accident conditions.

Recommended strategies for accurately determining injury causation, for accidents involving airbags and/or seat belts, will be discussed. In addition, field accident case studies will be presented to illustrate how relevant engineering, medical, and biomechanical engineering data can be considered and evaluated to enable synthesis of auto occupant injury mechanisms that are sound.

Motor Vehicle Collisions, Impact Injury Mechanisms, Biomechanics

C32 Playground Safety: A Forensic Human Factors Analysis of Fall Injuries

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This paper discusses public playground accidents from a forensic safety and human factors engineering perspective.

Because the user population of playgrounds has a limited cognitive ability, their age-appropriate capabilities and limitations, as well as the level of necessary supervision are also described. Important maintenance and inspection issues related to playground to fall protection. Finally, this paper presents a challenge to engineers.

More than 200,000 children are treated in U.S hospital emergency rooms annually. Injures associated with playground equipment account for most of these incidents. While some of these injuries may be avoided by providing community parks with equipment that is properly designed, installed and maintained, others could have been prevented if the children were properly supervised.

The User Population

Preschoolers have limited cognitive and physical abilities depending on their developmental level. Physically they often need adult help. Young children need clear and simple directions to do most activities and do little monitoring of their own memory and comprehension. Furthermore, they have little or no understanding of their mortality. What seems risky or dangerous to an adult does not seem so to a young child. Under-developed attending skills prevent children from seeing the whole picture and from being able to carefully explore the totality of their surroundings. Since people make decisions based on prior experiences, young children may make illogical choices because their existing knowledge base is limited.

Because of these limitations, adequate supervision is necessary. Supervisors should guide children to play on age-appropriate equipment; play structures designed for children ages 5-12 are too big for preschoolers. Young children may not have the coordination needed to successfully negotiate a large piece of equipment alone. However, playgrounds are full of attractive “toys” that children are often anxious to explore. Since they are not aware of their own physical and cognitive limits, adult supervision is an essential part of a safe play environment.

In one recent case, a 3-year-old boy suffered a serious head injury as a result of falling off a slide platform. Despite having been shown the proper way to use the slide and having successfully negotiated the slide in the past, this little boy suffered serious head trauma from the fall. The child’s guardian noted that the sand around the play equipment was hard and that there was not very much of it. Upon inspection, it was discovered that the compressed sand was 8-inches deep. The slide platform that the boy fell from was 9’6” off the ground.

Maintenance and Inspections

City parks and recreation departments have limited resources to spend on park equipment and maintenance, which may result in broken and ill-maintained play structures and ground surfacing. As part of a maintenance program, playground equipment should be inspected regularly for potential hazards and deterioration. The playground area should also be checked for broken glass or other dangerous debris.

Depending on playground location, weather conditions and frequency of use, maintenance is necessary to insure adequate depth and to loosen the surfacing materials, which may become compressed. Markers can be attached to equipment support posts that indicate the level of loose-fill protective surfacing around the equipment. Such markers will assist maintenance workers in determining when replenishment is necessary.

Inspections should also encompass less obvious hazards such as protruding nuts and bolts. These items can catch fingers and hooded clothing and may result in injury. It is also important to inspect for loose handrails because these items typically cannot be identified through visual inspection. It is necessary to check for some potential hazards by getting on the equipment. Hazards or defects identified in the inspection should be repaired as soon as possible. All inspections and repairs should be documented, indicating the date on which the inspection or repair occurred.

Critical Height

Because falls account for the majority of serious playground injuries, the surfacing materials are critical. Proper surfacing can be a

factor in determining the injury-causing potential of a fall. Acceptable playground surfaces are comprised of two basic types: loose-fill or unitary. *Unitary materials* are generally rubber mats or a combination of rubber-like materials held in place by a binder that may be poured in place at the playground. *Loose-fill materials* include sand, gravel, shredded wood and shredded tires and have acceptable shock absorbing properties when installed and maintained at a sufficient depth. Loose-fill materials should not be installed over hard surfaces like concrete.

A fall onto a shock-absorbing surface is less likely to cause a serious injury than a fall onto a hard surface. *Critical height* is a term used to describe the shock-absorbing performance of surfacing materials. It is considered an approximation of the fall height below which a life-threatening head injury would not be expected to occur. The surfacing material used under and around a particular piece of play equipment should have a critical height value of at least the height of the highest designated play surface of the equipment. This height is the *fall height* for the equipment. Table 1 is an excerpt from CPSCs table pertaining to sand. If for example, uncompressed course sand is used at a minimum depth of 9 inches, the critical height is 5 feet. Note that the same critical height applies to a sand depth of 6 inches. This table *does not mean*, however, that if a fall is below the CPSC recommendations for critical height that a child will not be injured.

Table 1. Critical Heights (in feet) of tested materials (sand only)

Material	Uncompressed depth			Compressed depth
	6 inches	9 inches	12 inches	9 inches
Fine sand	5	5	9	5
Coarse sand	5	5	6	4

Limitations of the CPSC Critical Height Table and a Challenge to Engineers

When working on fall cases, we often come across issues that are not accounted for by the CPSC table. Frequently, sand playgrounds are a combination of loose sand over compressed sand. For example, I have found 2-3” of loose sand over 6-10” of compressed sand. Furthermore, this table only goes up to 9” deep for compressed sand. Finally, when reviewing the CPSC data underlying the table, Impact Attenuation Performance of Playground Surfacing Materials (3/90), it becomes evident that the data are not linear and there appears to be a large standard deviation (SD not reported) even though the impact velocity measured did not vary more than ± 0.5 ft/sec from the theoretical free fall velocity. Only three trials (“drops”) were used for each level of the IV (sand type/height). Each trial consisted of the dropping of an instrumented “head” a specified distance on each of the loose fill surfaces. In order to increase the reliability of the data used to construct this much-used table, a larger number of trials should be used for each condition.

We challenge the engineers to “complete” this table by devising a reliable measure of the conditions described on the table, as well as to address other common playground loose fill types (such as mixed loose/compressed sand).

Children, Playground Safety, Accident Prevention

C33 Applying a Forensic Human Factors Engineering Analysis to Falls in Elderly People

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The objective of this paper is to discuss factors associated with the increase in fall-related injuries as people age.

While seniors (over 65 years) comprise about 13 percent of the population, they account for 26 percent of the total fall-related injuries treated in emergency rooms (about 1.8 million annually). Investigating accidents involving the elderly often necessitates looking beyond the basic facts of the case. Older people often develop specific cognitive and physical limitations that must be considered when performing a forensic investigation on such accidents.

In one recent case, an eighty-three year old woman fell as she was going to get her mail. Although she typically used a walker to assist her with traversing long distances, she did not use it negotiate the 15 feet to her mailbox. One day, as she set out to retrieve her mail, she did not notice the water utility access hole in the driveway had its lid removed due to nearby construction. As she walked toward the mailbox, she accidentally stepped into the hole, fell, and broke her hip.

Physiological Changes of Age

Fracture injuries are more common among seniors, and these injuries often take longer to heal. Falls can also have serious psychological and social consequences, affecting confidence, mobility and general well-being. What characteristics of aging contribute to the frequent fall and injury rates of this age group? Several factors that impact fall accidents with this population include reduced visual acuity, muscular weakness, arthritis, osteoporosis, abnormal gait, medication side effects and cognitive impairment. The functioning of the systems necessary for safe walking – including perception and motor coordination – diminishes with age, affecting all facets of movement initiation. Once older people begin to lose their balance, it is almost impossible to recover. As we age, we often need to wear bifocals. This type of glasses make it more difficult to discriminate details in the lower portion of the visual field (such as the ground).

As people age, it is typical for them to consume an increased number of both prescription and non-prescription medications. These drugs affect the central nervous system, causing reactions that may inadvertently affect the systems necessary for successfully negotiating pedestrian walkways, thereby increasing the risk of falls. Older people have a higher active blood level of the drugs in their systems for longer periods of time. This reduces the body's ability to inactivate and excrete many medications. The decrease in the functioning of perception, motor coordination and cognition seen in older people reduces their capacity to compensate for drug-induced impairment of the central nervous system. Drugs that interfere with these processes that are often prescribed to American seniors include antidepressants, anti-psychotics, antihistamines, narcotic analgesics and hypoglycemics.

Women tend to both fall and become injured more often than men. In people over 75 years, falls are the only major accidental death classification in which women grossly outrank men. Women tend to lose their balance more often due to changes in the configuration of their lower extremities. Whereas younger women have straight or a slightly knock-kneed stance, women over 75 manifest some degree of bow-leggedness. They also have a narrow walking and standing base. Women over 75 tend to step down differently than men or younger women; the elderly women drop in almost a falling step that is less controlled muscularly. Therefore, they hit the ground with more force, requiring their bones and muscles to absorb more stress. Women are more prone than men toward osteoporosis, which causes softening of the bones and a tendency to a stooped posture which thrusts their center of gravity forward and decreases their stability.

Environmental Design

The physical environment is a significant factor in about a third of all fall cases among the elderly. Problems may include poorly designed walkways, floor surface coverings in ill-repair, uneven walkways, insufficient lighting and objects left on the ground as tripping hazards. An unexpected change in elevation is one environmental condition that is particularly dangerous to the elderly population. Regional standards for accessible facilities typically specify that elevation changes for walking surfaces should not exceed ¼ inch. For public outdoor sidewalks, that standard is often relaxed to ½ inch. Courts at times treat elevation changes of up to ¾ inch as a “trivial defect.” For older people, a ½ -inch or more elevation difference can be problematic as their gait often produces less than a ½ inch clearance during the swing phase of a walk. It seems clear that the changes in motor coordination

in addition to poor vision and muscular weakness combine to create a condition that is more likely to lead to falls among the elderly.

Floor surfaces have varying degrees of slip resistance. While a 0.5 static coefficient of friction (COF) is the general accepted standard of care, the unexpected presence of fluids on a floor can reduce this friction to a dangerous level. Thus, in stores, restaurants, and other areas that often become wet and serve a senior population, it is important to consider the COF when selecting flooring. High-gloss ceramics often mask fluids and greatly diminish in COF when wet.

Environment Interacts with Physical Limitations

An interaction between environmental features and physical limitations often results in elderly fall accidents. For example, a ½-inch change in elevation on a sidewalk is more difficult to see for those with reduced visual performance. As people age, eyesight is one of the primary biological functions that deteriorates. Reduced illumination also contributes to these accidents as age-related visual deterioration is more pronounced at lower lighting levels. The ability to detect small changes in walkways is difficult for older people and even more so in nighttime conditions.

Human factors experts must also consider other factors when investigating a fall accident including available light, contrast, line of sight, and footwear. In investigating cases where perceptual factors are important, effort should be made to document the fall site as it was at the time of the incident. For outdoor falls, this often requires attention to time of day, season, moon phase, and weather. If possible, it is better to inspect the accident site close to the anniversary of the incident when the sunlight angles are similar, since the visual aspects of the environment are critical for aging eyes. Glare and brightly lit conditions, in addition to reduced illumination situations, are more difficult for aging eyes to accommodate and should be recorded to duplicate the conditions that were present on the day of the accident.

Falls are frequently the result of a slip. Since elderly people typically have shorter strides, this would suggest a reduced chance of a slip accident occurring. However, the elderly are less able to anticipate and adjust to changing walkway conditions. Many slips result from older people's reduced ability to compensate for changes in the friction and texture of a floor surface. For example, slip accidents often occur when an older person takes the first step off of one surface (such as a rubber floor mat) onto another surface with a different texture (such as a ceramic tile floor).

While this paper has discussed some of the key characteristics for forensic human factors consultants to consider when investigating fall accidents among the elderly, it is important to remember that there are a lot of individual differences in the rate and degree of changes brought on by the aging process. When investigating this type of incident, it is essential to identify related physiological factors in the analysis of the facts of a case. Going back to the case discussed earlier, it is important to analyze the access hole as it was viewed by the Plaintiff at the time of the accident. Did the slope of the driveway obstruct her ability to perceive the hole? Was there glare at that time of day? Were her bifocals a factor? Was she taking medications that affected her balance? Did her mobility impairment necessitate her to use her walker even for the short trip to the mailbox? After these issues are identified, then it becomes possible to identify the causal factors of a fall accident among the elderly.

Aging, Falls Accidents, Accident Investigation

C34 Avoiding Pitfalls in Video Image Processing

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The goals of this research project are to exemplify errors made in video image processing and how to avoid this situation.

The number of surveillance cameras, web cams and other cameras is growing rapidly, so crime scenes are often recorded. In our laboratory we digitize uncompressed video material, providing it is recorded using

an analog technique. This way the image itself will not be changed. Compression algorithms, on the other hand, might alter the contents of the image.

There are several software packages on the market for video image processing. These packages can be very useful. However, training and quality control are required before using them. Several image processing techniques, such as contrast enhancement, may be used without risk. Other image processing techniques, such as super resolution or non-linear filters (e.g., Wiener restoration, maximum entropy or maximum total variation) may also be used. However, in practice it does not often happen that there is a substantial improvement in the processed image when these filters are used.

Super resolution is a technique whereby several images of the same scene are registered on each other and then averaged. It requires little movement between the different images. With this method, more information can be seen in the final image, due to the reduction of noise (averaging) and the combining of the contents of several images. Though this method has shown to work well, it is not yet foolproof. Trials have revealed where this method will yield the wrong conclusion if used for a number plate, e.g., letter "B" appeared to be a "D." These errors can be avoided by examining all images for artifacts. Artifacts can also be caused by compression algorithms, and for this reason it is important to validate the method with the same camera system as well as with known number plates, providing a controlled environment.

Yet another error may occur if the camera system and the area that is recorded by the system are unknowns. An example of this is where in an image taken in daylight a certain object is visible, but at night is not visible. These kinds of errors may be avoided by first examining the complete video system, watching the video images in different situations both during the day and at night.

In commercial packages there are also photogrammetry tools available. These present another obstacle. Often the height of a person is important to know particularly if he or she could be the suspect. In order to better gather information of this kind, there should be reference points or lines in the images for measuring. For this kind of measurement, it is required to go to the place where the image has been recorded. The camera should be in the same position and the reference points should be fixed in relation to the image with which it has to be compared. The measurements must be accurate since this will cause an error in the final results.

Often the lenses of surveillance cameras cause distortions in images if, for example, a broader, as in a fish eye lens, or panoramic view is desired when doing the photogrammetric measurement. This should be taken into account

The position and action of the person in the video creates the potential for one final error. If the person is running or bowing, this could result in a different measurement in height. Generally speaking, the soles of the shoes, the hairstyle and/or mask, etc., of the person on the video may result in errors and misinterpretations. The most optimal solution to this is to ask the suspect to stand in the same position in the image with the same clothes and shoes. However, in such a reconstruction, putting a person in the exact same position may be very difficult, especially if the person was moving/running.

Commercial packages, such as 3D Studio Max and Character Studio, offer photogrammetry. So, one preventative method is to put a "human model" around the suspect using this software. This model has the same properties as a human, thus making it theoretically possible to measure the height of a person accurately even if the person is, for example, bowing. However, significant errors may be made with these kinds of software, since positioning the human model on the person in the image may cause big errors. Not all software packages will give error estimation, and this may result in incorrect measurements if the person using the software does not have experience with forensic photogrammetry. Furthermore, an image does not always contain enough information for estimating the pose of a person. Other pitfalls are caused by the method of extrapolation, as well as the extrapolations themselves, and missing frames. These factors

potentially make it so that it cannot be precisely distinguished whether or not it is the same person that is being observed throughout on the video.

To avoid these pitfalls, it is important to know exactly how a recording system with optical properties works. Furthermore, all measurements should be validated, and the most optimal results are achieved if the inspection is done on the actual video system doing the recording.

Image Processing, Video, Super Resolution

C35 Computerized Morphing to Illustrate Actual vs. Planned Construction

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This paper illustrates the utilization of computerized morphing of photographs to contrast what was intended versus what was constructed in order to demonstrate the cause of large cost overruns in a major project.

When planning approval was obtained for the "Village on Main Street" in Wilsonville, Oregon, the approval documents showed a pedestrian-friendly development with no external stairs, ramps nor retaining walls. The entire project was to have been handicapped accessible. However, when the construction plans were issued, there were marked differences from the planning approval drawings.

The site included 15 commercial buildings and 23 apartment/condominium buildings of from 8 to 12 units. All the commercial buildings were subject to the requirements of the Americans with Disabilities Act which had been adopted into the building code for the state. All the apartment buildings were required to conform to the Fair Housing Act which, in effect, adopted the same disabled guidelines for all ground floor apartments. Fixed price bids were received for all the work based on the planning approval design. Those fixed prices were then used to negotiate the financial package. A part of that negotiation was the pre-leasing of the commercial buildings at specific rental rates. The rental rates for the apartments and the sale price of the condominiums were well known from detailed records of the market rates in this area. It was not anticipated that there could be any increase in the rentals or sales values. Though there was a "normal" contingency allowance, after the project had gotten well under way, it became apparent that the cost overruns would exceed the contingency allowance and there was a severe potential for the project to become uneconomic and fail, resulting in the potential bankruptcy of the developer and loss of substantial investment by the financiers who were using retirement funds.

Review of the site showed that in the commercial area there was 3 to 5 feet of unnecessary fill, that the fill in the commercial area resulted in the need to provide stairs to the sidewalk and ramps to serve each building. The first floors of the commercial buildings were in general 2-1/2 to 3 feet above the sidewalk of the adjacent street which was also constructed as a part of the project. The closeness of the commercial buildings to the sidewalk meant the soil could not merely be sloped down, but had to be supported by retaining walls. The stairs and ramps all required railings and/or guardrails.

In the residential area, the first floor of several of the units was below the level of the adjacent sidewalk less than 10 feet away. This created the need to install area drains to drain the rain water to prevent the dwelling units from being flooded. In other areas, the parking lot was constructed two feet above the floor of the adjacent apartment buildings so that vehicle headlamps would shine directly into the first floor windows of the dwelling units. This required masking shrubbery and ramps down to the building entries. In some areas, the first floor of the dwelling units was more than two feet above the elevation of the sidewalk which served them from an expected distance of 8 to 15 feet. This disparity also required retaining walls and, in addition, required that the entry walkways, instead of going directly from the sidewalk or the parking lot to the dwelling unit,

serpentine around the property in order to keep the slope of the walkway within the requirements for disabled access.

Preparation for this trial required that a study be performed to ensure that the project could have been constructed economically in conformance with the planning approval and that none of the retaining walls or external steps or ramps were necessary and that direct walk access was feasible without the serpentine route that was necessary in several instances. In addition, it was necessary to show that the maximum 100-year rainfall could have been received and discharged on the surface without flooding any building.

Another factor in the cost overruns was excessively deep sanitary and storm sewers, depths that were 12 feet and more deep than was necessary to handle the maximum design flows. This required the verification of the hydraulic design.

The contract for the construction design required that it be the most cost effective and that it be completed by a specific date. All the construction plans were not delivered on time, and construction was begun on that work which was reportedly complete. There were many changes during the course of construction which adversely affected the construction costs and also the completion time which resulted in loss of rentals and in some instances loss of the tenant.

The challenge was to present this complex situation to the jury in a manner in which they could understand and appreciate the problems which would be difficult to discern from the plans. The manner in which this was done, in color, and using LCD projection in the courtroom illustrated the evidence in a clear and understandable manner. A site plan was prepared showing every building, street, and walk per planning approval; then, the added construction items (steps, ramps, retaining walls, drains) were highlighted. Cross sections were prepared to illustrate the problems which arise when the floor levels aren't coordinated with sidewalk levels. Then, each side of each building with the adjacent area was photographed so that the presenter could "walk around" the building. Each side view was then digitally altered into the planning approval form. The view was returned to the as-built condition and each of the items of excessive cost was successively identified with a running total shown at the top of the screen. Figures 1 and 2 in this abstract illustrate the technique for one side of one of the buildings.

This interactive computerized presentation was created to show images of the buildings and surroundings as-built in comparison to images of the construction as it would have looked if it were built as planned. The computerized slide show was created using the program Macromedia Director, a multimedia presentation program that allows sequential and random access to all exhibits and photographs using a simple hand-held remote control hooked to a laptop computer and presented using a projection device.

Morphing, Computer Display, Actual vs. Planned Construction

C36 Validating and Developing Tools for Examining Digital Evidence

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The goals of this research project are to give an overview of different methods in the field of Digital Evidence used and developed by the Netherlands Forensic Institute. The projects can be classified within the net areas of embedded systems, image processing, data communication, and encryption. The efforts for validating the methods are discussed.

At the Netherlands Forensic Institute the Digital Evidence section has been working for eight years examining cases and developing tools that can be used by the police in accordance with a proper manifestation of the science of forensics.

We distinguish the next steps, which are applicable to the complete field of digital evidence:

- Getting Access (e.g., getting raw data from a hard disk);
- Data Recovery (e.g., converting the raw data in readable files);
- Data Analysis (e.g., searching for images in data);
- Interpretation (e.g., determining whence the image originated).

For the first three steps it is possible to create automated tools. However, for the step of interpretation, this is often not possible. In our laboratory, we try to develop tools for cases that have to be investigated often for acquisition, decoding and analysis, and where no validated product is available on the market, or there is no product available that could be validated.

The first effort in our laboratory was developing a standard tool for cracking the passwords of commonly used PDA's by a standard user interface in a way proper according to the science of forensics, i.e., not altering the contents of the PDA itself. It uses the standard serial interface with the PDA for cracking the passwords. After this, a backup of the organizer may be made with the manufacturer's software. The tool, ZERT, is still frequently used in many countries. We have developed the software and hardware ourselves in such a way that we know exactly how the system works.

Another project covers reading out chip cards in a proper way according to forensics. Cellular phones in Europe often have a chip card, which may be valuable for recovering information. We use standard chip card readers from commercial companies; the software is developed in the department and the source code for it is made available.

Since cellular phones often contain memory themselves, they can also store information. A standard is available for reading out the user-related data via existing interfaces of a phone with an Infrared port, a serial cable, or any other available PC interface which connects to a standard PC serial port. The software we are developing will reduce the time needed to examine information stored by a cellular phone.

We also developed our own software for interception of data-communication and decryption of encrypted data. In the past we have also developed software for media analysis. However, nowadays we use several commercial packages (e.g., Encase, Ilook). These software packages are widely used. If challenged in court, we do not have the source code. We then would have to rely on the company that developed the software or other people that validated the software. In theory, the Court could request a full disclosure of the software's source code for examination by another expert. For validation, the results of the software that we developed ourselves could be compared with commercial packages.

In image processing we have developed our own algorithms with software when the source code is available. It appears to be difficult to get the exact same results in/as commercial packages for the same image. A simple enhancement, such as contrast stretching, might give a different gray-level distribution with our software since the implementation of such in commercial packages differs slightly. Very sophisticated methods, such as Maximum Total Variation, are even more difficult to validate if the source code and implementation instructions are not available.

Since the amount of data to be examined is growing rapidly, it is necessary to screen the data. For this reason, proper search tools that also may be used by the defense are required. An "open source" policy for forensic software and hardware tools might be a way to have it validated by many people. However, often this is not of commercial interest and will be even more complicated when it comes to proprietary methods. By "open source," it is not meant that all software will be reviewed since this very much so depends on the actual need to review any given piece of software. A mutually agreed upon review process to be performed by a trusted professional organization might be a good alternative.

Digital Evidence, Validation, Decryption

C37 Investigating Hidden Information: Steganography and Computer Forensics

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The goals of this research project are to present to the forensic community with information to aid in the investigation of covert and clandestine information (steganography).

This paper provides an overview of some characteristics in information hiding and steganalysis for investigating hidden information. Sample steganalysis methods are presented covering three aspects of steganalysis: detection, distortion, and extraction of hidden information.

Steganography is the art of hiding information in seemingly innocuous carriers in an effort to conceal the existence of the embedded information. Steganography may be viewed as akin to cryptography; both have been used throughout recorded history to add some form of protection to communication and information. At times these two technologies seem to converge while the objectives of the two differ.

Cryptographic techniques “scramble” a message so if it is intercepted, it cannot be understood. Steganography, in an essence, “camouflages” a message to hide its existence and make it seem “invisible” thus concealing the fact that a message is being sent altogether. A ciphertext message may draw suspicion while an invisible message will not. Much has been written about cryptology (the combined science and art of cryptography and cryptanalysis). Steganography and steganalysis are gaining in popularity and only in the past few years has information been written to explore such techniques in digital media.

Steganography poses a significant threat to forensic analysts, as they now must consider a much broader scope of information for analysis and investigation. Instead of scanning computers for information, (at times encrypted) they must also keep in mind that the suspect information may be hidden. When information is hidden within a carrier, some kind of manipulation to that carrier must take place. This manipulation may result in producing some anomalous characteristics, which in turn, may be used to detect that steganography has been used (*stego signatures*). At times these characteristics may even point to the tool being used to hide information. The carrier of hidden information is not the only object being manipulated through the use of steganography tools. Computer systems are also changed when applications are installed and executed. Software is required to embed and extract hidden information. If this software, or its artifacts, is found, then suspicion is also raised (*system signatures*).

Computer forensics involves the investigation and analysis of digital information. This digital information may in turn be the carriers of additional hidden/illicit information. A goal of steganography is to avoid drawing suspicion to the transmission of hidden information. Documents may be modified to hide information by manipulating positions of lines and words [5]. Many different methods for hiding information exist. Carriers for hidden information include storage devices [2, 11], network communication packets [7], images [4], and audio [6] (for an overview of steganography techniques for various media types, see [1, 3, 8, 12, 14]). Just about anything that can be represented in a data bit stream may be taken advantage of to hide information. Unused space in file headers of image and audio may be used to hold “extra” information. Information may be hidden within audio and video with virtually no impact to the human sensory system.

Taking advantage of unused or reserved space to hold covert information provides a means of hiding information without perceptually degrading the carrier. This “extra” space can be used to hide information without showing up in the directory. If the user knows the file name and password, then access is granted to the file; otherwise, no evidence of the file exists in the system of the hidden files.

The abundant availability of steganography tools on the Internet and the possibility of hiding illicit information via web page images, audio, and

other files being transmitted through the Internet has law enforcement concerned. The steganalysis “attacks” of interest to the forensics investigators involve detecting and if possible extracting the embedded information. Unusual patterns stand out and expose the possibility of hidden information. Images and audio may also produce distortions from the embedding of hidden information. Selecting the proper combination of steganography tools and carriers is key to successful information hiding. See [8, 10, 15] for examples of unique signatures of steganography tools as applied to images.

Hiding information in slack space on a storage device poses a different problem. A steganographic file system is vulnerable to detection through analysis of the system’s partition information. Tools that hide information in the network traffic headers [13] appear to produce predictable patterns that may trigger responses from intrusion detection systems.

Many steganography applications require a password to hide and recover embedded information. Steganography tools that require passwords to hide and recover embedded messages are vulnerable to attacks similar to cryptanalysis in brute-force or dictionary attacks. Brute-force and dictionary attacks are general threats to password-based systems. This paper provides a brief overview of discovering hidden information with respect to computer forensics and introduces some characteristics of steganography that point to signs of information hiding.

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Computer Forensics, Steganography, Steganalysis

C38 The Invisible Ink: Metadata

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The goal of this research project is to present to the digital forensic community information on metadata.

This paper provides an overview of the metadata and examples of how Microsoft stores the metadata in their Office documents.

There are many definitions of metadata. For the purpose of this paper, we define metadata as “any information that is stored within a document to provide additional information about that document.” This information may be in binary format, or it may be hidden from the user of the application, and it will not be displayed if the document is printed. However, if the binary file is examined correctly, it can yield a large amount of information about the author of the document and the environment in which the document was created. Since the metadata is part of the document, it will be distributed when the document is distributed electronically.

Microsoft uses metadata for a variety of purposes to enhance the editing, viewing, filing, and retrieval of office document. It has published a series of article [1] on how to minimize metadata in Microsoft Office documents to address the concerns of privacy issues.

Some metadata are readily accessible through the Microsoft Office application user interface. Others may be only accessible through extraordinary means. Some examples of metadata that may be stored in the document:

- Name of generating application
- Name of the Operating System
- Author's Name
- Author's Organization
- The name of network server or hard disk where the document was saved
- The names of previous document authors
- Document revisions
- Document versions
- Hidden text
- Template information

Microsoft uses the Object Linking and Embedding (OLE) interface for their metadata entries. OLE allows programs to interact with each other in a standard format. By using an OLE environment within Microsoft Office documents, Microsoft allows a document to have different forms of media in a single file, such as images, sounds, and tables. The OLE structure of Microsoft Office documents has the similar problems as a normal file system; it can have free space, slack space, and can become corrupt. Free space and slack space are not viewable as part of the document, but they may contain data that are valuable for the investigation. Another challenge an examiner faces when trying to extract this data is that the information may be fragmented throughout the document. This fragmentation makes it difficult to read the information from the file without first interpreting the file structure within the document.

An object embedded within a document still retains its own metadata. For example, if an user embeds a Microsoft Excel workbook within a Word document, the document and the workbook each has its own individual metadata.

This paper provides a brief overview of the metadata and the Microsoft implementation. Currently, the software communities do not have a standard format on the implementation. They are strictly application specific. Even within the same company, each application may have its own method of storing metadata that creates many challenges for the digital forensic communities.

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Metadata, Computer Forensics, OLE

C39 Coal Bin Failure

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The goals of this presentation are to present investigation and analysis of coal bin collapse and to present standards applicable to construction and design of the bin.

One fall morning, workers at a preparation plant were ferrying mined coal over a series of conveyor belts toward the main coal bin. The coal bin served the dual purpose of storing and funneling coal into trucks for transportation. As normal daily operations ensued, some nearby workers witnessed the sudden catastrophic collapse of the coal bin. This collapse resulted in no deaths or injuries, but did produce significant damage to the bin and supporting structures. Furthermore, the plant operations were virtually shut down.

The coal bin was essentially a box frame structure composed of steel plates and rolled shapes. The bin was supported by four I-columns and erected over a steel cone chute, which funnels coal as it is dropped into the bin. The cone was connected to the bin by a series of bolts along the cone top. The inspection revealed that the bottom cone chute collapsed from its attachment to the supporting bin. The southwest corner of the cone, which located the initial point of failure, contained several bolts which had sheared. Most notable of these bolts was the fact that significant corrosion and rust existed along the shear plane of the bolts, indicating that these bolts failed some time prior to the collapse. It was noted that the bolt heads could pass through several other holes along the top of the cone due to elongation. The elongation indicated that the bearing strength of the holes was exceeded. Evidence of fatigue was presented by the elongation of the holes and wearing of the bolt threads. The failure also resulted in impact and buckling damage to the column legs as the bin came down.

The physical evidence indicated that failure of the bolted connections between the cone chute and bin precipitated the collapse. Furthermore, some of the connections failed prior to the collapse. The connection between the bin and cone was made with A32S-N bolts with a 5/9 inch diameter, ¼ inch length, and countersunk heads. The design drawings specified that all holes be countersunk and punched at a diameter of 13/16 inches. A friction plate was applied over the countersunk head to eliminate wearing. There were no torque specifications for any of the bolted connections, which indicate that the attachments constituted bearing connections.

The physical evidence enabled an analysis of the connection strength to be compared to factored loads. This analysis was performed in accordance with Load and Resistance Factor Design (LRFD) developed by the American Institute of Steel Construction (AISC). LRFD requires that bearing type connections be designed considering bolt shear strength, hole bearing strength, and rupture strength of the connecting plates or flanges. Calculations revealed that the factored load per connection exceeded the bearing strength of each bolt hole. LRFD standards were found to be directly applicable to the coal bin and the causes of its collapse. Firstly, bearing type connections are not allowed for those subject to cyclic loading, vibration, or fatigue. The bin and cone were subject to significant load reversal and fatigue. The connections should have been slip critical (SC), in which torque is applied to the bolt. Secondly, oversized holes are permitted for SIC connections, but not for bearing connections. The 13/16 inch holes are oversized for 5/9 inch bolts. Lastly, countersinking holes reduces the effective thickness of die connecting parts, which reduces the bearing strength of die holes. The ¼ inch plate was not thick enough to accept the tapered heads of the bolts.

Based on the findings and analysis, definite conclusions may be made about this failure. The cone chute at the bottom of the bin collapsed because of improper design of the bolted connections. These connections were not designed in accordance to applicable standards. The countersunk holes and insufficient plate thickness significantly decreased the bearing surface and strength. This surface acted as a knife edge, which contributed to the shearing of the bolt heads. The physical evidence shows that many

of the connections failed prior to the collapse. Through time and usage, the southwest corner of the cone began to fail and drop. On the day of the collapse, the supporting capacity of the remaining bolted connections was insufficient.

Slip Critical Connections, Countersunk Holes, Bearing Strength

C40 Quantifying Polluted Habitat: Persistence of Oil on Beaches 12 Years After the Exxon Valdez Oil Spill

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This paper will summarize a powerful statistical approach for measuring the amount of oil on polluted beaches when the oil distribution is highly variable and clustered.

The 1989 *Exxon Valdez* oil spill released a minimum of 11 million gallons of crude oil into one of the largest and most productive estuaries in North America, polluting a substantial proportion of the intertidal spawning habitat used by pink salmon and herring. After three years of unprecedented efforts to clean the polluted beaches, it was expected that natural processes would disperse any oil remaining. Follow-up studies showed that oil was surprisingly persistent at many locations within the affected area. This lingering oil was often present in a relatively unweathered state, containing high concentrations of toxic and biologically available polycyclic aromatic hydrocarbons (PAH). These remaining oil deposits have become a chronic source of low-level oil pollution within the spill-affected area. The extent of the remaining oil is unknown, and this uncertainty engenders public and scientific concerns about the effects the oil may continue to have on humans and on fauna through direct or indirect exposure.

The objective of this study is to measure the amount of oil that remains in the intertidal of Prince William Sound. A stratified random-adaptive sampling (SRAS) design was adopted to focus sampling effort in areas where oil most likely persists, while allocating some effort to discovering oil in areas where persistence is uncertain. This approach guarantees a credible minimum estimate of remaining oiled area, and will provide a confidence interval for the most likely amount remaining throughout the affected region.

Most of the oil remaining is thought to be buried beneath the surface of intertidal beaches that were most heavily oiled in 1989. The SRAS design includes some 8,000 test pits randomly assigned within 6 horizontal strata delineated by tidal elevation among 96 randomly selected beach segments. The pits are dug to a depth of 0.5 meters (1.6 feet). The selected beach segments were drawn from the total number of heavily, moderately, and lightly oiled beaches in 1989-1993. Most of the pits are allocated to beaches that were most heavily oiled in 1989 through 1993, based on shoreline cleanup assessment surveys during those years. Some of the pits are dug on beaches that received less oil to verify that oil on those beaches is not overlooked. Whenever oil is discovered in a test pit, the size and location of the oil patch on the beach is measured. The amount of oil within the patch is visually categorized, and the mean amount of oil characterizing each category is estimated by establishing a regression relationship based on the quantity of oil extracted and weighed from a subset of pits within each category. These results can then be combined statistically to produce an estimate of oil in the sampled beach, and the amount remaining in the entire spill area of PWS, without having to examine all the beaches there.

Sampling was 50% complete by 26 June 2001, with close to 4,000 test pits evaluated. Surface or subsurface oil was visually evident in about 10% of these pits. This means that the probability of encountering oil within or beneath a 0.5x0.5 m square quadrat placed at random on a beach that had been heavily oiled in 1989 and remained substantially oiled after 1991 is

about 10%. However, this 10% random encounter rate is not uniform among all the beaches examined. No oil was found on about 45% of the beaches sampled, compared with 53% of the pits with oil on the beach with the highest frequency (in Northwest Bay). Other beaches where oil was frequently encountered include one in Herring Bay (41% of pits with oil), one on Smith Island (32%), and one in the Bay of Isles (23%).

The oil that remains on the surface of the beaches is mostly hardened into an asphalt-like layer, so the toxic components are not very available to biota. The buried oil is more liquid, and may become biologically available if a disturbance event such as burrowing animals or a severe storm reworks the beach and disperses the oil into the water. Then fish and wildlife may become exposed by contact or by ingesting oiled prey. However, the amounts of oil found so far are unlikely to cause detectable effects on fish or wildlife populations. The effects would most likely be limited to animals living near the remaining oiled sediments.

Oil Persistence, Exxon Valdez, Habitat Loss

C41 Are We Over-Regulating Arsenic?

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This research project has four objectives: (1) review of the toxicological basis for the U.S. EPA's current and proposed drinking water standard for arsenic; (2) evaluation of evidence for threshold arsenic carcinogenicity; (3) development of an arsenic drinking water standard considering all of the available evidence; and, (4) a comparison of arsenic drinking water standards.

The U.S. EPA set the current standard of 50 ppb in 1975 to protect public health. In 1999, the NAS concluded that the U.S. EPA standard did not protect public health, and therefore, the drinking water standard should be lowered as soon as possible. The U.S. EPA proposed a new drinking water standard of 5 ppb in 2000, requesting comment on this proposed new standard and several other potential optional standards; 3 ppb, 10 ppb and 20 ppb. After considering 6,500 pages from 1,100 commenters, the U.S. EPA set the drinking water standard for arsenic at 10 ppb, a level that "maximizes health risk reduction benefits at a cost that is justified by the benefits." The new standard applies to all 54,000 community water systems, including those that serve as few as 15 locations or 25 year-round residents. The U.S. EPA estimates that approximately 5 percent or 3,000 community water systems will have to take corrective action to meet the new lower level of arsenic allowable in drinking water. According to the U.S. EPA, these corrective actions are expected to cost between \$150 and \$200 million dollars per year while preventing approximately 13 cases of bladder cancer and 3 bladder cancer deaths per year.

In January of 2001, the United States Environmental Protection Agency ("U.S. EPA") finalized regulation to reduce the drinking water standard for arsenic from 50 parts per billion ("ppb") to 10 ppb. According to the U.S. EPA, the purpose of the new drinking water standard is to reduce public health risks associated with arsenic in drinking water, providing additional protection for 13 million Americans against cancer and other health problems, including cardiovascular disease, diabetes, and neurological effects associated with arsenic. Upon entering office, the President of the United States, suspended the new drinking water standard for arsenic and called for a re-evaluation of the scientific basis for that standard. Currently, the U.S. EPA is working with the National Academy of Sciences ("NAS") and the National Drinking Water Advisory Council ("NDWAC") to reassess the scientific and cost issues associated with the new proposed drinking water standard for arsenic.

The scientific bases for the U.S. EPA drinking water standard for arsenic are studies demonstrating an association between long-term exposure to arsenic in drinking water and increased incidence of cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate, and the occurrence of non-cancer effects, including cardiovascular, pulmonary,

immunological, neurological, and endocrine (e.g., diabetes) effects. These include epidemiologic studies conducted in Taiwan, Japan, England, Hungary, Mexico, Chile, and Argentina, which report an association between arsenic in drinking water and skin cancer in exposed populations, but not recent epidemiological studies that show no association or an inverse association between arsenic in drinking water and cancer.

Several scientists have suggested that arsenic is a threshold carcinogen. Criticism of the U.S. EPA evaluation of the available evidence of arsenic carcinogenicity includes differences in dietary arsenic intake between the human population experiencing increased cancer incidence and target U.S. populations, limitations of low-dose linear modeling of dose-response, and the potential threshold for arsenic-induced carcinogenesis.

In this presentation, the toxicological basis for the newly proposed U.S. EPA drinking water standard for arsenic will be discussed with particular emphasis on evidence for a threshold for arsenic carcinogenicity. Finally, in this presentation, an arsenic drinking water standard will be developed based on all of the available evidence. The result will be compared with current and newly proposed U.S. EPA drinking water standards for arsenic, information regarding the national prevalence of arsenic in groundwater, and other relevant standards.

Arsenic, Drinking Water Standard, U.S. EPA

C42 Strategies and Instrumentation Developments for Forensic Analyses in the Field

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Several approaches to organic analyses in the field for forensics will be presented along with some new instrumentation developments that facilitate these analyses.

The FBI's laboratory division hazardous materials response unit and other operational units within the FBI require rapid and reliable chemical analyses in the field to improve their overall response strategy and effectiveness. Gas chromatography (GC) coupled with mass spectrometry (MS) is a mature and proven analytical technique that provides court defensible data. Raman spectroscopy is advancing quite rapidly in the amount of information that can be gleaned in a non-intrusive fashion. Ion mobility spectrometry (IMS) is another technique that is proven for its sensitivity. Each of these techniques can be field deployed; however, the use of these systems in the field, including exercising the available sample inlet methods, requires further development. The GC/MS systems available for the field are either too heavy, too power demanding, or have limited performance. The Raman systems developed for the field require evaluation, and the IMS systems developed for the field have new inlet capabilities that require evaluation. We will present data from a new GC design that is small, lightweight, and has low power requirements for eventual GC/MS field systems. We have explored the use of field Raman systems and will present our results from these evaluations. Also, we have experimented with the use of solid phase microextraction (SPME) interfaced to an IMS for the analysis of headspace organic mixtures.

To affect a wide range of organic separation capability, it is standard practice to increase the temperature steadily during a GC/MS analysis, causing less volatile components in a mixture to become increasingly mobile and thereby assisting the separation process. The practice of "temperature programming" is routinely done by changing the temperature of the oven containing a GC capillary column. This novel GC design does not require a convective approach to column heating. This new low

thermal mass (LTM) column heating design has a high thermal efficiency toroidal wrap that can be programmed at high speed while maintaining low power consumption. One of the columns selected for this work is a 15m DB-5MS 0.25mm id. with a 0.25um df. We will present data on the use of this column in a conventional GC oven versus that with the LTM GC on a mixture used as a performance test for chemical warfare treaty verifications. This quality control mixture will be analyzed under different chromatographic conditions in the "lab" for comparison with the low thermal mass toroidal heating and ramping column arrangement of our experimental system. Mass spectrometric parameters, such as sampling time, scan rate, and library matching capability, will be evaluated for several different, mostly high, ramping rates. Initially, for this mixture, the LTM GC will be optimized for rapid analysis while maintaining resolution adequate for correct identification via quadrupole MS. As the ramp rates increase for more rapid field analyses, the MS detection system becomes challenged and in many cases cannot keep up with the data rates required to maintain analyte integrity.

The development of a field-portable battery-operated Raman system enables the application of this non-intrusive technology to analytical measurement situations requiring reliable identification of potentially hazardous materials in the field. Raman spectrometers are just beginning to move from conventional bench-top to field portable systems. Evaluation of these instrument prototypes will provide feedback necessary for these instruments to develop into systems useful for on-site characterization of materials relevant to public or personnel safety and security issues.

SPME is a maturing sampling method that is well suited for field use; it is passive, requires neither power or solvents for sample collection or preparation, and the device is compact. The theoretical aspects of SPME indicate that in all but the smallest of samples, sample size (i.e., volume of water or air) does not affect the sample loading onto the fiber, whereas, analyte concentration and sampling conditions do affect quantitative fiber loading. US Customs is responsible for over 400 points of entry within the US borders. Trace detection of smuggled money has been difficult and current methods rely on the use of canines. With the large number of entry points and the problems with canines, such as exhaustion and maintenance, an improved methodology for screening incoming cargo is required. This research is designed to identify the VOCs and Semi-VOCs for targeted detection and identification in a rugged, field-portable system that is simple, sensitive, specific, and rapid. SPME will also be used as a sampling front-end for chemical warfare-related compounds followed by IMS and/or GC-MS detection. In-field use of the SPME and fiber still allows confirmation of results via GC-MS. SPME will be used as the trace organic concentrator followed by GC with IMS and MS detection.

The laboratory division and forensic community should benefit from these method and instrumentation developments because they will help reduce the time for mixture analysis of the various organic matrices, including semivolatiles as well as volatiles, typically encountered by responders and analysts in the field. These developments, in combination with the miniaturization of detectors, will also help drive the commercialization of small, low power, light weight instruments for field analyses.

GC-MS, Field Analysis, GC

C43 The Application of Stable Isotope Ratios in Environmental Forensics

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Stable isotope ratios are presented as an investigative tool in environmental forensics and litigation. Selected applications and the major limitations of the methods are discussed.

The measurement of stable isotope ratios for elements such as hydrogen, oxygen, carbon, nitrogen, sulfur, and chloride are reliable and

commercially available. Sampling procedures are straightforward and measurements can be obtained at reasonable cost for most environmental samples. Data can be obtained from whole samples, separated or extracted phases, and separated or isolated single compounds.

Stable isotope ratios are characteristic of the origin of chemical compounds and are influenced by physical, chemical, and biological processes. As such, isotope ratios can be quite informative in environmental investigations. Physical processes such as volatilization, distillation, or condensation are dependent on elemental and molecular masses and therefore can change isotope ratio values. The effects of physical processes are important in manufacturing and processing, and often result in products and waste streams with characteristic isotopic signatures. Chemical reactivity can lead to isotopic fractionation with heavier isotope(s) of an element often being differently reactive than the lighter one(s). The fractionation by chemical reactivity might be significant in industrial chemical processes but tend to be small or below resolution under environmental conditions. Biological processes can fractionate very effectively the isotopic composition of degradable organic compounds under conditions that occur naturally in the environment. Isotopic fractionation has been extensively studied for more than 50 years and is the subject of much on-going research for environmental and biological applications. The application of stable isotope ratios in environmental forensics can include, for examples; the tracking of the origin of manufactured chemicals or products in source investigations; the allocation of environmental liability in cases where potentially responsible parties are in need of a technical basis to evaluate contributions to a common problem; the evaluation of the performance of environmental remedy where natural attenuation or capture of a contaminant plume have to be demonstrated and/or predicted; the guiding of some aspects of the site characterization and assessment process; and; the evaluation of various hypotheses or litigious allegations to the extent that these might be determined with this type of data.

The analysis and interpretation of stable isotope ratios for environmental applications have limitations that cannot be understated. The major limitation to interpretation relates to the fact that isotope ratios reflect the sum of several complex processes that can be difficult to separate and quantify individually. Isotope data inform on trends imposed by the cumulative effects of various processes. It is up to the investigator to interpret the meaning of these trends, and interpretations can often be non-unique or inconclusive. There are, however, a few instances where isotope data can yield solid interpretation and strong evidence. For example, the determination of the origin of contamination can sometimes be simply resolved based on isotope data alone. Analytical uncertainty is relatively well quantified but is typically significant enough as to limit the usefulness of the approach. Analytical error bars can be too high to monitor the effects of many fractionation processes that occur under natural conditions. This limitation restricts the potential power of the method, and technological progress has been slow to improve on this topic. Because of these limitations, stable isotope ratio data for environmental applications are most often of use as complements to classical investigation. The interpretation of isotope ratios greatly benefits from a detailed understanding of site conditions and history, and the overall investigation process in turn benefits from the isotope ratio information.

Selected recent advances in the field of stable isotope research will be briefly presented. In particular, the potential application of chlorine isotopes to environmental forensics will be discussed. Two case studies will be presented in more details. The first case will present the application of sulfur isotope ratio data to identify and quantify the actual extent and volume of a man-made sulfate groundwater plume. The origin of sulfur in the studied area is from both naturally occurring hydrothermal sulfate and the oxidation of reduced sulfur in pyrite-rich ore materials. This study was conducted in the context of litigation (natural resource damage claim) and relates to the quantification of groundwater impacts from major mining operations. The second case will focus on the application of nitrogen isotope ratio data to differentiate or allocate between potential

sources for nitrate in private drinking water wells. This study examines the isotope ratio of nitrate nitrogen in an area where both cattle feed-lot activities and the spreading of sludge from a public water treatment plant took place.

Isotopes, Environment, Litigation

C44 Bicyclic Sesquiterpane Biomarkers— Useful Hydrocarbons in the Chemical Fingerprinting Class 4 and Class 5 Petroleum Distillates

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The goals of this research project are to present chemical data supporting the use of sesquiterpane biomarkers in the differentiation or correlation of distillate petroleum in environmental (and potentially in arson) investigations.

Petroleum biomarkers are ubiquitous and stable hydrocarbons that occur in crude oils. They are derived from formerly living organisms whose organic materials gave rise to the crude oil over geologic time. The biomarkers present in the “parent” crude oil feedstock are largely preserved during refining and thereby impart unique features to the “daughter” petroleum products. Thus, in forensic investigations where petroleum products are to be “correlated” to one another or to a suspected source, the biomarkers can prove particularly useful.

The biomarkers most commonly used in forensic issues are the C₂₇-C₃₅ pentacyclic triterpanes and C₂₇-C₃₀ steranes. Unfortunately, the high molecular weights of these particular biomarkers limit their applicability to petroleum products containing high boiling fractions (e.g., crude oil, residual fuels, and lubricants). Class 4 (kerosene or Jet A) and Class 5 (diesel fuel/fuel oil #2) fuels are middle distillate petroleum produced by distillation of crude oil feedstocks and often, by subsequent blending of refinery intermediates to meet product specifications. This paper describes a suite of “low” boiling petroleum biomarkers, bicyclic sesquiterpanes, which often occur in Class 4 and Class 5 distillate fuels that can provide specific information about the nature of these fuels, even after environmental weathering has occurred.

Bicyclic sesquiterpanes are, as their name implies, bicyclopentanes containing approximately 15 (‘sesqui-’) carbons. These compounds (i.e., C₄ to C₆-decalins) have molecular weights ranging from approximately 194 to 222 amu. Analysis of liquid petroleum products or petroleum-impacted soil extracts by gas chromatography-mass spectrometry (GC/MS; full scan or selected ion monitoring) reveals these compounds on the *m/z* 123 mass chromatogram, due to production of a strong C₉H₁₅⁺ fragment. The sesquiterpanes boil within the *n*-C₁₃ to *n*-C₁₆ range (approximately 240°C to 285°C). Identification of ten bicyclic sesquiterpanes within this boiling range has been published within the petroleum exploration literature, and is based upon a combination of synthetic standards and mass spectral interpretation. In environmental forensic investigations involving middle distillate fuels (kerosene, Jet A, diesel/fuel oil #2, etc.), the *m/z* 123 mass chromatogram and the various confirmation ions (*m/z* 179, 193, and 207) provide a sufficient basis for identification and qualitative fingerprinting of these ten sesquiterpane biomarkers. Ratios among these compounds’ peak areas can help demonstrate subtle differences. Quantification of these compounds has not yet been achieved due to the unavailability of authentic standards.

Data from a survey of fresh distillate fuels (kerosene, Jet A, and diesel fuel #2) are presented which reveals the variety of sesquiterpane patterns that can exist in these products. In some instances, fuels that are otherwise indistinguishable can be shown to demonstrate distinctive sesquiterpane patterns. These differences are reasonably attributed to the differences in the crude oil feedstocks used in the production of these dif-

ferent fuels. Some influence of distillation can be seen to influence some sesquiterpane patterns, depending on the end-boiling points of the petroleum product.

Data from an environmental forensic investigation involving spilled diesel fuel #2 are used to demonstrate the consistency in the distribution of sesquiterpanes over a wide range of environmental weathering. Non-aqueous phase liquid samples collected from the impacted area show that the sesquiterpane pattern remains unchanged between samples containing a full suite of *n*-alkanes and samples containing no *n*-alkanes, having been removed via biodegradation. This demonstrates the resistance to microbial degradation that sesquiterpanes demonstrate over environmental timescales.

Finally, a case study is presented in which the sesquiterpanes are used to unravel the source of weathered diesel fuel #2 impacting soils on adjacent properties. Weathering precluded use of most conventional "markers" in distinguishing among the diesel fuels. In this study, analysis of extracts of soils from the defendant's property were demonstrated to have been impacted by a diesel fuel #2 with a distinct sesquiterpane pattern. This was consistent with historical records that suggested a single release of diesel fuel #2 had occurred on the defendant's property. Notably, this sesquiterpane pattern was different from the multiple patterns observed in extracts of soils from the adjacent plaintiff's property. The variety of sesquiterpane patterns in the plaintiff's soils suggested that multiple releases of diesel fuel #2 had occurred on their site – all of which were distinct from the diesel fuel #2 that was released on the defendant's property. This chemical evidence, combined with the presence of "clean" soil at some key locations along migration pathways, convinced the plaintiffs to drop their lawsuit.

Petroleum, Chemical Fingerprinting, Environment

C45 Performance-Based Quality Assurance Program for the Analysis of PAHs, PCB Congeners, and Chlorinated Pesticides in Marine Tissue and Sediment Samples

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The objective of the annual inter-comparisons is to compare the data generated from different laboratories using the laboratory own methods on a common set of samples. Each participating laboratory receives a report showing how its data compare to data generated by the other participating laboratories.

Since 1987, the National Institute of Standards and Technology (NIST) has coordinated annual inter-comparison exercises for the determination of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyl (PCB) congeners, and chlorinated pesticides in marine tissue and sediment samples. These inter-comparison exercises have become an excellent tool for assessing the comparability of analytical measurements among the marine environmental measurement community. The program currently operates on a pay-to-participate basis with laboratories receiving a report showing their participation relative to other participating laboratories. In the most recent exercise, over 25 laboratories, representing federal and state government, private, and university laboratories, reported results on 26 PAHs, 25 PCB congeners, and 25 chlorinated pesticides in a frozen marine sediment material and a frozen mussel tissue. The laboratories concurrently analyzed reference materials, NIST SRM 1944, New York/New Jersey Waterway Sediment, and SRM 1974a, Organics in Mussel Tissue (*Mytilus edulis*). The data from the laboratories were evaluated and combined to assign a consensus value for each analyte of interest in the marine sediment and mussel tissue materials. *Z*-scores and *p*-scores are determined for assessment of accuracy and precision. The *z*-score assesses the difference between the result of the laboratory and the

exercise assigned value and can be used to compare performance on different analytes and on different materials. The results from the most recent exercise, as well as past exercises, will be summarized in this paper.

Interlaboratory Comparison, Polycyclic Aromatic Hydrocarbons, Quality Assurance

C46 Forensic Science in Remediation

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Forensic science is important in determining the efficacy of remedial actions, as well as in establishing the relative liability of potentially responsible parties. The bioremediation of contaminated soil at a petroleum storage terminal is used as an example.

The *site* was used predominantly for the storage of home heating oil (No. 2 fuel oil, or diesel), although aviation gasoline, motor gasoline, kerosene, jet fuel and some heavier fuel oils also were stored at various times. Portions of the *site* were developed by different entities from the 1920s to the 1960s. The type of products stored varied among such entities and subsequent operators. *Site* operations were terminated circa 1987, and the remediation conducted 1993-1998.

Due to the organic composition of petroleum hydrocarbons, indigenous bacteria in the soil are capable of using them as a food source. This process, called bioremediation, is an aerobic process which requires that adequate oxygen be made available to the soil bacteria.

The field bioremediation operations were ex-situ, in which contaminated soils were excavated, sieved to remove rocks, and spread out in large flat areas known as "biobeds." The soils in the biobeds are tilled periodically in order to provide the necessary oxygen. Different types of tilling equipment can be used. At the *site* most of the soils were tilled by a Brown Bear tractor with a front-mounted horizontal screw auger or paddle auger. The Brown Bear would progress through the contaminated soils, mixing them and moving them to the side creating long, parallel mounds of soil known as "windrows."

The remedial criteria for total petroleum hydrocarbons ("TPH") at the *site* were 50 ppm. Although soils from the portion of the *site* initially excavated approached 50 ppm over time, it proved very difficult to achieve an average level below 50 ppm. Soils from the second portion of the *site* to be excavated showed long-term recalcitrance to bioremediation, which prompted a comprehensive review of relevant variables including bioremediation science and field operation practices.

In this review, it was discovered that the contractor had established the biobeds by sequential placement of three one foot layers of contaminated soil. Although the Brown Bear would make a windrow approximately three feet high from the top one foot of soil, it did not till the lower layers. The contractor sought to compensate for this problem by the use of a tractor-pulled ripping plow between the windrows, in an attempt to oxygenate the lower layers of soil. The ripping plow, however, was obviously less effective than the Brown Bear in oxygenating the soil, and did not reach significantly into the deepest layer.

This led to a hypothesis that three stratified soil layers were being created in the biobeds, with remedial progress based upon the extent and effectiveness of the tilling each was receiving. In order to confirm this hypothesis, two biobeds of several acres each were evaluated by a grid of 27 surface locations with three depths being sampled at each location.

The data from these sampling events were evaluated by three-dimensional kriging. The kriging analysis, using different colors to represent a range of TPH values, clearly confirmed the hypothesis that the field tilling methodology being used was creating three distinct vertical layers of varying remedial progress. Further, the kriging analysis showed that this pattern held at both higher and lower absolute levels of TPH found in the two biobeds. This left the question, however, why biobeds created at approximately the same time, and treated the same way, would result in materially different TPH levels after extended periods of tilling activity.

A review of relevant science indicated that bioremediation progress typically produces a linear, declining concentration over time which eventually levels off at a plateau beyond which further bioremediation will not occur. The level of such plateau will vary according to factors including (1) the nature of the petroleum products present in the soil, (2) the soil type, and (3) the time period over which the contaminant has been present in the soil. In performing his pilot study, however, the contractor had incorrectly assumed that all of the *site* soil would bioremediate to the same degree as a random, homogenized batch of *site* soils collected for the pilot study. In fact, the bioremediation plateau, or end point, of contaminated soils from various portions of the *site* ranged from 50 ppm to 800 ppm, apparently based on the difference in products and age of the spills in those areas. A review of the pilot study results, using homogenized soil, showed that the bioremediation methodology selected had only achieved a TPH level of approximately 200 ppm, or four times the remedial standard. In an action seeking recovery against the contractor, who sought to defend themselves with data from field tilling experiments that were performed using different types and combinations of tilling equipment. A regression analysis performed by the contractor seemed to indicate that although the top layer of soil bioremediated three times as fast as the lower level, the result was no different since three times the volume of soil was remediated at the same time compared to use of the Brown Bear applied to one foot soil depths. The presentation will demonstrate why the contractor quotes regression analysis was an inappropriate statistical approach to evaluation of the experimental results.

Remedial Criteria, Bioremediation, Contaminated Soil

C47 Measurement Uncertainty in Environmental Analyses

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The difference between measurement error and uncertainty will be explained. Methods and examples for determining measurement uncertainty will be presented.

Quantitative measurement is required for forensic interpretation of environmental analyses. The concentration, presence, or absence of a contaminant can only be determined relative to the magnitude of the uncertainty in the analysis.

All measurements contain error which is both systematic and random. Accuracy is the closeness of a measurement to the true value. Precision is the closeness of agreement between repeated measurements. Measurement error reduces the usability of laboratory data. As a measured value decreases, its relative error will increase and the usable information will decrease. The description of the unknown error is "measurement uncertainty." Measurement error is the actual unknown deviation of the measurement from the unknown true value. Measurement uncertainty expresses the state of knowledge about the unknown deviation. Reported measurement uncertainty will contain the actual measurement error with a stated level of confidence.

Measurement uncertainty of environmental analysis methods is determined by a "passive empirical" approach. The standard deviation of sample measurements by different analysts, using different equipment in different laboratories is used to calculate the uncertainty in the method. Studies of environmental analysis methods involve submitting standard materials with known levels of contaminants to multiple laboratories for analysis. The laboratory results are used to generate equations for accuracy and precision and to determine the method detection limit (MDL).

Measurement uncertainty in an environmental method is decreased as familiarity with both the procedures and the matrix improves. On-site laboratories tend to have better accuracy and precision than fixed labs per-

forming the same analyses on the same samples. An example demonstrates the difference in measurement uncertainty for a project-specific on-site laboratory versus measurement uncertainty from fixed labs performing the same procedure.

Regulatory approval was required to close a former petroleum terminal in Tiverton, Rhode Island. Approximately 15,000 soil samples were analyzed at the on-site lab, and the data was submitted to the state to demonstrate compliance with the remedial criteria. The state requested confirmatory analyses of a subset of samples by independent labs.

A study was conducted to measure the precision of five laboratories analyzing weathered total petroleum hydrocarbon (TPH) in soil by gas chromatography with flame ionization detection. A soil containing biodegraded diesel fuel was prepared and shown to be homogeneous by TPH analyses at the on-site laboratory. Samples of the soil were sent to five independent laboratories for TPH analysis. The mean, standard deviation, and relative standard deviation (RSD) were calculated from the labs' results. The RSD was indicative of the analytical precision.

The on-site lab reported an average TPH concentration of 921 ppm and a RSD of 2.4%. The independent labs reported an average TPH concentration of 755 ppm and a RSD of 35.3%. A summary report submitted to the state noted that: the independent labs generally under-estimated the sample concentration, i.e., the results from the on-site lab were biased higher than the fixed labs' results; and, the on-site lab had better precision, or lower measurement uncertainty. The state accepted the data from the on-site lab for closure of the site.

Calculations of mean and standard deviation are not sufficient to determine measurement uncertainty. Graphical evaluations also indicate whether measurement uncertainty is acceptable. A critical review of the method performance study for Massachusetts Extractable Petroleum Hydrocarbon (EPH) shows that data generated by this analytical procedure are unusable.

Massachusetts presented calculations of data from their method performance study as demonstrative of the reliability of the EPH procedure for soil analyses. The average analyte recovery was 60%, which is representative of the accuracy of the method and the RSD was 17%. Massachusetts presented the results as demonstrating adequate performance for 19 of the 23 labs participating in the study.

Graphical evaluation of the Massachusetts data does not indicate the EPH method is reliable. The data from the EPH method study were normalized against the mean of the results and the resulting values sorted in order of magnitude. The normalized data points were graphed against their relative rank in the sorted data set. A graph of normalized, ranked data from a perfectly reproducible analytical procedure has a slope of zero, while random data has a slope of one. The slope of the EPH data is 1.0, indicating the results of the Massachusetts method study are random.

Evaluation and interpretation of measurement uncertainty are essential to forensic investigation. The methods and examples outlined above demonstrate procedures to calculate and present measurement uncertainty.

Measurement Uncertainty, Accuracy, Precision

C48 Quantitative Uncertainty Analysis

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The attendee may expect to be conversant with the terminology of uncertainty analysis and have an understanding of how this can be applied to specific problems. The object of the presentation is the reinforcement of sound engineering principles and a description of methods that seek to rigorously quantify quantities that are often purely on instinct.

Uncertainty is inherent in all analyses. In measurements, there is an uncertainty of what the actual measurement value is. In a spatial interpre-

tation of measurements, there is uncertainty associated with the value at any point. In model results, there is uncertainty associated with the predictions.

In engineering analyses, it is common practice to express results as a range. For example, in estimating the mass of a contaminant, the result may be expressed as 1000 kg, plus or minus 200 kg. The range is often based on a “gut feeling” the engineer has about the accuracy of the analysis or simply experience.

The approach described in this paper tries to be more quantitative. For example, the result may be described as 1000 kg with a probability of 50%, 900 kg with a probability of 20%, 1100 kg with a probability of 20%, 800 kg with a probability of 5%, and 1200 kg with a probability of 5%. While the results are the same as stated above, there is more information contained in the second result since the probability of reaching the end of the range is quantified.

The approach is most useful in cases where, in order to be convincing, there is a propensity to heap conservatism upon conservatism. The result is that the obtained result is hugely conservative and of very low probability. By performing a quantitative uncertainty analysis, the extremely conservative results are shown together with the more realistic-as well as the most optimistic results. By associating probabilities with each of these cases, it can be show what the most likely case is, while also showing the extreme cases, but tempering the these extreme cases by an associated probability.

The paper describes the theory of quantitative uncertainty analysis and also covers case studies of practical applications using both analytical and numerical methods.

When a process can be described using an analytical function, uncertainty can be described by analytical methods in terms of the uncertainty distribution of the independent variables or inputs. In cases where the function is very complex or embodied in a computer program, a Monte Carlo type simulation can be performed to obtain the uncertainty distribution of the output. These techniques are well developed and robust, yet the application to the types of problems encountered in environmental sciences is relatively new.

In some instances, the effort involved in performing Monte Carlo simulations is such that the classic techniques cannot be used in practice. For example, the simulation may involve running a groundwater model which takes in the order of minutes or hours to run. In such instances, judicial use of Monte Carlo simulations in generating input values can be used to select a smaller set of input data sets which are then run through the time consuming simulation. By selecting appropriate input values, the uncertainty can be propagated without being unnecessarily burdensome.

A number of case studies will be presented showing how uncertainty can be quantified. The case studies will include examples from spatial data analysis, air quality modeling, and groundwater modeling.

Uncertainty Analysis, Simulation, Analysis

C49 Old, Non-Weathered Petroleum Product in a Subsurface Environment—A Case Study

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The goal of this research project is to present to the forensic community a case study in which an arbitrator ruled against the fact that non-weathered petroleum product meant that the product was recent in age.

The relationship (if any) between the age of petroleum found in the subsurface and its non-weathered condition was considered during a recent environmental arbitration. The arbitration involved issues surrounding the purchase of a major petroleum company's former bulk petroleum facilities by a commercial wholesaler distributor (purchaser). At stake was the legal and financial responsibility for approximately \$2,600,000 in soil and groundwater remediation. The petroleum company took the position that because petroleum product encountered within the subsurface (after a series of remedial efforts were undertaken) had a non-weathered gas chromatographic (GC) profile, the petroleum was of recent origin. On this basis, the petroleum company denied legal and financial responsibility for the clean-up of contaminated soil and groundwater at the subject site. The wholesaler distributor argued that, while superficially a petroleum product exhibiting a non-weathered GC profile would appear to imply that the petroleum product was of recent origin, that conclusion is not necessarily correct and is subject to numerous local conditions.

During the lengthy arbitration process, the petroleum company spared no expense at trying to support its “non-weathered means recent” argument including the calling of evidence from four expert witnesses. Upon examining all of the evidence, the arbitrator concluded that the most likely source of the petroleum product was the historical petroleum storage tank facilities. The presence in 1992 and 1996 of free product (some of which was non-weathered) was, he concluded, simply the result of incomplete remedial efforts performed by the petroleum company. The arbitrator did not concur with the argument that the non-weathered nature of the product meant that it was recent. He cited with approval the evidence of two of the experts called for the purchaser. Commenting on one such expert, the arbitrator stated: *“I accept [the purchaser's expert] evidence that one cannot determine the age of [petroleum] product based upon weathering. If [petroleum] product is sheltered from oxygen, for example, being buried deep in the ground, it could be very old and not be weathered. The fact that the product is not weathered does not tell whether it is old or new.”*

The arbitrator concluded that the petroleum company did not prove that the unweathered petroleum product was of recent origin. In fact, the arbitrator went on to state: *“I cannot and do not accept (petroleum company's forensic chemist) testimony that the free product found at (S1) was less than five years old. On all of the evidence in the case, it had to be older than that.”*

This finding (and others) by the arbitrator ultimately led to his decision that the petroleum company was legally and financially responsible for the contamination on the two sites and ordered that it pay the commercial purchaser approximately \$2,600,000 for the remediation of the property. In addition, the petroleum company ultimately paid a substantial portion of the commercial purchaser's legal fees in this matter.

Based on the facts of this case study and the arbitrator's ruling, it is evident that one cannot assume that non-weathered free petroleum product found in the subsurface means that the product is recent in age. There are some scientific references available suggesting that under certain conditions old product can remain unweathered for many, many years. These articles, however, all suggest that this phenomenon tends to occur in the center of a relatively thick (i.e., several metres) petroleum column. In this particular case, the product thickness did not exceed 0.4 m of thickness and thus would appear to be markedly different from case studies that have been previously noted in the literature.

Based on the results of this case study, it is evident that an environmental investigator cannot simply look at the chromatographic profiles of a petroleum product to assess its relative age. Rather, one must carefully consider all factors ranging from product type to host conditions and carefully weigh all of these factors before making any age-related statements pertaining to free product in the subsurface.

Forensic Science, Case Study, Non-Weathered Petroleum Product

C50 A Critical Review of Contaminant Release Dating Approaches

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The goals of this research project are to provide a critical review of the environmental forensic techniques available for contaminant release dating. Participants will learn which techniques have merit for selected situations and the reliabilities of these techniques to the extent that reliability information is available.

Many environmental investigations have a forensic component, the need to identify the source(s) of historical environmental contamination. Source identification can be very difficult when multiple sources, in geographic proximity, used the same chemicals, e.g., chlorinated solvents and/or petroleum hydrocarbon fuels. Also, it is often the case that different owners or operators of a facility had the potential to release chemicals to the environment at different times. Estimates of the times during which the contaminants were released can support the identification of the most likely sources. Consequently, reliable techniques for estimating contaminant release times are often necessary to determine ultimate liability and to provide the basis for a fair allocation of cleanup costs.

Contaminant release dating approaches include techniques that are based on documentation found from records searches, known periods of chemical availability and usage, additives, and analysis of aerial photographs. Other dating approaches focus on the potential sources themselves, employing techniques that are focused on the contaminated environment, i.e., sample collection and analysis and the use of environmental transport models.

Sample collection and analysis approaches typically must rely on the data from samples which were collected during relatively recent periods (say over the last 20 or so years, if that long) compared to the times when the potential source facilities were operated. Mathematical transport models, used to estimate travel times to points in the environment where the chemicals have been found, require sufficient characterization of the site specific environmental properties that needed transport parameters, and, can be estimated to an acceptable level of accuracy. Also, in many cases, the chemicals of interest are reactive and the reaction rates appropriate to a specific site environment have a high degree of uncertainty. Nevertheless, approaches based on relative degradation rates exist and are often used. As always, the degree to which all of the different types of information “hang together” is critical to the robustness of the case that is argued.

Chemical fingerprinting techniques have merit as well, especially when a particular signature would be expected from a given source due to the possible presence of additives or other factors which would only be appropriate for a given time period, e.g., the presence of organic lead or MTBE in gasoline. Finally, several techniques based on isotopic ratio determinations exist as well.

The authors will present the results of a critical review of contaminant release dating approaches based on a review of existing literature and their experience with various approaches in actual environmental forensic application.

The techniques will be organized by contaminant type, dating approach, and potential costs.

Contaminant, Release, Dating

C51 Why Did the Marina Sink?

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As an expert witness, one should remain within one's field of science.

On a stormy night in New England, a power light pole with two transformers fell into the street. The transformers broke open and released transformer oil. A small percentage of the oil was transported with the storm water to a nearby river where the sheen of oil came into contact with the docks of a marina. The flotation for the docks was comprised of compressed polystyrene beads. Within a year or so, the docks began to tilt as the polystyrene bead flotation began to sink. Without repair, the process of sinking continued causing customers to move their boats to allow the marina docks to sink alone.

The marina owner sought to recover his losses and hired a hydrogeologist to be his expert witness. The expert decided that experiments implicating the transformer oil would be the best forensic evidence for the cause of the sinking of the polystyrene bead flotation. Further, he could then explain the process by which floats became saturated with water which was the ultimate cause of the floats sinking. The major contribution of the transformer oil in his causative explanation was that the transformer oil contained a high percent of aromatic solvents that are known to dissolve polystyrene. This allowed water to enter the honeycomb structure of the beads.

The experiments were depicted as simple and straight forward. A piece of polystyrene foam was placed into a dish containing water. A weight was placed on top of the polystyrene to keep it in the water (Experiment A). Another piece of polystyrene was placed into a dish with water containing a cloth dye from a local store (Experiment B). The third dish of water contained a small amount of transformer oil which was dyed red with a biological stain (Experiment C). Experiment D was the same as C except more dyed oil was added to the water. The experiments were placed in the office, and water was added from time to time. At the end of the experiment, the polystyrene pieces were weighed, and those weights were compared to the weights of the polystyrene pieces before the experiment commenced. The results are shown in Table 1.

TABLE 1
(All units in grams)

Experiment	Starting Weight	Final Weight	Oil	Weight of water gained
A	12.2	16.1	0	3.9
B	11.7	21.4	0	9.7
C	14.3	22.2	0.8	7.1
D	13.0	25.0	4.0	8.0

The experiments were not repeated. Experiment B was ignored, thus, showing that the transformer oil was responsible for the uptake of water by the polystyrene.

During trial, the expert proceeded to show the jury that the polystyrene foam would remove the dyed transformer oil from the water. Capillary action pulled the red-colored dye into the polystyrene as water would be pulled up into a paper towel. His problem was to explain how water followed the oil into the polystyrene foam to make it water logged.

The jury was not convinced by the hydrogeologist's chemistry. The chemistry of transformer oil is clearly adverse to dissolution of polystyrene and to water uptake.

Transformer Oil, Polystyrene, Scientific Method

C52 Environmental Sabotage

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The expert witness must be aware of who holds the power at trial and prepare the attorney in order to get all of the evidence into the record.

This is a case history concerning petroleum releases, remediation, forensic analysis, litigation, and how a homeowner copes with over a decade of an environmental roller coaster. The site is located on New York State Route 32 north of Saugerties. The area is rural with some residences around a gasoline station. Everyone's water supply is furnished by a shallow bedrock aquifer.

Leaking gasoline tanks were discovered and replaced in 1982. New wells were provided for the gasoline station and its owner at the site. No groundwater testing was done. The new underground storage tanks (USTs) required rock removal by blasting in order to have enough tank cover.

On February 11, 1986, gasoline vapors/odors were detected in the home approximately 75 feet south of the new USTs. The homeowner was moved out of the house as a safety precaution. Power, fuel to the furnace, and water were shut off. The short-term planned gasoline vapor remediation was to construct a trench between the USTs and the home down to bedrock and backfill with sand. This was done by NYS after a bizarre incident which happened on March 30, 1986 concerning a vandalized home heating oil tank at the unoccupied home. The remediation included groundwater analyses of the surrounding homeowner's wells and UST testing and removal at the gas station. The homeowner's well originally contained benzene, toluene, ethyl benzene, and xylene (BTEX), but after the vandalism, the well contained a fuel oil floating layer.

In 1988, NYS sued the homeowner as a co-spiller. A review of the NYS information and data along with the home's well specifications and a forensic soil gas survey clearly showed the NYS case against the home owner to be bogus. The free product in the well was #6 fuel oil and, thus, an obvious case of sabotage. However, at the 1998 trial the state suppressed the evidence and the homeowner was found liable for the cost of the remediation of the property and well cleaning.

The conclusion is that this homeowner lost the home due to the county taxes that were unpaid and unpayable due to the state's judgment. Woburn, Massachusetts and Hickley, California were towns in which many people were affected by groundwater contamination. Who protects the individual homeowner and why does it take money to provide protection by the court system?

Petroleum Releases, Remediation, Forensic Analysis

D1 Gone But Not Forgotten! AAFS Members Solve a Mystery!

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The goals of this research project are to understand the importance of 1) utilizing the team approach in focusing an investigation, 2) developing an investigative strategy, 3) conducting a thorough crime scene analysis, and 4) communicating between agencies.

On 03-26-1996, a train comprised of Tropicana Juice Company boxcars arrived in Jersey City, New Jersey from Florida. The temperature inside the boxcars had been maintained at 24 degrees throughout the trip. As each boxcar was unloaded, the refrigeration unit was turned off. The cars were unloaded between 0900 and 1200 hours. At the conclusion of the unloading process, the door to each boxcar was closed and marked with an orange plastic tie. The ties were used to indicate that the boxcars were empty, not as a means to prevent entry into the boxcars. The train remained on the track in an open yard until the scheduled departure at 1730 hours on the same date. The train made eleven scheduled stops while enroute to Florida. The train arrived at the Tropicana Dole Plant in Manatee County, Florida on 03-30-1996.

A Tropicana security officer noticed that the door to one of the boxcars was not sealed on 04-02-1996. Upon further inspection, he observed a bed sheet inside that had been tied into a bundle. The sheet contained the deceased body of a young black female. The victim was fully dressed in multiple layers of clothing, suggesting that she had been killed in a cold climate. Electrical cord and twine held her body in a position with her knees drawn up, and her hands and feet crossed. A metal chain was loosely secured around the victim's left ankle with a small padlock. A plastic bag and a pillowcase had been placed over her head. The cause of death was reported as possible asphyxia. Adhesive tape residue was noted on her hands, wrists, neck and face.

In 1996, the Medical Examiner estimated the victim's age at 17 to 24. In 1998, her body was exhumed and osteological and dental examinations were conducted by Dr. Murray Marks at the University of Tennessee. Dr. Marks estimated the victim's age between 14 and 16.

Numerous photographs were taken of the victim and her clothing. A police artist provided a sketch of the victim for distribution to the media. The victim remained unidentified, in spite of numerous calls to law enforcement agencies along the route the train followed from New Jersey to Florida.

With the permission of the investigating agency, Gregory Dickinson DDS presented the case information at BYOS at the 2000 AAFS meeting in Reno. Dr. Dickinson and SA Dayle Hinman teamed up to take on the task of identifying the youth. When the police investigation was suspended following the arrest of serial murderer Recindez-Rameriz, (AKA: the Railroad Killer) the AAFS team continued to press on. Using resources from the FBI and the Missing Children Information Clearing House, a missing teen from Pennsylvania became the focus of the case.

On 07-10-2001, the unidentified victim that had been buried in grave #62 in Palmetto, Florida was exhumed again and positively identified by a comparison of her dental records. She was laid to rest for the last time, in her hometown of Philadelphia. Her grave is marked with a headstone that bears her name – Latanya Reese. She was only 15 years old.

Odontology, Anthropology, Profiling

D2 A Signature Analysis of the Eight Whitechapel Murders Attributed to Jack the Ripper in 1888

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The goal of this research project is to understand the procedures involved in linking murder cases through *modus operandi* and signature.

In 1888, the now world-famous series of prostitute murders took place in the East End of London in an area called Whitechapel. By the fall of that year, a terrifying nickname had appeared in the popular press: Jack the Ripper. To this day the identity of the Ripper remains a mystery, yet public interest in these cases has never waned in the search for this Victorian serial killer. It has been documented as a historical true crime that has become entwined with so much myth that reality has all but disappeared.

In recent years, many old unsolved crimes have been resolved through the advances of forensic science. The automated fingerprint identification system and DNA technology have brought about the truth in many unsolved murders and rapes. There remains no evidence that would make these technologies useful in the Jack the Ripper cases. There is one advancement that has yet to be employed with the existing facts and evidence from the Whitechapel murders, that is, linking cases through *modus operandi* and signature analysis. Much has been written linking Jack the Ripper to all of the Whitechapel murders. The investigators at the time questioned this, but the myths portrayed in books and movies have made the extent of the Whitechapel murders all encompassing to include every Whitechapel murder at the time.

Linking cases by MO and Signature has proven important in the prosecutions of serial killers, such as Steven Pennell in Delaware, Cleophis Prince in California, Nathaniel Code in Louisiana, and George Russell and Robert Parker in Washington State. The signature of a killer is the actions a killer must do, over and above what it takes to commit the murder, for each and every murder that the killer commits.

For purposes of this submission, the facts known about each of the Whitechapel murders will be identified that pertain to the elements of the killer's *modus operandi* and presented to the participants. Then, the particulars of the killer's signature are revealed for each murder and only those murders linked to each other will be identified through this recent process of identifying the killer's signature.

The examination revealed that the killer's *modus operandi* remained fairly consistent throughout the five canonical murders attributed to Jack the Ripper. He attacked white female prostitutes in their 40's in a cluster of victims within a short distance of each other. The first four victims, Mary Nichols, Annie Chapman, Elizabeth Stride, and Catharine Eddowes, were killed and found outdoors in the Whitechapel area; then he changed his MO by killing and leaving the fifth victim Mary Kelly, indoors, still within blocks of the others in Whitechapel. By choosing to murder Kelly indoors, the killer demonstrated that he was an experienced nighttime (Cat) burglar and stalker, as he attacked all his victims in the early morning hours when dawn was approaching.

These victims were not victims of chance, but victims of choice. They were stalked. As Ted Bundy once stated, "the victim does not know the killer, but the killer knows the victim." The killer had to know who his victims were because they had to match his preferred victim type, penniless and needy prostitutes in their mid 40's. And most of all, he had to have knowledge, at least for the time that he spotted them, that the victims were alone and were not being followed.

Despite minor changes in the killer's *modus operandi*, his psychological imprint, or signature, was clearly detectable. The signature analysis will reveal that each victim was posed in a sexually degrading

position, intentionally left that way so the discovery of the bodies would startle the people who found them. They were not concealed or hidden away, but placed in locations where they would be easily discovered. The placing of victims on their backs, grotesquely laid out with their throats cut and viscera exposed or missing, reflect the cruel reality of the killer, his total mastery over their bodies. The pleasure for the killer was demonstrating each victim's vulnerability. Additionally, there was a progression in violence from the Ripper's first victim through the fifth. And, finally, an explanation will be presented as to why three Whitechapel murder victims were not murdered by Jack the Ripper.

Jack the Ripper, Signature Analysis, Modus Operandi

D3 "Who Let the Dogs Out?" The Case of a Staged Homicide

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The goal of this research project is designed to highlight the unique elements of staging, present in a case of a staged homicide.

The concepts of staging or staged elements portrayed within a crime scene are common within certain homicides. Staging can be defined as the purposeful alteration of a crime scene (Douglas, Burgess, Burgess & Ressler, 1992). The concept has been widely written on and has been accepted by the courts as a definable phenomenon. The basis of staging is to direct an investigation away from the person who stages the crime scene, because the person feels he or she would be a likely target of the investigation. Staging can be as simple as an intoxicated driver who wrecks his car, flees the scene, and reports the vehicle stolen. It can also involve a homicide staged to resemble a mugging, burglary, or sexual assault. The person who stages a crime scene, however, does so based upon his/her own experiences and perceptions of how certain crime scenes should look. This flawed perception leads law enforcement and medico-legal investigators to identify a crime scene as staged.

The FBI's National Center for the Analysis of Violent Crime (NCAVC) is routinely consulted by federal, state, and local authorities in cases of serial homicide, homicide, and other violent crimes, and, a significant number of these cases involve staged crime scenes. NCAVC assistance was requested by local authorities in regard to a case involving a woman who was found murdered in her residence. The victim had been strangled with a ligature and her head covered with a cloth, pillow case, and a plastic bag. The crime scene was staged to resemble a "burglary gone bad." There was some ransacking that took place in the bedroom, and the only items missing were \$200 in cash, and a handgun. The residence, however, was locked by deadbolts, which were still secured when the victim was discovered. The victim had three very vicious dogs which could only be handled by the victim, her husband, and daughter. These dogs were secured in a spare bedroom, ironically where the missing money was kept. The police were immediately suspicious of the circumstances, particularly concerning how the dogs came to be secured in the spare bedroom. The investigation quickly focused on the victim's husband as the offender. The investigation revealed the husband was the last person to see the victim alive, and he discovered the body of the victim. Autopsy findings showed the victim died of strangulation, and that the victim was killed a short time after eating. The husband was charged with the homicide.

A thorough analysis was conducted by NCAVC utilizing the crime scene reports, crime scene photographs, autopsy report, laboratory reports and investigative reports. The conclusion was that this was a staged homicide. The basis for that conclusion was a multitude of factors. The residence was occupied at the time of the burglary. Most burglaries are committed when no one is home. The victim's vehicle was parked in the driveway. The burglary occurred during an unusual time for theft. The residence was located in an area that was not easily reached from a main

thoroughfare. The residence had no signs of forced entry, and was secured when the victim was found. There were three protective dogs in the residence. The victim was very security conscious, and the victim's husband worked in law enforcement.

Statistically, burglary as a circumstance of homicide is a very rare occurrence. According to the FBI's Uniform Crime Reports (1996 figures), "Homicides committed during burglaries comprise less than .005% of all burglaries."

The issues involved in this case highlight how law enforcement's ability to recognize staged crime scenes allows investigators to immediately focus an investigation towards a particular offender, and concentrate investigative resources. This provides an opportunity for review by professionals who are able to draw conclusions and present these factors for the trier of facts.

Staging, Homicide, NCAVC

D4 When is a Spree Killer Not a Spree Killer?

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The goal of this research project is learning how to verbally define what the criteria for a spree killer are, how the term has been used in the past, and how some spree killers were actually serial killers.

This presentation seeks to answer the question, "When is a spree killer not a spree killer?" The presentation defines what the necessary criteria are for one to meet the government classification as a spree killer, and how others who have defined spree killing substantially different in the past use that term.

One of the first steps a scientist must take when s/he undertakes the study of something is to define and categorize what one is observing. This is what the Federal Bureau of Investigation's Center for the Analysis of Violent Crime did during a ten-year project when a team of experts adopted standards to define the various types of multiple murderers. These classifications were published in 1992 in the *Crime Classification Manual*. How does the definition of a spree killer in the manual differ from those terms used previously by the media, authors, criminologists, and sometimes, police officers?

The *Crime Classification Manual* defines a spree killing as, "A single event with two or more locations and no emotional cooling off period between murders." The editor of a book published in 1991 by Pinnacle Books entitled *Spree Killers*, defines this kind of killer as, "Men and women who suddenly go berserk, murdering unsuspecting people in a frenzy of blind destruction." Included in that latter book are the killers, John List and Richard Speck. List murdered his entire family including his wife and mother in New Jersey. Speck murdered eight nurses during the night of July 13, 1966, in Chicago. They would have been classified as a "Family Mass Murderer" and "Classic Mass Murderer" respectively according to the FBI's manual. Neither of them would have been considered spree killers. If one closely scrutinizes these cases, it is clear that spree killers can be placed into five additional sub-categories or types based upon their apparent reason for committing the killings and, in some cases, upon their method of operation.

First, there is the spree killer who robs and murders to eliminate witnesses who could possibly testify against him. "Dead people can't talk" is his creed. Charles Starkweather of Lincoln, Nebraska was a man who exemplified this kind of murderer. Although Starkweather has generally been classified as a spree killer, it probably would be more accurate to call him a serial killer since fifty days before he launched his murderous spree where he killed ten people, he murdered a gas station attendant.

The second type of spree killer is the person who kills other human beings in revenge for actual or perceived wrongs. An example of this kind of killer was Mark O. Barton. Barton was a day trader. When he lost nearly all his money due to risky investments, he blamed his investment

advisors. He murdered his wife and his children. Then he went into Atlanta, Georgia where he murdered his investment advisors. Although Barton was classified as a spree killer, he was, however, still the primary suspect in the murder of his first wife and her mother when he committed suicide as police were closing in to arrest him.

The third type of spree killer is one whose apparent reason for committing his crime is to rape, sadistically torture, and finally to take the victim's life. This feeling of power and control over the victim is apparently enhanced when he can overpower, by any means necessary, someone whom the female victim regarded as her protector. An excellent example of this type of killer is Danny Rolling from Shreveport, Louisiana. During the late summer of 1990, Rolling terrorized Gainesville, Florida, by murdering five college students. His method of operation was to burglarize the victim's apartment and attack the victim without warning. While Rolling has generally been classified as a spree killer, eight months before he murdered the five students in Gainesville, he murdered a beautiful, petite young model, her father, and her eight-year-old nephew in Shreveport. He would, therefore, more accurately be classified as a serial killer. Some spree killers have the same reasons for their criminal activities, but their methods of operation vary considerably.

Christopher Wilder of Florida was attracted to young women and girls and posed as a photographer for a fashion magazine to get them to come to his car so he could show them some of his work. At his car he would subdue them, put them into sleeping bags, and transport them to motels where they would be tortured with electric shocks, super glue put over their eye lids, raped, and, when he was through with them he'd kill them. There was one notable exception to all his killings, a sixteen year-old girl whom he had kidnapped in California. After taking her across the United States, he gave her money, put her on a plane in Boston and sent her home.

A fourth sub-category of spree killer is one who is completely, or nearly, out of touch with reality. He is psychotic. Martin Bryant from Australia is such a man. Over a two day period, Bryant killed thirty-five men, women, and children at different times and at different locations.

Finally there is the professional hit man. He is the killer who has a job to do and will kill in several different locations over a very short period of time. He feels no remorse for his crimes since he regards the killings as, "Just taking care of business."

Spree Killers, Serial Killers, Mass Murderers

D5 Sudden Death During Acute Psychotic Episodes

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The goal of this research project is to understand the phenomena of sudden death due to acute psychotic episodes; its presentation and its causes.

Cases of sudden death during or immediately after a violent struggle in which an autopsy fails to reveal an anatomical cause of death appear to be increasing in frequency. Such deaths usually involve police or medical personnel attempting to restrain a violent, irrational individual. The usual presentation is of individuals in excited delirium. They are confused, irrational, hyperactive, and usually violent. In an attempt to restrain the individual from injuring himself/herself and/or others, a violent struggle ensues. Immediately after the struggle ends, the individual abruptly becomes unresponsive, develops cardiopulmonary arrest, and does not respond to cardiopulmonary resuscitation. At autopsy, there is no anatomical cause for the death, though minor injuries may be present. Toxicology tests usually reveal drugs such as cocaine or methamphetamine, presumably the agents causing the excited delirium. Allegations that the individual died from a "choke hold" or "positional asphyxia" are frequently made.

While such deaths usually involve use of cocaine or methamphetamine, excited delirium may also occur in individuals with endogenous mental disease in the absence of stimulant drugs. Clinically, these are referred to as acute psychotic episodes. These tend to occur in individuals with schizophrenia, schizo-affective disorders or delusional disorders. Acute psychotic episodes occur both in and out of mental facilities. The episode may occur because of discontinuance of medications or development of tolerance to the medications. If the episode occurs outside a mental health facility, it is usually the police who have to deal with the individual; if inside the facility, nursing or support personnel.

Autopsy findings in individuals dying during the course of or after an acute psychotic episode are more varied than in the cases due to drugs. There is often some natural disease present. The exact role natural disease plays in such deaths is debatable and has to be considered on a case-by-case basis. It is the authors' opinion that the principal mechanism of death in such deaths is a fatal cardiac arrhythmia due primarily to the physiological effects of catecholamines and hypokalemia. Typically, collapse and death occur following cessation of the struggle. Following cessation of a violent struggle or any violent exercise, the levels of catecholamine continue to increase for approximately three minutes while the level of potassium drops dramatically, often to hypokalemic levels. These two factors predispose to the development of an arrhythmia. The time following the end of violent physical activity is referred to as the time of "post exercise Peril" by Dimsdale. Contributory to the death may be natural disease and the medications that the patient is on, many of which have a cardiotoxic potential, predisposing an individual to a cardiac arrhythmia. A series of cases will be presented illustrating sudden death in patients experiencing an acute psychotic episode in which neither cocaine nor methamphetamine played a role. Cases in which natural disease was absent, as well as cases in which it was present, will be discussed.

Sudden Death, Psychosis, Manic Delirium

D6 Psychological Expertise and Testimony Under Forensic Scrutiny

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The goal of this research project is to help the attendee understand that forensic psychology expert conclusions should be based on measurable grounds and can be applied even though there are multiple determinants of behavior.

Psychology and law approach the empirical world differently with varying objectives that inevitably affect the resolution of factual queries. Forensic psychology stands at a crossroads in providing an understanding of the evolving legal directives and contrasting professional differences, and in recognizing the independent principles of *justice* and *truth*. While the legal mandates are clear, educating forensic psychologists for the future is a critical challenge. Standardization expected by the legal system is only one piece of this complex puzzle. The audience will be challenged with the professional differences between psychology and law, and offered potential solutions to close the thinking process gaps between these divergent disciplines. The impact of the developing legal mandates, the language differences, the validity of information, ethical considerations, professional judgment, and the role of leadership will be presented. The institutional responsibilities of the legal system to dispense *justice* must be reconciled with the principles of *truth*. An attempt will be made to define the elusive concept of *reasonable psychological certainty*.

In legal cases, the doctrine of inferential relationships is applied in obtaining expert opinions with questions posited from the standpoint of possibility or probability. It is, however, of value to reframe the expert thinking process in terms of proximity, directionality, and causality. This

framework shift supports enhanced interpretation of information allowing the forensic psychologist to render more viable opinions and conclusions based on measurable grounds. The divergence between psychology and law results in the potential for confusion and misinterpretation. This requires education efforts to create understanding to bridge existing gaps.

It is necessary to evaluate the thinking processes used by psychologists in defining, diagnosing, understanding, explaining, and predicting behavior. There are multiple determinants of behavior. In considering psychology to be the study of the mind, the concept should be to understand human behavior through applying scientific principles including theory, taxonomy, instrumentation/measurement, data analysis, and intervention techniques. The intrinsic differences between the scientific/psychological disciplines and the legal profession will be explored while determining the similarities and commonalities to bridge any gap. With the widening of forensic psychology expertise, difficulties of assessment by lawyers, judges, and the courts continue to mount. Understanding the differences, the need for education and training of forensic psychology experts and legal professionals, the availability of information, and evaluating the validity of this information are all mandatory for any potential integration. The use of psychological data, information, and conclusions necessitate that forensic psychologists deal with integration of this information to allow for validity assessment and its presentation in an understandable way.

There is a practical need to deal with issues of admissibility of scientific, psychological, and complex testimony and evidence. The legal mandates embodied in *Frye*, *Dalbert*, *Joiner*, and *Kumho* necessitate review and understanding. These, along with the factor of a qualified expert, constitute the guiding constructs for the admissibility of expert testimony and evidence.

The scientific method guides the development, progress, data collection, data analysis, results, conclusions, and implications of scientific research. Confusion occurs for lawyers and judges in evaluating the meaning of various types of research studies. Similar confusion is generated by the meaning and applicability of published scientific and research literature. The types of research studies (basic science, double-blind, clinical, survey epidemiological) performed, the limitations, validity, and the characteristics of varying formats of publication require definition. The usefulness of any study depends on the quality of the underlying data, the reliability of the methodology, and the validity of the interpretation. An analytical gap may exist between the data and the expert opinion. It is essential to understanding the scientific method by which data should be evaluated, so that psychology expert opinions may be based on reliable methodologies and that may be verified.

Reasonable Psychological Certainty, Inferential Relationships, Measurable Grounds

D7 A Coroner's Death Investigation Influences the Police and Court Response to Domestic Violence

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The goals of this research project are to present a positive outcome of a coroner's investigation and subsequent public inquest on the response of police to intimate assault and the courts' approach to consideration of bail and prosecution of charges of domestic violence.

The role of a coroner in promoting public safety will be discussed. Dr. Porter will present a case of homicide/suicide of a couple involved in an intimate relationship and the impact of their deaths on nine surviving children. The case involved a couple related by marriage (not to each other), that began an intimate affair in 1994. The woman became pregnant and the violence began during the pregnancy, which resulted in a stillbirth. Violence continued and the woman presented herself to a shelter for assis-

tance in November of 1995. She was encouraged to seek medical treatment and to report the assault to the police. From that time until the time of her death in March of 1996 her partner appeared before the courts fourteen times. The problems of intimidation of the victim, multiple jurisdictional investigations, communication breakdown, and recording errors resulted in the male legally purchasing a firearm, entering the woman's residence, barricading her children in a closet for hours, and then sending them out of the house to call the police. Police responded and surrounded the home. After obtaining no response from the residence, police made entry and found the couple deceased in the bedroom.

The investigation identified a number of areas of concern and an inquest was called. It was the "representative" inquest into domestic violence for the Province of Ontario. The issues explored at the inquest included: the history and familial background of the couple and their previous intimate relationships, an examination of the police response to allegations of domestic violence, the advice given to the victim of the violence, risk assessment, the response of the crown attorneys and the courts to the charges laid, the conditions of bail and subsequent breaches of those conditions, the community responses to the violence, the supports available to the victim, and the impact on the surviving children – present and future.

After hearing from 76 witnesses and 51 days of evidence the inquest jury made 213 recommendations directed to the federal and provincial governments, police services across the province, the Ministries of the Solicitor General and Attorney General, firearms legislation, crown attorneys, courts administration and the judiciary, children's aid societies and victims' services. The implementation of these recommendations and the resultant change in approach of the police and courts to domestic violence will be presented.

The analysis of whether additional resources for police and victim support services and education of the judiciary about domestic violence have reduced the number of deaths will be discussed. New approaches to the social complexities of intimate violence will be offered for consideration.

Coroner, Domestic Violence, Courts

D8 Drowning Deaths in the Early Pediatric Population

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The goals of this research project are to present the findings in a series of fatal drowning in the early pediatric period, including cause and manner of death, to emphasize the importance of cooperation between the death investigator and the pathologist, and to remind those involved in death investigation that determination of the manner of death as homicide is not necessary for prosecution of a negligent caretaker.

Drowning is the second leading cause of accidental injury death in the pediatric population (0-19 years) in most states and in at least three states is the most common cause of non-intentional injury. Homicidal drowning while much less common also occurs particularly in the younger age groups because of their obvious vulnerability. Since drowning is essentially a diagnosis of exclusion, thorough and accurate investigative information is vital in cause, and especially, manner of death determination. Review of the records of the Dallas County Medical Examiners Office (SWIFS) from 1994-1998 revealed 73 cases of drowning in children six years of age or younger with records available for review in 71 of these. The majority of these cases (73%) involved children four years of age or less with two-thirds between one and four years of age. Only 7% were less than one year old. White children were most

commonly involved (44/71 or 62%) with 31 males and 13 females. Black and Latin children were much less commonly involved accounting for 14% and 16% respectively with equal numbers of males and females (five each) in the black population and more males (7) than females (4) in the Latin population. There were four cases involving Oriental males, one Pakistani female and one Middle Eastern male.

Most commonly the incident occurred in a swimming pool (29/71, 41%) with nearly all being residential, either private or apartment complex. One involved a public pool. Even when fences were located around the pool, there was often access through a space in the fence or gate, or the gate was not locked or functional. Lakes (16%), ponds (17%), and creeks (8%) were involved in an additional 41%. Hot tubs were involved in two cases (4%), as were wells and large buckets. In one case each, the event occurred in a drainage ditch or a canal. In only two cases were flotation devices mentioned in the investigative narrative, and in one of these, the father stated that the child was removing the devices at the time he last saw him alive.

May was the month during which the incident most frequently occurred (17/71, 24%), followed by April (11/71, 16%), July (10/71, 14%), August and June (each 7/71, 10%), October (6/71, 8%), November (4/71, 6%), and January and March (each 3/71, 4%). There were single cases in February, September and December (1% each).

In many cases, the approximate time of immersion was not known (23/71, 32%). The immersion time (or the time they were last known alive) was reportedly less than 5 minutes in 14 or 20%; while in 5/71 (7%) each, the time was reported to be 5 – 10 minutes and 20 minutes. The time was estimated at 45 minutes – 1 hour in 2 cases (3%). Ninety minutes was given as the estimated time since last seen in two cases also. The remainder were reportedly longer than 90 minutes ranging up to a day. Most of the children (60/71, 85%) were transported to the hospital where they were subsequently pronounced dead after periods ranging from minutes to 10 months. Only 11 (15%) were pronounced at the scene.

In the vast majority of cases, a family member was the caretaker (62/71, 87%) with the mother accounting for nearly half of these (30/71, 42%). Other relatives included the grandparents, siblings, aunt, father and stepfather. Family gatherings with many adults present accounted for occasional cases, though, in most of these, the mother was also present. A babysitter was the responsible party in 6% of cases and the caretaker was unknown in 4%. One incident was at a public pool with lifeguards on duty. In the cases involving the stepfather, he actually was the perpetrator of a homicide on the child and the cause of death in both cases also included blunt force injuries.

Only these two cases were classified as homicides with one case undetermined, and the other 68 ruled accidents. In nearly all of the cases classified as accidents, there were scattered cutaneous contusions and abrasions and foci of subscalpular hemorrhage without more serious underlying injury noted by the prosecutor at the time of autopsy/ post-mortem examination. In one case, there were skull fractures and neck injury thought secondary to a febrile seizure suffered while momentarily unattended in the bathtub. In the undetermined case, the 7 month old infant was found dead in the bathtub with the mother asleep on the floor next to the tub.

In some cases there were conflicting stories as to who had responsibility for supervision of the child at the time of death. In several of the cases where the incident occurred in the bathtub, older siblings had been placed in the tub with the child (some of them infants). In at least 2 of these cases the sibling admitted to pushing the baby under the water, and in another the decedent slipped and fell. These cases and others in which Child Protective Services became involved were still felt best classified as accidents with the knowledge that designation of the manner of death as accident would not preclude the possibility of future legal action. In at least two other cases charges were filed on the caretaker for neglect though the manner was classified as accident by the pathologist.

In conclusion, the pathologist must rely on the death investigator to provide pertinent and reliable initial information concerning pediatric

drowning deaths as well as follow-up when needed. The pathologist must then use this information in addition to the autopsy findings to arrive at the most appropriate cause and manner of death determinations. In spite of the best efforts of the investigator and pathologist, some cases may still be best classified as undetermined with the potential for reclassification if additional information arises. Designation of manner of death as accident or undetermined does not preclude the possibility of legal action against the caretaker.

Drowning Pediatric, Accident, Homicide

D9 Intentional Postmortem Burning of Homicide Victims in Kentucky: 1995-2000

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The goals of this research project are to give the forensic community a five-year study of homicide cases where intentional postmortem burning of the victims, and to outline techniques developed for the successful recovery and laboratory analysis of these victims.

This presentation outlines a five-year study regarding the intentional postmortem burning of homicide victims in the Commonwealth of Kentucky. The number of fire-related cases seen by Medical Examiners across the state during each of these years ranged from sixty-one to eighty-three. The percentage of homicides disguised by fire during this period ranged from 4.8% in 1996 to 24.5% in 1998. From the beginning of 1995 until the end of 1999, there were twenty-eight incidents where a perpetrator or perpetrators intentionally set a fire in an apparent attempt to disguise or destroy evidence of homicide. These twenty-eight incidents involved a total of forty-one victims. All but nine of these victims were burned in a structure or in a vehicle. There were three incidents involving three victims, and seven incidents involving two victims. All other incidents involved single victims. Homicide was officially determined to be the manner of death in all of these cases. In twenty-seven of these, the cause of death was gunshot wound, with one of these gunshot wound victims also run over by a vehicle. In eight cases, the cause of death was blunt force trauma, with three of these victims also stabbed. One of the victims of blunt force trauma was also strangled. One victim was stabbed to death and one was suffocated. In four victims the cause of death was not determined.

One of the most interesting findings in this study is the geographic concentration of incidents. A majority of these cases were concentrated in the southeast corner of the state. Seventeen victims were killed and then burned in the four adjacent counties of Knox, Laurel, Pulaski, and Whitley.

With this large percentage of confirmed cases involving the intentional postmortem burning of homicide cases, it was essential to try and develop protocols that could help first responders as well as investigators recognize and protect evidence associated with charred human remains. It was also essential to provide timely consultation and collaborative field recovery efforts with a forensic anthropologist or a medical examiner at suspicious fire scenes that involved severely burned human remains. The Commonwealth of Kentucky's Medical Examiner Division and several members of the Kentucky Coroners Association worked together to develop these protocols as well as specific training regimens dealing with the recovery, analysis, and identification of charred remains.

As in any crime-scene investigation, the complete and careful recovery of the remains depends on careful location and documentation of the body in relation to associated evidence. With severely burned bodies, this should be followed by systematic recovery and analysis of the extremities before any part of the torso is disturbed. Collection of underlying debris, which is then subjected to radiographic examination, has often proved to be a good method for finding associated evidence in an amorphous mass of burned material. Examination by a forensic anthropologist

working alongside the pathologist is standard protocol in those cases where any degree of skeletonization has occurred. In cases of extreme incineration, the entire recovery and examination is usually directed by the forensic anthropologist. An experienced professional examiner from the State Fire Marshal's Office, as well as a consulting odontologist is often present at the autopsy. This has also proved to be a valuable collaborative professional arrangement.

A heightened awareness of the high percentage of intentional postmortem burning of homicide victims in Kentucky has resulted in a systematic approach to the recovery and analysis of burned human remains. It has also proved invaluable in the prosecution of these cases.

Homicide, Fire, Forensic Anthropology

D10 Exhaust Fume Deaths With Non-Toxic Carbon Monoxide Levels

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The goals of this research project are to present to the forensic community a case series of suicidal exhaust fume deaths with non-toxic levels of carbon monoxide, with an explanation of the mechanism of hypoxic death.

The intentional inhalation of motor vehicle exhaust fumes with secondary toxic levels of carbon monoxide remains a common method of suicide in industrialized nations. During this presentation, a case series of seven deaths from the Ontario Coroner's System between July 1, 1997, and December 31, 2000, (42 months), from intentional exhaust fume inhalation with non-toxic ("normal") CO levels will be reviewed.

The decedents were all males with an age range of 28-54 years (median 44 years). The following features were common to all cases: vehicles had functioning catalytic converters; vehicles had been driven (and "warmed up") prior to the suicidal act; hoses were connected from the exhaust tailpipe to the interior compartment of the vehicle; vehicle compartments were well sealed; no anatomical cause of death found at autopsy; CO levels < 6% saturation and no toxicological cause of death on drug and alcohol testing. In five cases, alcohol was present in the blood (range 22- 94 mg/100 ml) and in four cases, toxicological testing revealed various combinations of drugs in non-lethal concentrations.

Death in all seven cases was attributed to hypoxia resulting from the diversion of catalytically converted exhaust fumes into the interior of well sealed vehicle compartments. Asphyxia under these circumstances is dependent upon a warmed up, properly functioning catalytic converter. The circumstances leading to an accumulation of carbon dioxide, reduced inspired oxygen concentration and hypoxia will be reviewed. Under these conditions, CO levels would be expected to be non-toxic.

It is important that Forensic investigators are aware of this mechanism of death in order to collect relevant information at the death scene, and to appreciate the significance of and explanation for a non-toxic CO level during toxicological testing.

Exhaust Fume, Carbon Monoxide Levels, Non-Toxic

D11 An Interdisciplinary Approach to the Study of Forensic Science

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The goal of this research project is to make aware to the forensic community the availability of an interdisciplinary forensic science major.

Undergraduate programs in forensic science have in the past focused on one or possibly two areas within forensic science with criminology, chemistry, and psychology being in the majority. Baylor University has developed a highly successful forensic science major incorporating all the sections in the Academy of Forensic Science as well as many others. This innovative program was initiated to target pre-medical students to give these students an applied program while they simultaneously took all required pre-medical courses. The author recognized the need for such a program while participating on the pre-medical advisory board at Baylor University. It was noticed that during the interview process students had little or no hands-on experience in traumatic events or had not observed death.

The major, in its second year, has drawn much attention nationwide. There are 300 declared majors making this one of the larger programs on the Baylor campus. Subjects taught include all the pre-medical requirements as well as forensic entomology, forensic anthropology, forensic archaeology, psychological profiling, hostage negotiation, crime scene investigation, criminology, death scene investigation, forensic photography, medicolegal investigation, and forensic pathology. Students have nine semester hours of internship that include working with the medical examiner, forensic odontologist, toxicologist, trace evidence laboratories, or wherever their interest. The students also have the opportunity to travel with the author to all forensic cases. They see first hand how to handle the collection of human remains and accustom themselves to working with decomposing bodies.

The Baylor Laboratory for Degradation and Preservation Science serves as a research and teaching laboratory. Any forensic science major has complete access to the research facility and all research projects are highly encouraged. The laboratory also owns a fifteen-passenger van with a moving laboratory in an attached trailer. The trailer is air conditioned with electrical outlets. It houses all the necessary forensic retrieval equipment for working in the field. In addition, a full forensic entomology lab is also located here. Whenever a decomposing body is found, the forensic science team is called to the case to collect all insect activity. They can assist in establishing time of death and also add to an insect collection located in the research laboratory. The collection is a collaborative effort with the Forensic Entomology department at Texas A&M University in College Station, Texas. It serves as a database of insect activity on decomposing bodies in Central Texas.

These students are excellent applicants to medical school and graduate schools. They have a very diverse and interdisciplinary background. All graduates are either in the graduate school of their choice or attend medical school.

Forensic Science, Education, Interdisciplinary

D12 Suicide: A Comparison of Five Counties Over Five Years (1994-1998) Using Medical Examiner/Coroner Office Records

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The goal of this research project is to demonstrate that suicide prevention and therapy programs should utilize both local and national data and should further our understanding of suicide.

The Office of the Hamilton County Medical Examiner conducted a five-year comparative study of 1,116 suicides using medical examiner/coroner (ME/C) office records from five different counties. The five counties (and major cities) from West to East are Clark County, WA (Vancouver), Washoe County, NV (Reno), Hamilton County, TN (Chattanooga), Erie County, PA (Erie), and Lehigh County, PA (Allentown). The primary hypothesis tested in our study was that ME/C offices that service populations of similar jurisdictional size certify an equal number of suicide death certificates per year. Hamilton County's mean population for the five-year period was 294,308, so ME/C offices

serving between 275,000 and 325,000 ($\pm 25,000$) were chosen for the study. Five of the twenty-three offices falling within this parameter responded to our questionnaire, thus making our sample one of convenience and not a truly random sample. Additionally, our sample is over time, geographically disperse, and encompasses both medical examiner offices and coroner offices.

Despite the sample's non-random nature, using jurisdictional population size as the constant has some theoretical foundation. Sociologist Robert Merton in the mid-20th century postulated his *strain theory* to explain deviant behavior. Strain theory essentially provides a functionalist perspective on deviance in society, which we adapt here to mean the social pressures felt by any one individual when he/she fails to achieve a desired outcome, or when access to the means to achieve a desired outcome is blocked. The result of this strain is what sociologist Emile Durkheim calls "anomie," a feeling of social dislocation and detachment that, if not adapted to or overcome, leads the individual to chose suicide. Examining suicide at more local levels, or relative to a particular community's social strain, leads to a better understanding of its nature within that particular community. This can provide the foundation for more effective prevention and survivor-therapy programs. National figures alone tend to generalize or "wash out" the local picture.

The results of our study show the five-year mean annual rate of suicides per 100,000 for each county studied are: Clark, WA (10.03), Erie, PA (10.91), Hamilton, TN (13.25), Lehigh, PA (13.67), and Washoe, NV (27.32). Clearly, as indicated by the high rate, the social strain unique to the population in Washoe County, NV, warrants further study to tailor prevention and therapy programs specific to that community's needs.

To better understand the nature of suicide at local levels, we also examined race, sex, age, and method of suicide. For all five counties ($n=1,116$) combined over the five-year period, the most frequent race and sex was white male, with a mean age of 45 years, median age of 42, and standard deviation of 18.21. The most common method of demise for all five counties was gunshot wounds (50% of males, 9% of females). Beyond age, sex, race, and method, not all of the variables we wished to examine were obtained from the contributing ME/C offices. These variables included marital status, toxicology, and employment. The marital statistics from four counties were as follows ($n=704$): married (44%), single (31%), divorced (17%), widowed (7%), and not reported (1%). The percentages of victims with negative toxicology are ($n=500$): Hamilton, TN (43%), Clark, WA (34%), and Erie, PA (16%). Employment for three counties ($n=479$) ranges from white collar to unemployed.

Additional data come from Hamilton County only and are provided as peripheral information for other researchers to compare their own data, and to further expand our understanding of the nature of suicide. These data are educational level in years ($<12 = 23\%$, $12 = 39\%$, $>12 = 33\%$, not reported = 5%); blood alcohol content ($<0.1 = 38\%$, $>0.1 = 62\%$); the most common day of the week (Sunday) and month (August); correlation with lunar phases; and, reasons why the individuals committed suicide. We also discuss the disagreements and their causes between ME/C office data and state vital record data.

In conclusion, the local level examination of suicide should be used in conjunction with state vital statistical records to design prevention and survivor-therapy programs for that particular community's needs.

Suicide, Strain Theory, Anomie

D13 Sexual Assault of Young Children in Istanbul: Victim and Offender Characteristics

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The goals of this research project are to present to the forensic community a comprehensive overview of current knowledge about the

incidence and prevalence of violent victimization of children by sexual assault, the response of the criminal justice system to such, and crimes the characteristics of the offenders, victims, and scenes of crime.

Over the past years, the problem of child sexual victimization has received significant attention from researchers, clinicians, and policy-makers. The presented data is based on reports from law enforcement agencies and criminal court case files of Istanbul, Turkey and covers the years 1999 through 2001. Findings include statistics on the incidence of sexual assault, the victims, their offenders, gender, response to these crimes, locality, the levels of victim injury, and victim-offender relationships. Highlights include the following: Sixty-eight percent of all victims of sexual assault reported to law enforcement agencies were juveniles (under the age of 18); 42 percent of all victims were under age 15, one of sixteen victims of sexual assault reported to law enforcement agencies were under age six, and twenty-two percent of the offenders who victimized children under age six were juveniles (under the age of 18).

Crimes Against Children, Sexual Assault Victims, Sex Offenders

D14 Anti-Stalking Legislation: The First Decade

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The goal of this research project is to present an integrated approach to the management of the offense of stalking, from the law enforcement, victim advocacy, and clinical treatment community perspectives.

In late 1999, New York became the last of the fifty states to enact specific legislation establishing the criminal offense of stalking. While this new law may be a necessary first step toward protecting victims of the crime of stalking, it is not sufficient in and of itself to ensure that stalking victims receive proper support and services. Those on the front lines of the criminal justice system must not only be aware of the new law, but must understand its implications for victims and for the prosecution of these offenses, and have a good, general understanding of stalking and its sequelae.

This paper will explore how the Clinic Access and Anti-Stalking Act of 1999 (effective December 1, 1999) was shaped by the past ten years of experience in other jurisdictions. It will also highlight the major elements of the law, and the further actions needed to ensure appropriate implementation.

Stalking, Psychological Treatment, Victim Services

D15 Exploring the Needs of Victims of Stalking

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The goal of this research project is to present an integrated approach to the management of the offense of stalking, from law enforcement, victim advocacy, and clinical treatment community perspectives.

Most attention on stalking crimes has been focused on the perpetrator. There is limited research available on the response of the victim, and how falling victim to this type of predator impacts on them, their family, their employer, and any other present or future relationships that the victim may have. This presentation will explore the effect that a stalker can have on the victim's life. Included are a description of the services most frequently requested by stalking victims; the impact of gender, class, religion, culture, other societal influences on the system's responses to the crime; behavioral and psychological changes brought about by stalking; and, social and financial impacts on stalking victims.

Stalking, Psychological Treatment, Victim Services

D16 Serial Stalking

Steven Ceric, MD, Bellevue Hospital Center Department of Forensic Psychiatry, 27th Street and 9th Avenue, 19 West, New York, NY*

The goal of this research project is to present an integrated approach to the management of the offense of stalking, from law enforcement, victim advocacy, and clinical treatment community perspectives.

Stalking is by definition a crime of repetitive behavior, requiring more than one act by the perpetrator before charges can be brought. This research posits that while some stalkers can be deterred by the efforts of law enforcement, others will continue their stalking behavior regardless of legal intervention. A distinction is made between serial stalkers, who have targeted distinct victims over time, and persistent stalkers, whose harassment of one defined victim continues for months or years, even after the courts have interceded.

Stalking, Psychological Treatment, Victim Services

D17 Treatment for Stalking Offenders

Barry D. Rosenfeld, PhD, Department of Psychology, Fordham University, Dealy Hall 319, Bronx, NY*

The goal of this research project is to present an integrated approach to the management of the offense of stalking from law enforcement, victim advocacy, and clinical treatment community perspectives.

Although much of the research regarding stalking behavior has focused on defining and describing the perpetrators of this offense, very little emphasis to date has been placed on the treatment of this difficult population. This presentation will describe the factors associated with stalking recidivism and outline a model treatment program that is currently being developed to reduce stalking behaviors.

Stalking, Psychological Treatment, Victim Services

D18 Stalking Behavior and Voyeurism: A Case Study

Ken Cullen, MSW, Executive Director, CAP Behavior, 175 Remsen Street, 5th Floor, Brooklyn, NY*

The goal of this research project is to present an integrated approach to the management of the offense of stalking, from law enforcement, victim advocacy, and clinical treatment community perspectives.

This is a presentation of a case study involving voyeurism and stalking behavior, from the records of CAP Behavior, a New York City based agency specializing in the treatment of sex offenders. The application of the polygraph in the management of behavioral problems is reviewed. The polygraph is used as a tool in the assessment and monitoring of patient compliance with the treatment regimen and the orders of the court. The case study will demonstrate the need for legal authorities (such as Probation, Parole and the Courts) to work closely with treatment providers on case management issues.

Stalking, Psychological Treatment, Victim Services

D19 A Review of Forensic Computer Science Analysis Areas and Practices

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The goals of this research project are to provide an overview of the Forensic Computer Science areas of analysis, minimum standards and practices, and identify areas for future research and development. Attendees will have an understanding of three areas of analysis, techniques and problems in performing the analysis, and minimum practices when conducting such analysis.

The goal of this project was to review the various work programs using forensic computer science and related tasks being supported by the MITRE Corporation, examine the minimum standards for such work, and identify areas for future research and development. Defining minimum standards was complicated as a result of different agencies having different requirements both in investigative purview and legal sufficiency. It was still important to identify the most common tasks, what tools or techniques were utilized, and attempt to determine the best practices for such analysis. Additionally, it was important to identify areas where there were inadequate guidelines, standards or tools, so that future research efforts can work towards their development. For the purposes of this project, forensic computer science examinations were divided into three categories: media analysis, code analysis, and network traffic analysis. Many other types of analysis could be identified; however, many of the other types could be considered combinations of these three primary types. The areas are further defined below:

Media Analysis

Media analysis is perhaps the most widely known and recognized type of forensic computer science examination. Media analysis is the examination of data storage media to determine the digital contents of the media and the state of the contents. Often, operating systems will retain and store bits and pieces of previously deleted files, or files that have been accessed or modified by programs running on the operating system. A forensic computer scientist may be able to partially, or even completely, re-construct files that were deleted from the system. Conducting this type of analysis requires detailed knowledge of different operating systems, storage devices, interfaces, different types of media and file types.

Code Analysis & Reverse Engineering

Code analysis is the process of reviewing computer programs to determine the purpose and results of the execution of those programs. In today's world of highly interconnected networks and large numbers of privately owned computer systems with routine access to the Internet, hostile code has the means to be spread around the globe in a matter of hours. Identifying code and conducting detailed analysis of that code may enable the forensic computer scientist to identify a number of characteristics that could identify or eliminate suspect systems as the potential source of that code. Conducting such analysis requires detailed knowledge of operating systems, programming languages, programming techniques, interfaces, and protocols.

Network Traffic Analysis

Network traffic analysis is a process to determine events occurring on a network, their sequence, their significance and the resulting effect(s) on the computer systems in question. This analysis requires a detailed knowledge of communications protocols, networking systems (routers, firewalls, servers, switches, hubs, intrusion detection systems, etc.), computer systems and the vulnerabilities and weaknesses in all three.

Results

The result of the investigation the identification of minimum standards for conducting each type of analysis, as well as the identification of shortfalls in tools and procedures for conducting such analysis.

Additionally, a substantial collection of reference material including information on file types, some basic analysis checklists for conducting media analysis, and a listing/inventory of tools used for forensic analysis was compiled.

Forensic Computer Science, Media Analysis, Network Traffic Analysis

D20 Comparing the Resolution of Film to Digital Cameras: Cautions for the Forensic Community

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The goals of this research project are to provide the forensic community with a better understanding of how much more information can be recorded by film than by most digital cameras, and, to alert the community to some possible consequences if the resolution available with film is abandoned for mere convenience.

Law enforcement agencies across the country and around the world are rushing to convert their photographic and imaging systems from traditional film systems to digital ones. Many of the decisions to do so are being made based on the perception that digital imaging is better than traditional film systems. Although digital cameras can provide some benefits over film, those who must conduct detailed analysis of photographs taken in a forensic environment — such as footwear and tire tread examiners — are discovering that the quality of digital photography does not, yet, match that of film. This paper will explain one reason for this observation.

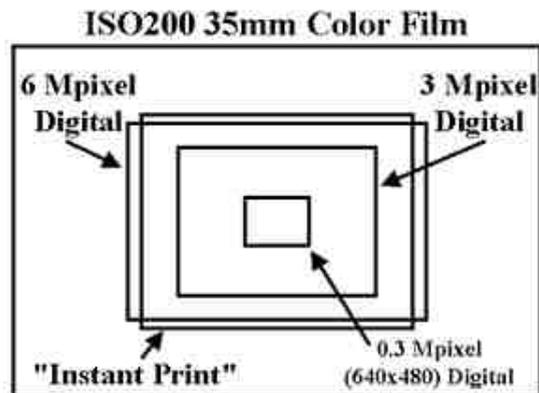
Resolution is defined in ANSI/AIIM Technical Report TR26-1993 “Resolution as it Relates to Photographic and Electronic Imaging” as “The ability of a photographic system to record fine detail.” Although the quality of images recorded using any imaging system depends upon a number of factors, including the quality of the lenses used and the lighting conditions, the intrinsic resolution of the detectors represents the most fundamental measure of the system. Thus sensor resolution is the focus of this paper.

Traditionally, film manufacturers have measured resolution in terms of line pairs per millimeter (lp/mm) or lines per millimeter. A line pair consists of a black line and an adjacent white line. Lines per millimeter refers to each individual line (black or white), thus there are always twice as many lines as there are line pairs over a given distance. The resolution of digital cameras is frequently described in terms of the total number of pixels in a single frame, or as the number of pixels in the horizontal and vertical direction. It is possible to directly compare the maximum amount of information that can be represented by any two sensors by comparing the total number of pixels per frame. To compare film to the sensors in digital cameras it is necessary to relate line pairs per frame to pixels per frame.

Under idealized conditions, two pixel columns (or rows) represent one line pair. Using such a conversion factor, a single frame of 35-mm color ISO 200 film, rated at 50 lp/mm, would contain 3600 x 2400 pixels, for a total of 8.64-million pixels. Such resolution compares quite favorably against a 3-Megapixel digital camera commonly encountered in law enforcement applications, which only has 2008 x 1504 pixels for a total of 3.02-million pixels. If one equates number of pixels to information, then the film records almost three times the information recorded with the digital camera.

The analytical resolution that can be achieved using digital cameras will be less than the ideal described above. Some researchers suggest that it may be more appropriate to represent one film line pair using three or more pixel columns. Such an assumption has the effect of reducing the quality of digital detectors relative to film to an even higher degree.

The figure below demonstrates just how much more information film could record than digital detectors, under idealized conditions, if one fixes the resolution within the scene. In other words, the same size feature — such as a single ridge on a fingerprint — can be seen in each of the areas noted, but the film covers more area at that resolution than the digital detectors do.



Consequences: Examiners of footwear and tire tread impression evidence are already facing the consequences of reduced image quality. Although no formal studies have been conducted, discussions with numerous examiners indicate that the number of “inconclusive” results in these examinations is increasing at a rate that parallels the rate at which digital images are submitted for comparison. Another type of examination that could suffer from reduced image quality is blood spatter examinations. One community, the latent fingerprint community, is fortunate enough to have a recommended standard in place for the capture of latent impression evidence — 1000 pixels per inch. Although this standard was designed to meet transmission standards, it has the added benefit of placing a minimum resolution standard for image capture. Using this standard, a photographer who chooses to photograph a latent print with a typical 3-Megapixel camera (2000 x 1500 pixels) will be restricted to photographing an area 2” x 1.5” - an area slightly larger than that covered by a single fingerprint.

Forensic Photography, Digital Imaging, Footwear Impression

D21 An Evaluation of Ferromagnetic and Non-Ferromagnetic Fingerprint Powder on Ceramic Materials

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After attending this presentation, the participant will understand: (1) the use of ferromagnetic fingerprint powder compared to non-ferromagnetic fingerprint powder used to process the surface of glazed ceramics, (2) variables that affect the condition of latent fingerprints, and (3) a method of assessing and evaluating the quality of latent prints based on their appearance.

The purpose of this presentation is to present the results of a study that evaluates the quality of latent prints collected from the surface of glazed ceramics using ferromagnetic and non-magnetic fingerprint powders. In general, ceramic type material is typical when processing crime scenes, especially in residential burglary cases. The use of the powder method for processing surfaces or items is routine in investigations where objects may have been touched recently by perpetrators. However, some fingerprint powders have different adhesive qualities based on the characteristics of the powder as well as the surface or matrix of the object being processed.

The investigator’s awareness of the magnetic interference using ferromagnetic powder on the surface of ceramics will provide him/her with a better understanding and utilization of this type of powder.

The familiarity with processing recently touched glazed ceramics with ferromagnetic powders compared to non-ferromagnetic powder will provide the investigator with information on latent print quality and the interference of ferromagnetic powder with the matrix of ceramic material. Ferromagnetic powders adhere more readily to the surface of ceramic material than non-ferromagnetic powders because the matrix of ceramic material contains minerals that have some magnetic properties.

The term ceramics refers to non-metallic inorganic material including pottery, porcelain, tiles, and bricks. The base material used in ceramics is clay and the clay contains minerals that are magnetic. When a ferromagnetic fingerprint powder is used to dust the surface of a ceramic material, there is interference from the two magnetic materials that come into contact with each other. This interference affects the quality of the resulting latent prints because there is more powder adhering to the background or area around the latent print.

In addition to the two types of fingerprint powders used in this study, there are other variables that affect the quality of latent prints obtained from evidentiary objects at the crime scenes. Some of those variables include: the age of the print, the chemical composition of the perspiration, climatologic environment, the porosity of the surface, the material type and its matrix, as well as the type of latent print method such as powders or chemicals that are used to process the objects. The estimated age of the latent print is an important factor used in selecting the processing method. The age of the latent print may not be known by the investigator but can sometimes be estimated based on information from witnesses or persons who had knowledge of the conditions at the scene before it was altered. For this fingerprint study, twenty cups were collected from flea markets and yard sales. The sampling includes cups of various qualities. Some are marked as fine china and others as stoneware or ordinary cups. The outside surface of each cup was selected for testing. The range of thickness for the cups' sides is from .090 to .270 thousands of an inch. The average thickness is .204 thousands of an inch. The cups are mostly white to cream in color with the presence of company logos and other designs present with different colors. The area selected for testing is absent of any logo or designs. The impression on the bottom of the cups revealed that one-cup was from Bavaria, five from China, two from England, four from Japan, one from Korea, one from Taiwan, two from Thailand, and four from the United States.

The cups were washed and wiped cleaned before testing. An area was circled in pencil on the outside of the cup and a latent print placed inside the marked area. An impression with the same approximate pressure was used to leave each of the latent impressions. The hands of an adult female were dipped in a water solution to obtain the same amount of residue on each finger. The hands were allowed to dry for 5 minutes and the cups were kept in a room at 70 degrees Fahrenheit for two hours before dusting for latent prints. Black ferromagnetic and non-ferromagnetic powders were used to process each of the ceramic cups.

A Likert type scale was developed and used to evaluate the quality of each latent print in the study. Latent prints were given a number between 1-5 depending on the evaluator's assessment of each print. The latent print scale included: 1) acceptable ridge detail with some powder adhering to the background surface, 2) some ridge detail present with light amount of powder adhering to the background surface, 3) some ridge detail present with moderate amount of powder adhering to the background surface, 4) no ridge detail present with light amount of powder adhering to the background surface, and 5) no ridge detail present with moderate amount of powder adhering to the background surface.

The quality of each print was evaluated after the impression was lifted from the ceramic material and placed on a latent lift card using clear two-inch latent lift tape. The evaluation of the impression was performed using four-power magnification.

The results of the study indicated that ferromagnetic powder produced better quality latent prints even though there was more background powder adhering to the glazed surface of the ceramics than the non-ferromagnetic powder. The ferromagnetic powder produced some ridge

detail on 35 % of the cups processed and 15% of the impressions had acceptable ridge detail for comparison purposes. The non-ferromagnetic powder produced some ridge detail on 30 % of the cups, but none with acceptable ridge detail for comparison purposes. Using non-ferromagnetic powder, 70 % of the cups processed had no ridge detail and but had some adhesion of the powder to the background. Using ferromagnetic powder, 65 % of the cups processed had no ridge detail but had a moderate amount of powder adhering to the background. There was no observable difference for either type of powder based on the thickness of the cups; however, there were some detectable differences in the degree of magnetic attraction between the magnetic powder applicator and some of ceramic cups.

Fingerprint Powder, Latent Prints, Ceramics

D22 Investigation of Abuse in Nursing Homes

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The goal of this research project is to provide an understanding of the investigation process of resident abuse occurring in nursing homes.

The government for abuse of residents has cited over one-third of the nation's nursing homes. This is almost double from the 1996 figures and yet many instances of abuses still go unreported.

Federal Health Care Finance Administration(HCFA) in its Medicare State Operations Manual defines abuses as follows: Verbal abuse is the use of oral, written or gestured language to the resident or his/her family. Sexual abuse includes, but is not limited to, sexual harassment, coercion, or assault. Mental abuse is humiliation, harassment, threats of punishment and deprivation of services. Involuntary seclusion is another form of abuse which is the separation of a resident from other residents. Finally, the worst form of abuse in the nursing homes is corporal punishment which includes hitting, slapping, pinching, and kicking the resident to control his/her behavior.

Federal law requires nursing homes to develop and implement policies and procedures to prevent abuse which include: screening employees and training and educating the staff and families on what constitutes abuse and what must be reported for prevention of abuse in the nursing home.

All surveyors are trained by state and federal agencies and must pass the surveyor minimum qualification test, which is a federal mandated surveyor examination, before they are authorized to survey facilities.

The investigation of abuse follows the pertinent survey tasks for a regular or standard survey as specified in the survey procedures for Long Term Care Facilities. TASK 1. The complaint investigator must review the complaint and conduct a telephone interview, if possible, with the complainant. Specific dates and names are extremely important to obtain and clarify the who, what, when, where and why of the written complaint. TASK 2. The complaint investigator enters the nursing facility unannounced and is required to notify the administrator or the designee administrator the nature of the complaint. The facility staff is advised of the nature of the complaint, but the complaint investigator reveals no names of complainant or residents. TASK 3. The complaint investigator obtains a list of all residents residing in the facility. The investigator usually takes a brief tour of the facility to review the appearance of the residents, delivery of services to the residents, staff interaction with residents, physical environment, and other areas related to the complaint. The investigator will obtain vital information concerning the abuse. This is followed by a review of records and related documentation. TASK 4. The investigator reviews all the information collected to determine if there are inconsistencies or if additional data collection is needed. If the investigator substantiates the abuse, the facility is cited for violating one or more of the approximately 350 federal and state regulations. The investigator must determine the scope and severity of the deficiency. TASK 5. There is an exit conference conducted by the investigator with the nursing home

administrator. The administrator is informed of the findings of the investigation and also the deficiencies. The administrator will be instructed that these citations will be written as a statement of deficiencies and reviewed by the investigator's supervisor.

The statement of deficiencies is a written document of the investigation and the citations. This document is prepared according to the federal requirements utilizing the principles of documentation. The statements are written in terms that a lay person can understand. The report and a statement of remedies are sent to the facility. The complainant is sent a copy of the report. The facility must respond to the state agency with a Plan of Correction within ten days. The remedy for an abuse deficient practice can range from a fine of \$100 to \$10,000 or more, depending on the level of harm to the resident.

The facility administrator states a date, usually about 50 days, that he/she will have corrected the deficient practice on the plan of correction. Following this date, the facility is revisited by the state agency to ensure that the deficient practice has been corrected.

The facility is required to investigate all alleged or suspected abuse, and if validated, report the results of the investigation to the state agency responsible for the licensure and certification of the nursing home and to the state nurse aide registry or licensing authorities.

Elder Abuse, Nursing Homes, Investigation

D23 Postmortem Genital Examinations

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The goals of this research project are to discuss current research on postmortem genital anatomy. The objective is to describe the salient findings accumulated during the first year of clinical adaptation of sexual homicide, research undertaken by this author since 1995.

Collaboration of a Forensic Clinical Nurse Specialist with a Criminal Investigative Analyst illustrated the complementary nature of the two disciplines during the investigation of sexual homicide (Crowley & Prodan, 1996). A *Sequential Methodology for the Examination of Sexual Homicide Victims* (©Crowley, 2001) was developed to respond to the need for a systematic approach to the genital evaluation of deceased sexual homicide victims (AAFS, 1998). This protocol, which incorporated colposcopy, was refined and other aspects were expanded. These included the collaborative role of the Forensic Nurse and Forensic Pathologist, the use of reflective and fluorescent imaging, and the sexual homicide database (Crowley, Barsley, Peterson, & Wood (AAFS, 2000).

The use of colposcopy in living sexual assault victims is well established. Patterns of injury have been described, and findings compared to a control group of women who engaged in consensual sex (Slaughter, Brown, Crowley, and Peck, 1997). Prior to the incorporation of colposcopy for the evaluation of living sexual assault victims, traditional methods of exam yielded a paucity of physical findings (10-30%). Similarly, during the autopsy, gross visualization alone may not allow detection of the more subtle findings that usually constitute genital trauma during sexual assault. The colposcope affords both magnification and photographic capability. This enhances visualization, provides photo documentation, and makes peer review possible. Higher magnifications make it feasible to study the effects of the postmortem interval and other factors on the anogenital tissue.

Materials and Methods:

Eighteen deceased patients (15 female; 3 male) were evaluated using a protocol that included colposcopy. Causes of death included suicide, accidental, and natural. All cases were examined using the mobile system of technology described by Crowley (AAFS, 2001). Examinations were done in collaboration with Brian Peterson, MD, Forensic Medical Group, Inc., of Fairfield, CA. Photographs were available for review on 10 cases, all female. In this group, the ages ranged from 6 years to 72 years old, with a mean age of 48.8 years. The postmortem interval varied from < 24 hours through several days, with active decay. All but one of the cases was

examined with colposcopy, using a fixed magnification of either 7.5X or 15X. In most cases, photographs were also obtained using a 35mm SLR camera, for comparison with colposcopy. Two cases were documented only with macro-photography. The cases were assigned an identification number and entered into a modified version of the *Sexual Homicide Database* (Crowley, AAFS, 2000). Data included the age, ethnicity, race, date of exam, postmortem interval, cause of death, major medical conditions, reproductive status, known gynecological history, gross non-genital trauma, and exam technique. Eleven anatomic sites were included for review. These included the labia majora, labia minora, peri-urethral area, posterior fourchette, fossa navicularis, hymen, vagina, cervix, perineum, anus, and rectum. The nature and pattern of postmortem genital findings are described in a manner consistent with conventional design, i.e., sharp vs. blunt force. The database provides a conceptual framework in which to analyze data and evidence, categorize postmortem genital findings, and describe anogenital anatomy. Careful study of "normal" postmortem anogenital anatomy will allow eventual comparison to the physical findings of sexual homicide victims.

Colposcopy, Sexual Homicide, Genital Anatomy

D24 Enhancement of the NIST Human Mitochondrial DNA Standard Reference Material 2392 — Addition of DNA From the HL60 Cell Line

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The goal of this research project is to learn how NIST plans to enhance the current human mitochondrial DNA (mtDNA) Standard Reference Material for sequencing the entire mtDNA. The outcome will be an improved SRM which will provide greater utility to the FBI and forensic laboratories.

Every human cell has from a few dozen to several thousand mitochondria, each of which contains mitochondrial DNA (mtDNA). The sequence of the entire human mtDNA (16,569 bp) was determined and published by Anderson et al. in 1981 (Nature 290:459-465). MtDNA is used by the forensic community for human identification and by the medical community for diagnoses of a number of human diseases now known to be associated with specific mutations and deletions of mtDNA. A mtDNA Standard Reference Material (SRM 2392) was prepared by the National Institute of Standards and Technology to provide quality control to the scientific community when they amplify and sequence human mtDNA. This SRM includes two human DNA templates (CHR and 9947A) and all the information necessary to successfully conduct the PCR amplification process, cycle sequencing steps, gel separation, and data analysis to obtain the final DNA sequence. The information on the sequence of 58 unique primer sets that allow the sequencing of the entire mtDNA is also provided. This SRM also includes information on the sequence of a third human mtDNA that is not provided in SRM 2392 but can be obtained from a cell culture line available from Coriell Repository. Following an interlaboratory evaluation, this initial version of Standard Reference Material 2392 was completed and released to the public in December, 1999 (Levin et al., 1999. Genomics 55:135-146).

DNA testing to identify unknown human remains has become a very important program within the law enforcement community. To promote this program, additional indices have been added to the CODIS (Combined DNA Index System) program of the Federal Bureau of Investigation (FBI) to include mtDNA sequences (and nuclear DNA loci when possible) from unidentified remains, as well as from relatives of missing persons. In order for authorized laboratories to contribute or upload to these indices, the FBI has deemed that certain quality standards must be met. In particular, a positive control from the human cell line HL60 must be run in conjunction with the sample. HL60 was chosen by

the FBI Laboratory as the positive control because of several features present in HL60 but not in the cell lines currently available in NIST 2392. Some of the advantageous features of HL60 are well-spaced polymorphisms throughout the HV1 and HV2 areas of the mtDNA control region, and no insertions at the HV2 C-stretch area (positions 303-310). The CHR DNA has a C-stretch in the HV1 region caused by a T to C change at position 16189. Sequencing through this C-stretch is difficult and results in the need to perform additional sequencing reactions to resolve this region. The CHR template was chosen by NIST specifically for the C-stretch region since some laboratories wanted the opportunity to specifically address this difficult sequencing problem and try to resolve it. The DNA from 9947A has only one polymorphism in the HV1 region with respect to the Cambridge Reference Sequence (Anderson et al., 1981) and that polymorphism is a common site. For the work that the FBI is doing on human identification, several evenly spaced polymorphisms are more desirable to differentiate the positive control from the test sample. Thus, the FBI suggested to NIST that the addition of HL60 to SRM 2392 would greatly increase its utility. This work is currently in progress and we will report on our accomplishments to date.

The FBI needs DNA Standard Reference Materials to provide the quality control and assurance that the results from sequencing unknown samples are correct. On July 15, 1998, the FBI Director signed Standard 9.5 that stated "The laboratory shall check its DNA procedures annually or whenever substantial changes are made to the protocol(s) against an appropriate and available NIST Standard Reference Material or standard traceable to a NIST standard." With the addition of HL60 to the NIST human mtDNA sequencing standard 2392, this standard will provide more utility and greater quality control when sequencing mtDNA. Corroboration of the SRM results will provide assurance that any unknown DNA is also being amplified and sequenced correctly.

Mitochondrial DNA, Standard Reference Material, Forensic Identification

D25 An Overview on Crimes by Women in Turkey

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The goal of this research project is to determine the properties of women's crimes.

The crime is an action and behaviour tended to abolish and erode the existing social regulations secured legally. Crime is of a universal nature and has been in existence since the oldest epochs of history.

Social and psychological interferences have been increasing violence and crime potentiality. But, some other factors also play roles in the formation of crime. For this reason, the feeling of deprivation is an important factor. Learning is also another important factor in the formation of violence. Today, the fact that the violence is learned is a common concept. Beside the transfer of violence through inner-family violence, to become aware of violence by means of media is a common problem today.

Women are seen to be involved in crimes less than men in all societies when the relationship between gender and crime is considered. The rate of female criminals differs from country to country and according to socio-cultural structure differences. There are similarities between male and female criminal tendencies, who belong to the same race and social class. The contents of crimes committed by men and women especially from the lower income groups are utterly identical.

When the crimes of women and men are compared, criminal women are expected to be psychologically more atypical because of their less

aggressive nature compared to men. It is obvious that women tend to kill and injure mostly in order to defend themselves. Women generally commit crimes by themselves and do not participate in organized crimes. Women are generally in very close connection with the victims. The rate of crime is higher in married women depending on the problems of marital circumstances.

Women's crimes appear as an important legal and bio-psycho-social problem having many aspects such as inner-family violence, disintegration, and social collapse.

The study aimed to analyze the demographic characteristics, inner-family violence stories, and crime properties of the criminal women.

Between November 2000 and March 2001, we investigated women criminals sent to the Council of Forensic Medicine, 4th Specialization Committee (Forensic Psychiatry Department), the unique official referee under the Ministry of Justice, by the courts throughout the country, to determine if they have psychiatric disorders which affect their crime liability. In this sectional period, 64 women out of 84 sent by the relative courts, who accepted to participate in the study after being informed about the objectives of the study, were interviewed by face-to-face method and by means of a pre-prepared questionnaire having multi-questions. All interviews were conducted after juridical examinations.

Mean age of 64 participants was 35.51 ± 11.09 ; 26.6% of the women (n: 17) were illiterate and 53.1% were educated for five years; 59.4% of the cases (n: 38) were married; 75% were (n: 48) unemployed; 4.7% of them (n: 3) had previous crime records; 3.1% (n: 2) had been drunk during criminal incidents; 67.2% of total cases had inner-family violence stories; 62.5% physical and spiritual (n: 40) and 4.7% spiritual only (n: 3); physical and spiritual violence was realised by spouses only (58.1%) and the collaboration of spouses and parents (41.9%); women had pre-crime 35.9% (n: 23) and post-crime psychological disease stories 39.1% (n: 25); the committee agreed that 60.9% of the cases (n: 39) had "complete crime liabilities"; 48.4% of women committed homicide, 48.4% of which (n: 15) against husbands or lovers; 74.2% of them had complete crime liability and 71.0% had inner-family violence stories. There was no statistical significance to determine between their exposure to inner-family violence and their crime liabilities of women who murdered compared with other criminal women, ($p > 0.05$).

The most frequently used criminal tools were fire guns 26.6% (n: 17) and cutting and perforating tools 18.8% (n: 12). Murders were realized by fire guns at a rate of 48.4%.

In the USA, women executed only 12% of all murders. Most of them killed their partners who abused or violated them. It was postulated that every year about 750 men are killed by their wives, girlfriends or lovers and almost all killing women were beaten ones. The study emphasized that about half of the killing women had killed their husbands and lovers, which was very striking; this matter must be paid attention since all the women sent to our department for "murder liability" examination do not represent all criminal women.

The new role of the woman in the social economic life might be supposed to increase the crime rates of the women. With more and more women entering the workforce, new legal regulations are needed to define the socio-demographic properties of "women's crimes" and to support more adequately the criminal women and their families.

Female, Offender, Violence

D26 Prior Abuse Reported by Male Inmates in 17 Turkish Correctional Facilities

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The goal of this research project is to present to the forensic community the results of the most comprehensive survey of male inmates ever undertaken in this country.

Statistical data are provided on offender characteristics in seventeen correctional units under the jurisdiction of the Ministry of Justice, Department of Corrections on June 30, 2001. The Survey of Inmates in Correctional Facilities (SICF) designed by the Institute of Forensic Sciences of Istanbul University for the Department of Corrections was applied to nationally representative samples of inmates. Offenders responded to 323 questions in hour-long interviews about their current offense and sentence, criminal history, personal and family background, prior drug and alcohol use and treatment, past physical and sexual abuse. This paper presents findings from SICF of male correctional populations regarding relationship to abuser (by the inmate reporting abuse); relationship prisoner's prior abuse to their family background (nonparental care, parental drinking and drug abuse, incarcerated relative); association of past physical and/or sexual abuse with current and past violent offenses and past alcohol and illegal drug use. Descriptions of methodology, sample design, standard error calculations, question wording problems and respondent sensitivity will also be discussed.

**Physical and Sexual Abuse, Survey of Prison Inmates,
Prior Abuse - Crime Relationship**

D27 Development of Personnel Portals That Detect Explosives and Other Contraband

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The goal of this research project is to update the forensic community on the development and testing of several personnel portals that can detect various explosives.

The Federal Aviation Administration (FAA) has funded several projects through the Aviation Security Research and Development Division that have resulted in the successful development of four personnel portals that could be used to screen airline passengers. These portals use a variety of techniques to collect trace amounts of particles and/or vapors from clothing that may have been contaminated due to an individual handling and/or concealing an improvised explosive device (IED). The collection varies from actually vacuuming the clothing while the passenger walks through the portal to sampling the 'thermal plume' generated from body heat. Air jets accomplish further enhancement of the collection process, which facilitates the dislodgement of particles. A critical part of the development was to preconcentrate the collected sample into a volume that was compatible with the detector. By way of example, the collected volume can be as much as 2000L and the maximum volume for one detector is less than 2mL.

After collection and preconcentration, the trace particles and/or vapors are analyzed by one of three detectors. The SecurScan (Thermedics Detection, Inc., Chelmsford, MA) utilizes a chemiluminescence detector coupled with a gas chromatographic column. The Sentinel (Barringer Technologies, Inc., Warren, NJ) and the EntryScan3 (Ion Track Instruments, Inc., Wilmington, MA) utilize ion mobility spectrometers for detection; whereas, the Sandia/Syagen portal (Sandia National Laboratories, Albuquerque, NM; Syagen Technology, Inc. Tustin, CA) uses a dual ionization mass spectrometer. The Sentinel and the EntryScan3 are now commercially available by the manufacturers. All the portals are undergoing extensive testing and evaluation by the FAA's Trace Explosives Program.

Explosive, Portal, Aviation Security

D28 Development of Two New Quality Control Aids for Use With Airport-Deployed Trace Explosives Detection Equipment

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The goal of this presentation is to show the forensic science community recent progress in the development of quality control materials for assessing the performance of trace explosives detection systems deployed in domestic airports.

The Federal Aviation Administration (FAA) Aviation Security Research and Development Division has developed and evaluated two new Quality Control Aids (QCAs) for use with explosive trace detection (ETD) equipment that is currently in use at domestic airports. These QCAs are designed to assess two different components of ETD performance. The first QCA, referred to as the Instrument quality control (IQC), contains a known quantity of pure explosive dissolved in an alcohol matrix (isobutanol). The purpose of this product is to detect changes in detector sensitivity over time. Although various explosives have been tested, this presentation will discuss only the use of RDX (cyclonite). One drop of IQC solution is dispensed by means of a plastic dropper bottle directly onto the sampling media used by the respective ETD instruments. The drop is allowed to dry, and then the sampling medium is inserted directly into the ETD for analysis. Drops of IQC solution are shown to be reproducible and quantitative. Explosive concentrations are selected such that the ETD system gives a detector response of approximately 120% of the response expected from trace explosive contamination of passenger luggage. The IQC solution has been tested on six versions of ETD systems from three manufacturers. All are currently deployed in domestic airports. These systems include the Itemiser (DOS and Windows versions, Ion Track Instruments, Inc., Wilmington, MA), the Ionscan (Models 400 and 400B, Barringer Technologies, Inc., Warren, NJ), and the EGIS (Model 3000 and Model II, Thermedics Detection, Inc., Chelmsford, MA).

The second Quality Control Aid is called the System QC (SQC). This product is designed to challenge the quality of the entire testing process, to include the sampling skill of screening personnel employed at airport security checkpoints. This QCA differs from the IQC in that commercial or military grade explosives are used to prepare dissolved explosive solutions, instead of pure explosive compounds. In the case of plastic explosives, plasticizer and oil components are also present in the dissolved solutions in addition to the pure explosive component. The dissolved explosive is then deposited quantitatively on a small strip of Teflon sheet (Bytac) and allowed to dry. The Teflon sheet is then rubbed onto any suitable test article, such as a luggage handle, by a Dry Transfer technique (pat. pending). The test article is then sampled using the routine sampling protocol for that particular ETD system. Studies show transfer efficiencies from Teflon to test article of 90% or better. Concentrations chosen are higher than those used for the IQC to allow for greater variability in sampling. The System QC has been tested on all ETD systems described above.

The Quality Control Aids described here, when used together, are intended to facilitate the increased use of accepted forensic laboratory practices in trace explosives detection.

Explosives, Trace Detection, Quality Control

D29 False Personation and Substitution of Laboratory Blood Samples Challenge Genetic Testing and Child Support Enforcement

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The goals of this research project are to present challenges of identifying fraudulent results that were the product of criminal conspiracy and substitution of laboratory blood samples during DNA paternity testing and resultant criminal penalties. This presentation will demonstrate the discovery, investigation, and identification of fraudulent blood sampling and personation during genetic paternity testing, resulting in criminal penalties and on-going child support.

Nationwide, establishment of paternity and collection of court ordered child support is a billion dollar undertaking mandated by federal and state law. Government agencies at the local, state, and federal level strive to collect child support from non-custodial parents in order to provide necessities of life for minor children. Complex legal issues and family emotions present a highly charged atmosphere with potential for costly, and sometimes violent, ramifications. While statistics indicate that the majority of non-custodial parents willingly comply with child support issues, there are those people who will do anything and everything to evade, avoid, and otherwise fail to comply with such support responsibilities. These efforts sometimes involve criminal activity, and the exact number of these cases is unknown. The widespread impact of this is felt by families, social service agencies, and taxpayers.

In California, the local district attorney offices have been at the forefront of these efforts. Child support enforcement divisions are most often separate from the criminal divisions and are staffed by family support officers, attorneys, and trained criminal investigators.

When a member of the U.S. military was declared by a custodial mother to be the father of a two-year old child, a routine genetic test was ordered. Unexpectedly, the results were exclusionary. A photograph of the alleged biological father, taken at the time of the blood draw, was identified by the mother as the correct person. Other men outside the time frame of conception were subsequently located and tested, also with negative results. Investigative interviews and fingerprint identification led a veteran criminal investigator to conclude that a personator had been substituted.

With the cooperation of military authorities, the location of the reputed father was quickly determined. He had threatened the young mother and then transferred across the country shortly after learning she was pregnant. However, the identity of the suspect who furnished blood remained a mystery. Strong cooperation between civilian and military enforcement personnel ultimately established the unknown. Through the quiet involvement of unit commanders, investigators learned the source of blood was another member of the suspect's unit. Unlike many other personator cases, this subject bore an uncanny resemblance to the declared father. Crossing the nation, the investigator obtained partial admissions from the true father and an uncontaminated blood sample. Returning to the west coast, a total confession was obtained from the blood donor, a man in the final stages of application for employment as a police officer. The supervised blood sample taken from the named biological father confirmed paternity. The result was on-going collection of child support and two criminal convictions.

Fraudulent Blood Samples, Impersonation, Child Support

D30 Forensic Science and Forensic Mythology: Making the Distinction

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The goals of this research project are to examine the current standards of acceptability for proven forensic science methods and unproven, traditional methods that are commonly accepted as being valid. The latter methods may be placed under the classification of "forensic mythology," and the present paper aims to trace their origins in popular media and common misconceptions about science, as well as to examine what effect forensic mythology continues to have on our legal system. The author proposes an intellectual standard for the assessment of forensic science techniques in order to enhance the efficacy of the existing judicial standards.

Ever since the District of Columbia Court of Appeals issued the *Frye* decision of 1923, forensic scientists have been charged with the responsibility of proving that their scientific evidence meets a certain standard of credibility before it may be admitted into court. While the *Frye* standard served as a solid benchmark for expert testimony until the U.S. Supreme Court's *Daubert* decision of 1993, it did not completely block the admission of pseudoscientific and unreliable testimony from the courts, nor has the *Daubert* standard strengthened the barrier against bad science in the courtroom. Some would argue that the *Daubert* decision was a step backward in this regard. In addition, both the *Frye* and *Daubert* rulings have had no effect on the scientifically unfounded forensic techniques used by authorities to identify suspects, elicit confessions, jog the memories of witnesses, and weed out undesirable potential employees. Indeed, the so-called "lie detector," which the *Frye* court deemed unscientific and inadmissible as evidence, has recently shown an upsurge in use by state and federal agencies, as well as by private companies. If the lie detector, along with other such scientifically unfounded forensic techniques as hypnosis, criminal profiling, psycholinguistics, and eyewitness identification do not meet the standards for validity that would be demanded in any other scientific field, the questions must be asked: Why are these techniques still being used, and why is our legal system so ineffectual at blocking bad science from the courtroom?

The endurance of pseudoscience applied to forensic ends may be partly to blame on the popular misconceptions of forensic science that are perpetuated through popular entertainment as well as highly-publicized historic criminal cases that have taken on an aura of legend. Of particular importance is the longevity of Arthur Conan Doyle's fictional character Sherlock Holmes, who provided the public with an archetype of the forensic investigator as highly rational, scientifically methodical, keenly observant of detail, and ultimately infallible. The popular conceptions of forensic science echo the popular misconceptions of science as a whole. While many lay persons may believe, erroneously, that science is always objective and infallible, a large portion of Americans simultaneously accept as true such blatantly false techniques such as astrology and mind reading. The unfortunate overall picture of America's scientific literacy is that of a population largely lacking the educational background and the intellectual skills to be able to discriminate between credible science and scientific-looking chicanery. Because most attorneys, judges, and jurors are scientifically lay persons, the American legal system is by extension dangerously vulnerable to the lures of *scientism*, that is, unproven methods that are cloaked in the mantle of scientific-sounding jargon and impressive-looking data. All of these factors contribute to the perpetuation of a forensic mythology, by which the perceived truths of forensic science are accepted on faith and passed on through tradition, rather than scrutinized and repeatedly tested.

If forensic science as a whole is to be elevated from the mire of mythology, it is the responsibility of each forensic researcher and expert witness to set an example through his or her professional conduct. The only intellectually honest position to take as a professional in the forensic

sciences is one of perpetual skepticism, always demanding that the reliability of forensic techniques be tested, and always ready to disclose a technique's fallibility.

Admissibility, Mythology, Skepticism

D31 Integrating Forensics Into Nursing Curricula

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The goal of this research project is to acquaint those involved with forensic education of ways to promote and integrate forensic concepts into a baccalaureate nursing curriculum.

This presentation will address how the mission and philosophy of the college or university and the demographics of the community that the college serves are utilized to justify integrating forensic concepts into the nursing curriculum.

In the past, curriculum content has been based upon the ten leading causes of death in the U.S, the major health problems of the United States; the major health problems of various age groups throughout the life span, and other strategies. With the preponderance of violence in today's society, forensic considerations of interpersonal violence, suicide, trauma, sexual assault, substance abuse, toxicity from accidental prescription and O-T-C drug use and misuse, and environmental poisoning are but a few examples where the forensic sciences have much to contribute. Proper wound identification, evidence recognition and collection in the clinical setting, proper written and photographic documentation that withstands courtroom scrutiny, recognition of primary and secondary crime scenes which patients may present, prevention techniques of document alteration (patient records) are important subjects with which the nurse should be acquainted in this litigious society. A nurse is educated to look beyond what meets the eye, and a basic understanding of selected forensic concepts will improve the recognition and collection of evidence and data of patients and their significant others. Documentation of these findings may be crucial if those patients and their significant others later interact with the criminal justice system.

The nursing curriculum is already overloaded with content, and faculty may not consider that coverage of this content can be in few-minute segments as it is integrated into various nursing courses. For example, when wound care is discussed, forensic wound terminology can be introduced. When learning physical assessment, the forensic implications of carefully documenting suspicious lesions or wounding which might create an index of suspicion as to their cause can be emphasized. This would include obtaining the history of how these wounds were incurred according to the patient. In pharmacology, actual cases histories of accidental poisoning with one or interacting drugs can impress the student with the vital need to elicit patients' histories and patterns of consumption. The pathophysiology of drug abuse and misuse can be included in pharmacology and/or mental health nursing. How much more exciting and pertinent to have a document examiner describe and display how changed or forged documents are detected than to just emphasize proper documentation techniques with their medicolegal implications. These and other examples of how specific content can be integrated into nursing courses will be included in this presentation.

If no forensically-trained faculty are available, content selection and integration assistance can be elicited from forensic clinical nurse specialists, forensic pathologists, toxicologists, criminalists, questioned documents examiners and other forensic scientists. A list of applicable commercially available videotapes will be distributed.

Nursing Education, Nursing Curricula, Forensic Concepts Integration

D32 A Cross-National Comparison of Selected Police Investigative Support Services in the United States and South Korea

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The goal of this research project is to report the preliminary findings of a cross-national assessment, including the United States and South Korea, of the police criminal investigation process.

Criminal investigation is a core component of the general police mission. How effectively it is carried out is strongly related to the overall performance of criminal justice systems and the institutions in those systems. For example, prosecutorial decision-making depends, in large part, on information resulting from police investigative activities. Courtroom proceedings, and even court sentencing practices, are influenced by the presence of evidence collected by the police; the availability of certain physical evidence has been shown to increase both the likelihood and length of incarceration. Of course, police investigation activities also influence the nature and volume of the workload in crime laboratories. Police investigation, in short, is the essential gateway to crime laboratory, prosecution and court activities, all of which, in turn, drive prison populations.

In spite of this importance, there has been surprisingly little scientific inquiry regarding the police investigative function. The overwhelming bulk of research attention focused on policing in the past 30 years has concentrated on police patrol and service activities. In fact, a recent content analysis of the research articles published in major criminal justice and criminology journals revealed that less than 2% of those were devoted to police investigation (Horvath, Lee, & Meesig, unpublished manuscript). For that reason, little reliable information is available in the United States about such topics as investigative policies, practices and effectiveness and how those interact with support services, such as crime laboratory personnel and activities. Of course, assessing differences in the police investigative function between countries is a much less empirically explored area. It is that topic to which this paper is devoted. In this paper we consider selected issues regarding forensic services for police investigators and we discuss how these are related to police investigation in two different countries, South Korea and the United States.

In South Korea, the justice system is considered to be primarily of the inquisitorial type. In such systems, forensic science laboratory services are often provided by large university-based medico-legal institutes or separate national forensic laboratories which assist the court (as well as the police) in determining "truth." In the United States, where the adversarial legal tradition is prevalent, crime laboratories are commonly appended to police organizations. Forensic services therefore are not uniformly provided and, perhaps, in part, for that reason, are sometimes matters of dispute between the prosecution and defense. Both the relevancy and reliability of scientific tests may be at issue during criminal proceedings and, at times, the outcome may depend on the prevailing view of such tests.

In addition to how their Criminal Justice Systems differ, in general, Korea and the United States also differ considerably with respect to the organization of their police. One of the peculiar features of law enforcement agencies in the United States is how decentralized they are; there are more than 18,000 separate, autonomous police departments. Similarly, crime laboratories in the U.S. provide services in a very decentralized way, according to their diversified local situation. Some laboratories, organizationally attached to local police departments, provide almost exclusive forensic services for such departments. Other laboratories, often those affiliated with a state or federal organization, provide services to police agencies unable to afford either their own laboratory or specific forensic techniques. In contrast, the Korean police, a National police force, have one centralized national crime laboratory system. That system and its services, attached to the Ministry of Interior in South Korea,

are nationally administered and managed; importantly, the crime laboratory is, in principle, separated from the police organization.

In this study, we carried out mail surveys of representative samples of law enforcement agencies in the United States and South Korea. For the U. S. sample we surveyed 3,124 police agencies; the sample included all of those with over 100 sworn employees, all state police agencies, and a representative sample of smaller municipal agencies. The response rate was 56% (n= 1,746). For the South Korean sample, all police departments (actually separate sites of the National police organization) in the country were included in the sample; the response rate was 97% (n= 224). In both countries, the data collection instrument included items addressing five general areas of interest: the work and role of investigators, the work and role of patrol officers as they relate to investigations, investigative management, investigative effectiveness, and, investigative support units, including certain forensic services.

The purpose of this paper is twofold. The first is to identify similarities and differences between the two countries with respect to four issues: (1) police evaluation of crime laboratory services; (2) requirements for and use of evidence technicians; (3) perceptions of funding needs for enhancing investigative effectiveness; and, (4) the role of patrol officers in investigations.

Our second purpose is to contrast, in terms of investigative policies and practices, police agencies in the U. S. who do not have their own crime laboratory with those who do. Since this is not a concern in South Korea, that contrast was explored in an effort to shed light on differences between South Korea and the U.S. in terms of general investigative practices.

The differences in the crime laboratory systems in the two countries suggest that there may also be differences in how the services of those systems are viewed. On this issue, our preliminary findings show that a greater percentage of the police in the U. S., 24%, report a "timely" turn-around time for crime laboratory services than those in South Korea, 12%. However, a large proportion of police agencies in both countries evaluated turn-around service in crime laboratories as "somewhat slow," 49% in the U. S. and 72% in South Korea. Such service in both countries was almost equally considered completely inadequate, 3% in the U. S. and 1% in South Korea. In other words, although the countries differ in important respects, evaluation of support services for investigation is less than positive in spite of those differences.

With respect to the use of evidence technicians, more American police departments (89%) require specialized experience or training than is true in South Korea (72%). (We note here that in spite of the apparent uniformity of policy and practice across South Korea, in some instances, such as with respect to evidence technicians, geographic and other jurisdictional disparities permit local needs to prevail.) Perceived funding needs in the U. S. were primarily for investigative personnel (42%), whereas in South Korea investigative operations (63%), that is, the need for funds to execute investigations, was the predominant view. Similarly, the South Korean police expressed a greater need for funding (55%) of evidence processing than did their American counterparts (11%). South Korean patrol officers' evidence collection activities at crime scenes were only slightly more frequent than for their American counterparts. In 20% of their cases, South Korean patrol officers always collect evidence from crime scenes whereas 17% of American officers do. With respect to submission of collected evidence for forensic analysis, South Korean police officers make such submissions in 23% of their cases whereas only 15% of American officers do.

In an effort to explore some of the differences between the investigative process in the U. S. and South Korea, multivariate analysis was carried out. This analysis, conducted initially to identify those variables most influential in explaining differences between police agencies in the U.S. who have their own crime laboratory facility from those who do not, showed that those police agencies with their own laboratory were more likely to employ evidence technicians, had more timely crime laboratory service, and made use of specialized investigative units (e.g., task forces), after controlling for jurisdictional size. However, investigative produc-

tivity and easier access to laboratory services were not related to police ownership of the laboratory.

Other findings related to differences between the U. S. and South Korea, their meaning for the police investigative function in general and, more specifically, with regard to their value in understanding police investigative activities in the context of different organizational, legal, and social environments, will be presented in this paper. We will conclude our presentation by focusing on the effect of contextual differences on investigative outcomes, particularly case clearances, and productivity.

Criminal Investigation, Police Investigation, Cross-National Investigations

D33 The Effect of Prior Knowledge, Practice, and Countermeasure on the Accuracy of Control Question Testing

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The goals of this research project are to gain knowledge in the current literature about the effect of countermeasures on the results of polygraph testing using the Control Question Technique (CQT), the most common approach to "lie detection" in the U.S. The preliminary results from an ongoing study will be used to indicate gaps in the current knowledge base in this area.

When polygraph testing is carried out using the CQT, a subject's physiological responses to a set of "control" questions and a set of relevant (crime related) questions are compared in order to determine the subject's truthfulness. Simply stated, more consistent and pronounced responses to control questions than to relevant questions leads to a decision of truthfulness; whereas, consistently greater responses to relevant than to control questions will produce a decision of deception. Persons who are lying about relevant questions, however, may employ countermeasures during a CQT; that is, they try to "beat the test." This can be done in one of two ways. First, physiological responses to relevant questions may be suppressed, relative to control question responses. Second, physiological responses to control questions may be "artificially" enhanced. In either instance, the result is intended to show greater responses to the control than to the relevant questions in order to change the outcome from a "deception indicated" one to a "no deception" indicated result, what is termed a false negative outcome or an actually deceptive person reported as truthful.

The effectiveness of countermeasures on CQT outcomes is not well established. Laboratory, "mock crime," studies reported to date have examined the effect of a number of mental and physical countermeasures. In one study, Honts (1986) reported that 37 % of the "guilty" subjects who were trained to use either pain or another physical countermeasure, or both, were able to defeat the CQT. In addition, 25% of the guilty subjects in this study, who were specifically trained in the use of a cognitive countermeasure were also able to defeat the CQT. In an earlier study, however, Dawson (1980) reported that guilty subjects who were trained in the use of a "method acting" procedure were unable to alter the outcome of their CQT examination. In his study, all "guilty" subjects were correctly detected. The reason for the difference in findings between the two studies may be that the guilty subjects in Dawson's study did not have prior practice sessions as was the case in the Hont's study.

Rovner (1979) and Honts, Hodes & Raskin (1985) have reported additional countermeasure studies. Rovner found that the false negative and inconclusive rates among guilty subjects who were given detailed information and practice were significantly higher than those rates among guilty subjects who were given either no or some information about the CQT without practice. The Honts, Hodes & Raskin study showed that untrained guilty subjects using spontaneous countermeasures did not

affect the outcome of the CQT. However, in a follow up study, subjects trained in the use of physical countermeasures were able to produce a much higher rate of false negative outcomes (47%) as compared to subjects in the guilty control group (0%).

Aside from studying the effectiveness of countermeasures, research also has been conducted to determine if, and how well, countermeasure attempts can be detected. This research suggests that attempts to detect the use of physical countermeasure by means of additional sensors (e.g., Electromyographic recordings) may be of limited value. Even if such sensors were effective, it is perhaps unlikely that they would be useful in detecting mental as opposed to physical countermeasures. Furthermore, there is some research which shows that the use of a test question, included in the testing protocol, to detect countermeasure attempts may not be of value.

Considered together, the available laboratory studies suggest that “guilty” subjects may avoid detection with the CQT if they have specific prior knowledge of the testing conditions and, importantly, if they are given intensive practice in applying countermeasure maneuvers. This is, of course, a concern in the polygraph examiner community. And, it is seemingly even more important today. There are now many sites on the World Wide Web accessible to anyone with a computer which post considerable information about polygraph testing and the CQT, in general, and about countermeasure usage in particular. In fact, there is at least one location which provides, at some cost, printed material detailing methods that may be used to defeat a polygraph examination.

The vast amount of information available about polygraph testing, the suggestion that some countermeasure usage may be difficult to detect, and the widespread use of the CQT show that it is important to carry out additional research. The design and intent of some of that research, along with the preliminary results of an ongoing study, will be discussed in this presentation. We will also highlight the features of the research which are different from what has already been reported and we will consider the remaining gaps in our knowledge of this issue.

Polygraph Testing, Countermeasures, Control Question Testing

D34 Servant Leadership in a Forensic Setting

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The goals of this research project are to study the proliferation of books on leadership and leadership styles, this paper will present an oft-misunderstood means of leadership that has the advantages of promoting morale and personal and professional growth within a typically high stress environment such as a forensic laboratory.

Servant leadership is a leadership style in which, “the great leader is seen as servant first, and that simple fact is the key to his greatness.” (Robert Greenleaf, *Servant Leadership*, New York: Paulist Press, 1991, 7.) Robert Greenleaf, a former executive at AT&T has espoused servant leadership as the leadership style that will build morale, allow opportunities for personal and professional growth, and allow all individuals within a workplace to have the opportunity to reach their potential.

The concept of servant leadership is a difficult one to articulate because the common meanings of the individual words appear to be incompatible when used together. Some may even consider the term to be an oxymoron. However, when viewed in their proper context the term servant leadership is best viewed as a tension to be kept in balance.

In order to keep this tension in balance, one must have an appropriate view of servanthood and leadership. In its simplest form, servanthood is neither a weakness nor a lesser position. Rather, servanthood is an opportunity to provide an individual with the means through which he or she will be able to accomplish a specific task, or a continuing set of tasks. It involves the provision of tools, both tangible and intangible, that allows an individual or group of individuals to successfully complete the task(s) set

before them. Leadership is best seen not as an opportunity to wield authority, but an opportunity to work with a group of individuals for the purpose of teaching and mentoring them so that they can find their niche within an organization and grow to their fullest potential within that organization.

The complicating factor in all this is that such a leadership style is not particularly advocated within law enforcement organizations, of which most forensic settings are a part. Law enforcement agencies are typically militaristic in their leadership style primarily because of the tasks in which they take part. Unfortunately, when such organizations offer training classes to their managers and supervisors, there is little distinction made between leadership styles and methods that are effective for street officers and those that would be effective for civilians working in a different environment. Yet, it is the forensic setting in which servant leadership can have a tremendous impact.

One of the chief advantages for effective servant leadership in a forensic setting is the tremendous boost in morale and interpersonal relationships not only among peers, but also between managers and staff. This is not to be taken lightly because one of the chief concerns among staff is that managers either do not have an understanding of their situation or they are non-responsive and do not listen well. Forensic managers have generally attained those positions because, at least in part, they have served a length of service within an organization. Generally, they have survived throughout that period, at least in part, because, working in a law enforcement organization, they have been told to regularly detach from unpleasant circumstances, lest they be adversely affected. Unfortunately, it is not so easy to reattach later on in one’s career. Far too often, managers have become so adept at detaching from circumstances that they also detach from people and their circumstances as well. Effective servant leadership is a way in which managers can successfully reattach to their people, recognize and validate the feelings and emotions they have when they encounter a particularly unpleasant situation, and teach them coping mechanisms so that the situation can be dealt with and appropriately dissipated over time.

Another advantage of servant leadership is the promotion of personal and professional growth of individuals within an organization. In contemporary society, it is critical that managers recognize that their employees have a significant life outside of work. In addition, many of these individuals are inexperienced in methods of trying to reconcile seemingly conflicting needs, schedules and priorities. A laboratory manager is in position to effectively help those for whom they are responsible to learn how to prioritize and adjust their schedules so that there is ample opportunity for personal and professional fulfillment. In addition, laboratory managers are in position to effectively find means to promote the professional growth of those under their charge, helping them to grow to their fullest potential through recognizing their strengths and building upon those without regard for position or status within the laboratory. An effective servant leader has the ability to discern needs because he or she communicates effectively and often. An effective servant leader also recognizes that personal and professional fulfillment are not in conflict with one another, but absolutely vital to the continued health of an organization.

Forensic Laboratories, Management, Servant Leadership

D35 The Dynamics of Human Movement in Shooting Incidents

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The goal of this research project is to have participants become familiar with how the dynamic elements can affect the reconstruction and analysis of shooting incidents.

This presentation will discuss the results of research and experimentation in the dynamics of shooting incidents including the time intervals of rapidly fired shots; the muzzle-to-target bullet travel time; the minimum

and other time intervals required for a human to fall from standing to prone positions; the time required for body rotation; human reaction time; and, other related elements which affect the analysis and reconstruction of shooting incidents.

The experimental methodology included the use of high-speed and frame-by-frame video analysis which allows slow motion and stop action review of fast events and accurate time correlations to be determined.

Most shooting incidents include movement by victims. The author has been involved in several cases in which movement by a person just prior to and during the shooting event has caused confusion and misinterpretation relating to the initial position, stance, and orientation of the person shot.

Two situations occur frequently which require an understanding of shooting dynamics for an accurate reconstruction:

* A person who has made a deadly force threat against another person will be shot sequentially as he falls to the ground. Under currently used doctrines on the use of deadly force by law enforcement officers, it is permissible to continue to shoot until the person is clearly no longer a threat to the officers or to others. During the interval between the first shot to the last, the person being shot will often not fall directly from a standing position to a prone position. More common is a crumpling fall that can require several seconds (or more) during which time many shots can be fired. The number of shots and the placement of wounds can lead to a superficial analysis of the incident concluding that an excessive number of shots was fired and/or the misperception that the person was shot in the back while standing.

* Two people (A and B) face each other, both are armed. A perceives a threat by B and he reacts by drawing, aiming, and firing his weapon at B. While B was facing A at the initial moment, B has recognized A's initial movements and he has started to make a defensive movement, i.e., to turn away from A. By the time A has completed all the elements required to discharge his weapon, B has rotated at least partially. The bullet strikes B behind the coronal plane – "in the back" — and A's account of the event is erroneously determined to be inconsistent with B's wounds.

The author's findings from human movement experiments established typical minimum time for the fast rotation of a person's body, time of falling, minimum time for shooters to react and fire a weapon, maximum rate of fire for common handguns, and typical bullet travel time.

The author believes that an accurate reconstruction of shooting incidents requires a broad understanding of all the significant dynamic events involved and the knowledge of fundamental ballistic and physical phenomena which do not support the common misconceptions that a bullet can knock a person down or cause the rotation or "spin" of an adult body. Another misconception is that a shooter will or should have the ability to know if his bullets have actually struck the person he is shooting at or that large amounts of blood will be immediately visible at the point of bullet entry. This paper will also discuss and demonstrate the fallacy of these beliefs.

Shooting Reconstruction, Reaction, Ballistics

D36 Child Homicides in the United States Air Force, 1989 – 1999

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The goal of this research project is to better understand the demographic and situational factors that pertain to child homicides associated with the United States Air Force.

The United States has the highest rates of childhood homicide and firearm-related death among industrialized countries (Centers for Disease Control, 1997). According to the Uniform Crime Reports published by the Federal Bureau of Investigation, over 1,400 children under the age of 18 were victims of homicide in 1999. Of all persons murdered in 1997, 33% of them were under six years old (Snyder & Sickmund, 1999). The United States Department of Health and Human Services (1999) found that children younger than one year old accounted for 42.6 percent of all abuse related child fatalities, and children younger than six years of age accounted for 86.1 percent of all child fatalities. As laboratory and diagnostic techniques have improved with technology, many deaths once thought to be accidentally or naturally caused have been re-categorized as homicides. Since these deaths often become targets of media publicity and public scrutiny, child homicides have begun to be studied in more detail. For instance, several researchers have identified head trauma and asphyxia as common causes of non-accidental child death. Other studies have identified that most children are not likely to be killed by strangers, but by people who know and care for them. In addition, child deaths are often intentionally presented with misleading or false histories that can confuse initial medical diagnoses, criminal investigations, and prosecution.

The United States military is a unique subset of the larger American population. Many selection factors make it unrepresentative of the American society at large. The US military employs screening systems to preclude entry of certain groups of people (e.g., repeat felons, mentally disturbed persons, etc.). In addition, military families have access to free or heavily subsidized health care from an entity who is not only a care provider, but also an employer, prosecutor, and in some cases, warden. What's more, military families are generally more mobile than their civilian counterparts, and therefore tend to establish more transient social support systems. Few studies address household mobility as it potentially relates to child abuse, and the studies that do exist provide conflicting data (Anderson et. al., 1983, Myers, 1970, and Schloesser et. al., 1992). During a review of the literature, the authors found very few studies that examined the military community exclusively as a separate entity.

In this paper, the authors describe an ongoing research project developed to better understand the interaction of the many demographic and situational factors that contributed to the murders of children who had an association with members of the United States Air Force. This project was undertaken to extend the findings of Brewster, Nelson, Hymel, et al, (1998), who described 32 Air Force-related infanticides (children under one year of age) occurring between 1989 and 1995. That study found that the infant-victim was likely to have a history of physical abuse, exhibit colic-like behavior, and was about five months old at the time of death. The caretaker-perpetrator in those cases was most likely the biological father. The most common scenario involved the male caretaker being left alone with a crying infant in the home on the weekend.

The authors of the present study will present an analysis of child homicides perpetrated worldwide and investigated by the US Air Force Office of Special Investigations (AFOSI) during a ten-year period (1989-1999). Three hundred fifty three cases involving the death of at least one child, five years of age or younger, were initially identified through the agency's investigative database. Cases were then further screened to identify homicide cases where one or more perpetrators were charged with acts that demonstrated intent to fatally harm the victims. Cases were also included where the child's murder was a component in an overall homicide-suicide scenario. Over thirty factors were extracted from each incident's report of investigation to better understand the victims, perpetrators, families and commonalities present in the cases. The statistical analysis of the child homicides and potential points for possible intervention and prevention will be presented.

Child Homicide, United States Military, Death Investigations

D37 Imaging the Unimaginable: Radiology's Reluctant Recognition of Child Abuse

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The goal of this research project is to present the peculiar history of the delayed recognition of child abuse as a clinical entity, a lesson in the scientific consequence of non-objectivity and culture-based mind-set.

Practically every application of radiology in the forensic sciences had been accomplished or proposed within one year of Röntgen's discovery. The greatest exception is perhaps also radiology's greatest contribution to this field, the recognition and awakening of public consciousness to the heretofore unimaginable evil of deliberate injury of children by their caregivers. This took half a century and the reluctant conclusions of a compassionate pediatrician cum radiologist. The very concept of child abuse is modern, not rooted in our ancient culture in which parental power over the child was absolute.

The industrial revolution with its insatiable appetite for cheap labor, and the social excesses attendant to child labor, did stimulate the social concerns of Dickens and a handful of other writers. It was only after successful argument that children really were but animals that a Society of Prevention of Cruelty to Children could be established in the United States — under the aegis of The Society for Prevention of Cruelty to Animals.

In 1860, Ambrose Tardieu, a French pathologist specializing in public health and legal medicine, published an article (republished 19 years later) describing all of the salient features of child abuse (except for the radiologic). Tardieu, unfortunately, seems to have stirred the interests of modern historians far more than those of his contemporaries and the entity remained largely unrecognized.

In the 1930's John Caffey, a pediatric radiologist at Babies Hospital in New York City, began to notice and collect patients with an unusual concatenation of findings: chronic subdural hematoma and multiple fractures in different stages of healing. (The unarguable opinion of a famous pathologist, Virchow, had obscured and delayed the recognition of the traumatic origin of subdural hematomas for 70 years).

In this, and subsequent papers, Caffey described the entire radiologic spectrum of child abuse which will be illustrated. Finally and reluctantly, he and his disciples and colleagues, including the pediatrician Kempe and social workers, defined child abuse holistically as both a socio-economic and medico-legal problem.

This sad history of delay and missed opportunity does not end with child abuse. It was three decades after Caffey's work before the publication of a paper describing almost identical medical findings and social histories on "granny battering," abuse of the elderly. Still later we have come to recognize spousal abuse or abuse of intimate partners as a problem whose victims exceed child abuse in numbers.

Child Abuse, Radiology, History

D38 Recognition of Child Abuse

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The goals of this research project are to recognize bite mark evidence. Participants will learn the proper handling of bite mark evidence in order to facilitate the forensic dentist's work and to minimize potential problems. Issues of photography, lifting of the tissue, fixation, preservation, transportation and transillumination will be reviewed. The importance of preserving the excised tissue without sectioning will be demonstrated. The analysis of the evidence and the pertinence of computer software programs will be mentioned. Cooperation and communication between forensic pathologist and dentist will be emphasized.

A two and a half month old white male was found to have contusions on the face and shoulder with a barely perceptible patterned injury on the abdomen. The skin superior to the umbilicus was excised, fixed and preserved. The transilluminated specimen showed two distinct bite marks of human origin. The interpretation of the patterned injury could not have been elucidated without the use of this technique.

A five-month-old black male was admitted to the emergency room unconscious with cerebral edema. The child was diagnosed with multiple non-depressed comminuted bilateral skull fractures, and with a mildly displaced mid shaft fracture of the right clavicle. The examining physician noted contusions of recent origin on the legs, arms, abdomen, chest, back, neck, left and right cheeks, and left heel. Despite initiating emergency treatment, the child died three days later. Although the bite mark was accurately identified at autopsy, odontological analysis was hampered by a lack of properly scaled photographs and unsuitably preserved tissue.

A fourteen-month-old white male was found lifeless in bed. The child was pronounced dead, his body embalmed. Suspecting child abuse, burial was halted, and an autopsy ordered. The autopsy attributed death to asphyxia by suffocation. Though there was no evidence of trauma to the hyoid bone or thyroid region, the pathologist noted multiple blunt traumatic injuries to the head, trunk and extremities in various stages of healing. The right humerus and left tibia were fractured, and there was edema of the cerebrum and occipital lobe. Most of the anterior teeth had erupted, and the lips, cheeks, and frenulum were bruised. Head shaving revealed a contusion over several areas of the head. Retraction of the scalp confirmed the presence of arch-shaped hemorrhages consistent with bite marks of human origin. The analysis of this case was restricted by improperly scaled photographs and because the bite mark tissue was not preserved.

A seven-year-old girl was found dead and mutilated in her basement. Her mother was charged with second-degree murder and denied bail. The pathologist attributed the cause of death to more than eighty stab wounds created by scissors and/or knives. The defense maintained that the injuries were caused by animal bite marks.

Bite Mark Recognition, Bite Mark Photography, Bite Mark Fixation

E1 The Good, The Bad, and The Ugly: Legal Perspectives of What Makes a Good Expert Witness

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The goals of this research project are to remind the audience of the importance of building and maintaining one's credibility and reputation, and to educate the audience about what makes for an excellent expert witness and what diminishes one's value as an expert witness.

Credibility, competence, excellence, and ethical are qualities for which expert witnesses should strive. One's credibility as an expert witness is enhanced when one is seen as an objective expert, on whom both sides of legal table rely upon to resolve a legal issue. A credible expert witness often has a strong background and understanding in his/her field of expertise.

Working as an expert witness, one frequently hears about or encounters expert witnesses who are labeled as *hired guns*, *hacks*, and worse terms, because they are lacking in credibility, competence or ethics. A *hired gun* is a term used to describe an expert witness who can always be counted on to give the desired opinion, regardless of the facts. For example, a hired gun might be a witness who always opines that a defendant or plaintiff is malingering, or the opposite, that they he/she is always mentally disabled and should be receiving worker's compensation benefits.

This panel, comprised of a superior court judge, the district attorney, a deputy public defender, and an ethicist, will offer the audience their perspectives on the traits, attributes, ethics and qualities that make up good and bad expert witnesses. A question and answer period will follow the presentations.

Expert Witness, Credibility, Ethics

E2 Ineffective Assistance of Counsel and the Right to a Defense Expert

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After attending this presentation, the participant will understand: 1) the constitutional basis for the right to competent legal representation at trial, 2) the significance of this right in dealing with expert and scientific testimony, and 3) the use of this right in gaining access to defense experts for indigent defendants.

The constitutional right to the effective assistance of counsel is a two-edged trial weapon. It not only shields the accused from inadequate representation in dealing with expert testimony but may also be the foundation for a request for a defense expert.

The first ethical rule stated in the American Bar Association's Model Rules concerns lawyer competence: "A lawyer shall provide competent representation to a client. Competent representation requires the legal knowledge, skill, thoroughness and preparation reasonably necessary for the representation." Model Rule 1.1. In addition, the Sixth Amendment right to counsel includes the right to effective assistance of counsel. See *McMann vs. Richardson*, 397 U.S. 759, 771 n. 14 (1970) ("It has long been recognized that the right to counsel is the right to the effective assistance of counsel."). See also *Strickland vs. Washington*, 466 U.S. 668 (1984); *United States vs. Cronin*, 466 U.S. 648 (1984); *Powell vs. Alabama*, 287 U.S. 45, 71 (1932). And yet, the evidence that indigent

defendants frequently do not receive adequate representation is overwhelming. A *New York Times* article captured the essential truth here: Poor Legal Work Common For Innocents on Death Row. Dirk Johnson, Poor Legal Work Common For Innocents on Death Row, N.Y. Times, Feb. 5, 2000, at A1.

Moreover, effective assistance cases involving scientific evidence are not hard to find. For example, in *Baylor vs. Estelle*, 94 F.3d 1321 (9th Cir. 1996), the Ninth Circuit wrote: "We have difficulty understanding how reasonably competent counsel would not recognize 'the obvious exculpatory potential of semen evidence in a sexual assault case,' particularly when the criminalist's report plainly indicates that the donor was an ABO nonsecretor whereas Baylor was an ABO type, 'O', secretor and that this 'would thus eliminate Baylor as the perpetrator unless a test ... on a liquid semen sample showed that he mimicked a nonsecretor ... Whether or not Stockwell's report was itself conclusive, it was one test away from tilting the scale powerfully in Baylor's direction.'" *Id.* at 1324. Similarly, another court found ineffectiveness where defense counsel knew that gunshot residue testimony was "critical," but nevertheless "failed to depose ... the State's expert witness, nor bothered to consult with any other expert in the field." *Troedel vs. Wainwright*, 667 F. Supp. 1456, 1461 (S.D. Fla. 1986). Numerous other cases can be cited.

The Justice Department's study on DNA exonerations also underscored this point. A professor of forensic science wrote: "One problem that DNA testing will not remedy is inadequate legal counsel. In case after case reported here, defense counsel failed to consult competent scientific experts." Walter F. Rowe, "Commentary," in Edward Connors et al., *Convicted by Juries, Exonerated by Science: Case Studies in the Use of DNA Evidence to Establish Innocence After Trial xvii-xviii* (1996). Furthermore, in their book, *Actual Innocence*, Barry Scheck, Peter Neufeld and Jim Dwyer examined 62 of the 67 DNA exonerations secured through Cardozo Law School's Innocence Project to ascertain what factors contributed to these miscarriages of justice; one of the more astounding conclusions was that a *third* of these cases involved "tainted or fraudulent science." *Id.* at 246. They also devote an entire chapter to lawyer incompetence.

The right to ineffective assistance of counsel can be used as more than a mere "shield." It can be used as a "sword" to ensure that indigent defendants' have access to defense experts. In *Ake vs. Oklahoma*, 470 U.S. 68 (1985), the United States Supreme Court for the first time recognized a right to expert assistance for indigents. Although *Ake* is grounded in the due process clause, the right to counsel provides an ancillary foundation for the right to a defense expert.

If failure to secure expert assistance may constitute ineffective assistance of counsel, then it is but a short step to recognizing that the Sixth Amendment places an affirmative duty upon the state to provide expert services to indigent defendants upon request: "The right to counsel is meaningless if the lawyer is unable to make an effective defense because he has no funds to provide the specialized testimony which the case requires." *Bush vs. McCollum*, 231 F. Supp. 560, 565 (N.D. Tex. 1964), *aff'd*, 344 F.2d 672 (5th Cir. 1965). A number of courts have taken that step. See *Lickey vs. State*, 827 P.2d 824, 826 (Nevs. 1992) ("If failure to request a psychological examination constitutes grounds for a finding of ineffective counsel, it logically follows that a defendant facing charges of sexual assault of a minor should be afforded an expert psychiatric witness."). See also *Rogers vs. Gibson*, 173 F.3d 1278, 1284 (10th Cir. 1999)(psychiatrist in capital case) (*Ake* "principle is derived in significant part from the Fourteenth Amendment's due process guarantee of fundamental fairness, and in part from the Sixth Amendment's guarantee of the 'fundamental right to a fair trial'") (citing *Strickland*).

Effective Assistance of Counsel, Right to Expert, Indigent Defense

E3 Battle of Forensic Fraud: Views From the Front Line

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The goal of this research project is to explain the issues facing the forensic science community in the oncoming and ongoing battle of forensic fraud, a developing legal theory currently exploding in the American justice system.

This presentation will introduce the forensic science community to the issues of forensic fraud from a litigation perspective. The presenters have been involved in multi-case litigation involving some of the most notorious allegations of forensic fraud brought against a crime laboratory and its employees. The presenters are pioneers in this area, having gained a view of the legal battle of forensic fraud so that their experiences can inform the forensic science community of the emerging issues: who will be future targets, successful defenses and general damage to the forensic science community at large. The presenters will share with the audience first-hand knowledge of the issues facing the forensic science community as this area of the law continues to develop.

The purpose of the presentation is for the audience to understand the legal definition of forensic fraud, the legal requirements to prove forensic fraud, the legal defenses to forensic fraud, the legal consequences of the forensic science community's reaction to such allegations, the role of the laboratory in preventing forensic fraud, and the role of the laboratory in ferreting out forensic fraud. The presentation will address the use of tools such as accreditation, education, training, and experts in the battle against forensic fraud.

This presentation will explain the legal and factual issues which arise in defending allegations of forensic fraud. The presenters will discuss the meaning of forensic fraud from a scientist's or juror's perspective and appropriate and inappropriate internal responses by crime laboratory supervisors to forensic fraud allegations. Also discussed will be the possible consequences of forensic scientists acting as experts accusing each other of fraud and how evolving science affects the definition of forensic fraud; will certain DNA methods today be considered fraud in the future?

Among the specifics addressed are methods of peer and other employee review, whether peer review should be confidential, how the law treats peer review and how each method of review could prevent future claims of forensic fraud, as well as how peer review can be used in defense of fraud claims. The presenters will also touch upon media exposure of fraud claims and how crime lab employees or forensic scientists can explain the issues to the media so that they gain a balanced perspective for unbiased reporting. Also at issue will be quality assurance standards, how they should be tailored to prevent future claims of scientific fraud and their interplay as a sword and shield in litigation. Accreditation will also be discussed: Is it insurance against future fraud? Is fraud more prevalent in unaccredited labs? Do claims of fraud from an accredited lab tarnish the concept of accreditation in the public eye? How will accrediting bodies modify their scrutiny in the future in the face of claimed fraud in accredited labs? Should state or federal law require accreditation of laboratories? The presenters will discuss the use of expert testimony in forensic fraud cases, and the dilemma of providing such testimony in a forensic fraud case. Also discussed will be the issue of who should become an expert against other scientists, what qualifications should control, and how experts should be monitored in such cases.

This presentation is of interest to anyone in the forensic science field who is concerned with the standards applied to forensic science, the accreditation and integrity issues facing crime laboratories, and the education, training, and integrity of forensic scientists.

Fraud, Peer Review, Accreditation

E4 The Los Angeles County Model for Post-Conviction DNA Testing: A Search for the Truth

Ellen J. Aragon, JD, and Lisa Kahn, JD, Office of the Los Angeles County District Attorney, 210 West Temple Street, Los Angeles, CA*

After attending this presentation, participants will recognize the ethical and practical advantages of having the prosecution and defense bar cooperate in reviewing prisoners' requests for DNA testing to establish factual innocence.

Many states have enacted or are about to enact legislation that allows convicted felons to request DNA testing of evidence that they believe may exonerate them. California's new laws provide for testing to be done at the state's expense if certain conditions are met. The law also requires all biological evidence collected at crime scenes to be retained for this purpose.

In their discretion, while the courts may appoint counsel for prisoners who petition for DNA analysis, they are not required to do so unless a motion is filed. Many prosecutors' offices have had to respond to letters or pro se motions filed by the convicts.

The prosecutor usually has the advantage of being in possession of the case file and a law degree. Prosecutors in many states have been accused of using unfair legal tactics to defeat claims of factual innocence. Prisoners in these jurisdictions complain that the courts deny their requests based solely on the prosecutor's representations.

In an effort to avoid even the appearance of impropriety or heavy-handedness in responding to prisoners' requests, the Los Angeles County courts, District Attorney's Office and the defense bar have developed a cooperative model for processing letters and motions from prisoners for DNA testing. Prisoners may address their requests to the court, the prosecutor, the police, or to their attorneys. All prisoner correspondence on the subject of DNA testing (other than that which is directed to their attorneys) is referred to the court.

A dummy file is created in court and the court appoints the appropriate office to represent the defendant. This will be the defense organization that represented the defendant at the time of his or her conviction. One lawyer represents each of the three defense organizations in Los Angeles County. The district attorney's office is also notified. Los Angeles has several attorneys who are versed in DNA issues and evidence who will review the requests.

The defense attorney reviews the available documentation (often securing police reports and case information from the district attorney's file if the defense file is no longer available). The defense attorney determines whether the facts of the case make it an appropriate case for DNA testing. With the cooperation of local law enforcement and the crime labs, the defense attorney also determines whether evidence still exists which can be tested.

Only if the appointed defense attorney determines that evidence exists and the facts of the case support a valid request is a motion to test or retest the evidence filed. In most cases, the district attorney will already have reviewed the case file if notified informally by the defense. The district attorney will then respond to the formal motion, either conceding that the evidence is relevant and should be tested, or opposing the testing of evidence on the grounds that a test will not be probative of the defendant's guilt or innocence.

The court, of course, ultimately decides whether or not to grant the defendant's motion to test the evidence. If the evidence was previously tested using only conventional serology, DNA testing represents a significant leap forward, especially in sexual assaults or homicides with a sexual component.

A critical issue is whether the chain of custody of the evidence in question has been properly maintained. Even in cases that appear to have strong evidence of guilt, the district attorney may concede that the evidence should be tested if it appears relevant and has not been tampered

with. Prosecutors should help facilitate post-conviction DNA testing when the interests of justice will be served. Eyewitnesses may be mistaken, but the double helix does not lie.

Conviction, Ethics, DNA

E5 Sexual Dangerousness: Unraveling the Legal, Clinical, and Policy Dilemma

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This paper will review the legal history of sexual offender laws, and take a first look at this new generation of hotly contested research. Out of this analysis will come an understanding of contemporary sexual offender law and treatment, as well as a perspective from which emerging and policies can be viewed, and standards for admissible evidence and testimony established.

Each year in America, approximately one million children, teenagers, and adults are victims of sexual assault. By any standard, this is a condition of grave scope; having not only physical consequences, but far-ranging psychological and social impacts. Any purely medical disease with such an incidence rapidly earns recognition as a public health threat generating a corresponding level of funding and research. Sexually offenses, however, are not as simple as other health and safety issues. The reasons for this distinction, moreover, place sexual crime and abuse at the very heart of legal and psychophysical controversy and fundamentally challenge the knowledgebase and traditions of forensic science and evidence law.

Sexual encounters, by their nature, tend to occur away from the presence of witnesses. Therefore, any understanding of the facts must rely upon physical evidence that may be subject to multiple interpretations, and upon accounts of the involved parties that may be influenced by self-interest and complex counter-intuitive agendas. The experiences of past few decades — during which society, science, and the law have shifted in this reliance upon the accounts of one gender or the other — have demonstrated the dangers and limitations of first-party testimony. Recovered (or implanted) memories, the recognition of the extent to which sexual accusations are used in divorce and custody disputes, the rise of a men's rights movement as a counter to feminism and greater insight into the dynamics of human memory have created a society wary of hasty conclusion.

On the other hand, perhaps more than at any other point in recent generations, society is sensitive of the pervasive damage of victimization. We demand justice, and have little tolerance for politicians or experts who appear to stand in its way. This has placed particular pressures on alleged perpetrators of sexual crimes. On one hand, their actions are often the height of heinous exploitation. On the other, there is now an acceptance that sexual dangerousness is part of a unique category of transgression. While the public understands that crime can be committed out of greed or anger or even lust, we have come to view sexual dangerousness as the product of *aberrant propensity*. Unlike the motives for theft and most other crimes against persons and property, where the public can identify with, if not condone the motive, sexual crimes are today attributed to a compulsion beyond common experience. Like the crimes of the violent mentally ill, the sexually dangerous offender (who may be of either gender) is *different*, and *sick*.

One problem with this characterization, while it may have varying degrees of truth from case to case, is that it further removes an accused from the realm of average human experience. If the sexual offender is not like everyone else, than the fundamental concept of American justice — that the fate of all accused should with a jury of their peers — becomes at least one step less applicable. As this happens, the fate of those accused of being sexually dangerous begins to shift from the judgment of lay peers to the province of specialized experts. Similarly, rights to due process and freedom from preventative detention are more easily justified and

rationalized. Basic constitutional rights and liberties, that we fight to preserve for both the good and bad among us, are easily compromised for the sick and the mad for whom we attribute our deprivation of rights to a compassionate guarantee of treatment protection and care.

The history of 20th Century American mental health practices demonstrates both the dangers of this approach and the limitations of its alternatives. Nevertheless, while the traditional mental health professions seem now to be emerging from their struggle with these competing forces, and working toward a broader range of services and balance of interests, the sexually dangerous offender has recently become the focus of a new debate in which similar issues are being confronted in a somewhat different context.

This Panel will examine the unique challenge of the sexually dangerous offender. Always a problem for justice administration, and a population with which traditional mental health professionals have had limited success, sex offenders have been subject to diverse philosophies and policy experiments. During the middle of the 20th Century, “sexual psychopath” laws prescribed indefinite hospitalization and treatment. As this evolved largely into permanent incarceration with few if any “cures,” activists on both sides of the prison wall joined the political forces of the Sixties and Seventies and spawned a return to “determinate sentencing.” By the late Eighties, however, public concern over sexual victimization was mounting and became focused on “sexual predator” laws that were passed in a number of states. In 1997, the U.S. Supreme Court upheld the concept of these laws in *Kansas vs. Hendricks*. Since that decision, most states have debated similar legislation, and more than a dozen have passed bills and instituted programs that are only now producing the data necessary to evaluate their effectiveness and consequences.

This paper will review the legal history of sexual offender laws, and take a first look at this new generation of hotly contested research. Out of this analysis will come an understanding of contemporary sexual offender law and treatment as well as a perspective from which emerging and policies can be viewed standards for admissible evidence and testimony established.

Sexual Dangerousness, Victimization, Mental Health Treatment

E6 Punishment, Protection, and Rehabilitation: The Role of a Prosecutor in Dealing With Sexually Dangerous Offenders

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The goals of this research project are to show the myriad of challenges for the prosecutor as he/she deals with the sexually dangerous offenders.

The role of a prosecutor in dealing with sexually dangerous and violent offenders poses a myriad of challenges. On the one hand, there is a duty owed to the victim to fashion some sort of punishment relative to the devastation exacted upon him/her. There is also a duty to the community to ensure a sense of safety by sending a message that this abhorrent behavior and violation of our society will not be tolerated. Along with the duties to the victim and citizens is the duty to form sentences and create solutions that will protect society and somehow deter or prevent the violent intrusions from increasing in number. The desired goal is to fashion our punishment so as to deter and ultimately decrease the incidence of sexual assault. Finally, while keeping in mind that victims and often citizens don't understand why, there is a need to look at the future of the offender. Are rehabilitation and re-entry into society as a productive citizen realistic or obtainable, and should they concern prosecutors?

Looking first to the issue of punishment, a prosecutor must have the experience as well as the investigative tools to allow the cases to be viewed from the perspective of the injury, both physically and psychologically to the victim, and to weigh all against the quality of the evidence

present in each case. While many sexual assault cases may ultimately have to be tried regardless of the quality of the evidence, one has to be able to reasonably assess the evidentiary problems that will be encountered. That information is also critical in order to have frank discussions with the victim regarding the advisability of trial versus plea and in preparing the victim for the almost certain re-victimization at trial. One thing to be considered in this regard is some system that allows the prosecutor to become involved as early as possible in the process. Involvement from the beginning gives a prosecutor a better understanding of the case and a consistent relationship with the victim. It can also assist in shoring up evidentiary issues for trial. All of the foregoing is necessary information for the formulation of appropriate punishment. Further, while punishment may be foremost in the mind of the victim, both protection and rehabilitation also play a role and must be considered prior to plea recommendation. Finally, in many states, prosecutors have little leeway in structuring sentences in sexual assault cases due to mandatory sentencing. Is that fair to the victim or the offender?

Protection is an equal concern for prosecutors and requires not only a thorough understanding of the circumstances leading to a pending charge, but also a view into the criminal history and an evaluation of the psyche of the perpetrator. Was the assault a result of drugs, alcohol, or financial factors? Do the victim and perpetrator know each other? Is there an ongoing relationship? What is the nature of the relationship? Are there prior acts of violence either with this victim or other victims? Is there an escalation of criminal conduct? How can we insure that the acts don't repeat? While also a consideration in rehabilitation, one must look at avenues available to ensure protection of future victims. How long does the perpetrator need to be incarcerated? When released, will the perpetrator honor instructions imposed by the Court? Do sex offender registries work? Are sexual offender DNA databases effective? Who should be required to contribute to the databases?

Finally, is rehabilitation a legitimate prosecution issue? Arguably, no, on its face; however, it is necessary especially when considering the protection component. While many would advocate no probation or alternative sentencing or punishment, the reality of the jail space availability, the quality of evidence, and risks involved with jury verdicts necessitate the utilization of punishment along with or other than incarceration. Understanding this, one must look to the ability to rehabilitate in both punishment and protection areas. Aside from incarceration, there is no better protection for the victim or society than to alleviate the problem. To address the issue, there must first be an objective evaluation to determine whether rehabilitation and treatment are viable options with a particular offender. If so, how much court involvement should there be and who should bear the costs, especially of an indigent offender? Where does society's desire to protect and rehabilitate cross with the prohibitive costs?

In reviewing these three issues, one must balance justice to the victim with the realities of our legal system and the protection of all.

Sexual Dangerousness, Victimization, Criminal Prosecution

E7 Sexually Dangerous Persons: Registration and Community Notification Requirements for Juveniles Deemed as "Sexually Dangerous"

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This paper will discuss the impact of state laws that subject juvenile sexual offenders to registration and community notification requirements.

Subjecting juveniles adjudicated as sexual offenders to registration and community notification requirements similar to those of adult offenders is counterproductive to the best interests of society on a local and national level. While the intent of such legal initiatives was to better protect communities from re-victimization from sexual predators, the results have been just the opposite. Communities are not any safer. If

anything, a new societal class of outcasts has been created with a corresponding increase in the incidents of violence and harassment not only to the registered offender, but also to their families and innocent others.

Over the past few years, several states have incorporated the Adult Registration and Notification provisions of their laws that were applicable only to adult offenders into their juvenile provisions. Numerous other states are in the process of doing the same. Adjudicated adult sexual offenders are classified into categories of "dangerousness" based on a judge's determination (following a hearing in which the offender can contest the classification). If adjudicated as "dangerous," offenders must register with their local police agency while supplying that agency with pictures, fingerprints, addresses, DNA, and so on. Those states that are applying these adult provisions to juveniles have added a new twist. Juveniles are automatically classified without a hearing based upon the crime they were adjudicated for. Depending on the particular state, juvenile offenders subjected to these provisions range from 12 years to 17 years of age.

Certain offenders, depending on their "dangerousness" classification or the crime they were adjudicated for, are also subject to community notification. This involves having their personal information distributed to neighbors, schools and other interested parties. Unfortunately, when "A Registered Sex Offender Lives Here" sign is posted on someone's house, a distinction is not made as to the seriousness of the offense the person committed. Persons convicted of indecent exposure or solicitation can be subjected to the same treatment by neighbors as the violent rapist.

Proponents of this type of legislation argue that communities can better protect themselves from further victimization by being on the look-out for dangerous sex offenders. This theory is premised on the belief that sex offenders are "incurable," have "uncontrollable urges" and high rates of re-offending. Further, proponents believe that violent juvenile crime is escalating out-of-control and community notification is one of the best weapons in curbing crime. The evidence indicates, however, that all of these premises are unfounded.

First, notification does not protect society or communities. Most sexual offenses are committed by a relative, family friend, or known acquaintance — not by a stranger or neighbor (U.S. Department of Health and Human Services, *Child Maltreatment 1998: Reports From the States to the National Child Abuse and Neglect Data System*). There is no research to show that Community Notification has decreased the number of cases of sexual abuse nor served as a deterrent to new sex crimes. On the contrary, there have been reports of otherwise law-abiding citizens committing crimes against registered offenders and others. Offenders and persons mistakenly thought to be offenders have been physically assaulted and verbally harassed. There have been several cases of arson with homes being fire-bombed because neighbors were incorrectly notified that a sex offender lived in a particular house.

Secondly, recidivism rates of convicted sex offenders in relationship to committing a new sex crime are among the lowest in all classifications of crime (U.S. Dept. of Justice, *Bureau of Justice Statistics* showing a 7.7% rate; Ohio Department of Rehabilitation and Correction, *The Five Year Recidivism Follow-up of 1989 Sex Offender Releases* showing a 5.3% rate; Hanson and Bussiere (1998) *Review of 61 follow-up studies* found the average rate of 13.48% from a group of 23,393 offenders). The press, interest groups, and politicians have misquoted the official statistics to perpetrate the myth that large percentages of sex offenders are released and commit a new crime. Most violations of parole are "TPV's", Technical Parole Violations. TPV's are a determination that a released offender violated a term of parole such as not attending a Sex Offender Treatment Class, arriving home after his curfew, or consuming an alcoholic beverage. TPV's are what causes the "recidivism" rate to be near the highest for sex offenders, not for new crimes. What the statistics indicate is that paroled sex offenders are targeted for violation on technical reasons rather than re-offending.

Third, a majority of sexual offenders can be effectively treated so as not to re-offend (Dr. Fred Berlin, John Hopkins, 1999, 2000). The Five-Year Ohio Follow-up Study also showed that those offenders who

completed a Sex Offender Treatment Class had a 50% less rate of committing a new crime (6.3% versus 13.1%). It would appear hypocritical that the proponents of Registration and Notification advocate that offenders are “incurable” yet insist on provisions compelling offenders to complete Sex Offender Treatment programs.

A major question that must be answered is whether society wants to “write-off” the 90%+ of the youthful sex offenders who will not commit a new sex offense. Once branded as a “Sex Offender,” a juvenile has limited or restricted educational and employment opportunities. Harassment from members in the community and peers only further alienates offenders from the main-stream of society and drives them into other anti-social behaviors.

From the Puritan days through the McCarthy era, labeling of people, holding them to public ridicule, and subjecting them to community harassment are non-effective and detrimental to society in general. Registration and community notification for adult offenders have not worked in protecting society from new sex crimes. Registration and community notification for juvenile offenders won’t either.

Sexual Dangerousness, Offender Registration, Juvenile Offenders

E8 The Effectiveness of Victim Assistance Programs for Female Sexual Assault Victims

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The problems relating to sexual assault are diverse and multi-variant. Society has sought to strike a balance between the rights of the accused and the rights of victims. The goal of this study is a critical literature review and analysis regarding the effectiveness of victim assistance programs in assisting female victims of sexual crimes. In recent years, there has been a decline in violent crime rates in the United States. Despite this overall drop in crime, sexual assaults remain on the rise. Rape continues to be the most underreported crime in the United States.

Shame over the sexual nature of the crime and fear of the aftermath of reporting a rape are among the most common factors which cause female victims of sexual crimes to be reluctant to report what has happened to them. Data obtained from the National Crime Victimization Survey and the Uniform Crime Reporting Program indicate that women are more likely to be victimized by someone they know than by a stranger. Acquaintance with an attacker is another prime reason victims do not report sexual crimes.

Reforms have been slow in coming but since the 1970’s numerous laws have been enacted to protect rape and abuse victims in court. Significant reforms in the treatment of sexual assault victims have been achieved in the legal medical, mental health, and victim services arenas. In conjunction with these changes, victim assistance programs have gained acceptance in many court systems throughout the country. This paper will report original research on the nature and effectiveness of government programs designed to assist victims of violent sexual crimes.

Through victim assistance programs, victims are provided advocates to assist them through complex law enforcement investigations, legal proceedings, and administrative procedures necessary to receive aid. Medical, psychological, and financial assistance is now available to victims from numerous federal and state sources. Early intervention often results in increased cooperation by the victim in the investigation and prosecution of the crimes committed against them. Research indicates that victims are benefiting from these programs. However, there are still issues to be addressed.

Implementation of many victim programs has been so recent that it is too early to determine their long term effectiveness. Problems exist in the continuity of victim services available from one jurisdiction to another. In some instances, assistance is available but information about these programs is not reaching those it is intended to assist. Their use within the

law enforcement community is not uniform. Providing victim assistance at the time when law enforcement officers have initial contact with the victim is a crucial intervention point for these programs. Integration of victim programs within the law enforcement community remains a challenge.

Research indicates that early intervention by victim advocates can enhance the outcome of the investigation and prosecution of sexual offenses. These programs are providing the means necessary to allow victims to play an active role in their cases and to deal with their circumstances. Surveys conducted by the National Crime Victimization Survey indicate that victims are finding victim services to be a powerful tool in recovering from their ordeals. Victim assistance programs can also serve as an important tool for law enforcement and prosecutors alike when they are available and utilized. Increased integration and support of these programs by the law enforcement community is the key to early intervention for victims and the continued success of victim programs.

Sexual Dangerousness, Victim Assistance Programs, Intervention and Treatment Program

E9 Psychopathy as a Taxon: Sex Offender Treatment and Legal Implications

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Those who attend this presentation will acquire an understanding of psychopathy as a taxon, treatment issues related to psychopathic sex offenders, and legal implications related to civil commitment of predatory sex offenders, specifically child molesters, incest offenders, and rapists.

Psychopathy is relevant as a taxon for understanding predatory sex offenders. Although psychopathy is commonly associated with violent criminal behavior, it is also evident in non-violent offenders. As a taxon, it has unique characteristics and is a separate species, independent from the broad criteria of its complement, the antisocial personality disorder described in the DSM IV. The U.S. Supreme Court has ruled that indeterminate civil commitment must be for the purposes of treatment. This poses a problem. Psychopathic sex offenders are resistant to treatment.

The standard for the diagnosis of psychopathy was ill defined until the early 1980’s. This was reflected by the different ways it has been described. Psychopaths have been described as “bad seeds,” “morally insane,” and “sociopathic.” Robert Hare, Ph.D, clarified the standard for diagnosis in the early 1980’s with the development of the Psychopathy Checklist. Through continued research, this became the Psychopathy Checklist– Revised (PCL-R) which is currently used. This instrument uses a 40-point scale to assess two distinct but correlated factors. Factor 1 includes traits such as lack of remorse or empathy, shallow effect, selfishness, and callous use of others. Factor 2 includes early and chronic behavioral problems, criminal history starting in childhood, unstable lifestyle, and lack of long- term goals. The diagnostic criteria for psychopathy on the PCL-R, is conservatively, 30 points according to Hare. However, research criteria for the diagnosis is in the low-to mid-20’s. Using 30 as a cut off score, 3 percent of child molesters, 3 percent of incest offenders, and 10 percent of rapists are psychopathic (Seto & Barbaree, 1999). Compared to non-psychopathic sex offenders, psychopathic sex offenders have the highest rate for recidivism for a new sex offense and the poorest response to treatment.

A taxon in abnormal psychology is a non-arbitrary class or entity, a distinct disorder. Unique characteristics differentiate a taxon in important areas; etiology that includes genetic determinants and environmental influences, unique behavior, and a characteristic response to treatment. An example is schizotypy and its complement, schizophrenia. Using rigorous taxometric analysis, researchers have found schizotypy to be a taxon that exists independently from schizophrenia (Golden & Meehl, 1979). The

same analysis for psychopathy has shown that it exists as a separate taxon from the antisocial personality disorder (Harris, Rice, & Quinsey, 1994).

Etiology of psychopathy is premised upon both genetic (heritability) and environmental influences. Multigenerational studies in three areas families, twins, and adoption, provide data on the percentage of criminal behavior that is inherited in comparison to that which results from the environment. Data summarized from studies of separated twins, suggest the proportion of heritability for multiple property crimes is about 60 percent (Mealey, 1995). The influence of the environment on criminal behavior is also illustrated in adoption studies. A greater risk of criminal behavior exists when a child of a criminal parent is adopted by a parent who is criminal or otherwise behaviorally disturbed (Mealey, supra).

Traits associated with poor control of behavior endure over time. Related to etiology are sample observations of children followed from 3 to 18 years of age. Traits related to poor control of behavior included emotional lability, restlessness, inattentiveness, impulsivity, and irritability. These traits were observed at age 3, confirmed by reports from parents at ages 13 and 15, and again observed at age 18. Subjects in the sample by the age 18 were also likely to have been arrested and convicted of a crime (Henry, Caspi, Moffitt, & Silva, 1996).

Taxometric analyses also support psychopathy as a taxon. Multiple analyses of life factors associated with adulthood, such as employment, marriage, and criminal offenses, were found insufficient to detect a taxon. However, a taxon emerged when data were analyzed from childhood factors such as elementary school maladjustment (suspended or expelled), teen alcohol abuse, and childhood aggression (Harris, Rice, and Quinsey, 1994).

Psychopaths have paradoxical responses to treatment. Recidivism rates are disturbingly higher for psychopathic offenders who participated in treatment while incarcerated compared to psychopathic offenders released without treatment. Comparatively, non-psychopaths who received treatment have lower recidivism than control samples. Increased recidivism is most notable when treatment of psychopaths occurred in a therapeutic community that was peer managed, with an emphasis on group participation and self-disclosure. Because of poor treatment outcomes and concerns about security, therapeutic communities are no longer recognized as optimal treatment for offender populations. Current "best practice" in sex offender treatment is cognitive-behavioral based with emphasis on relapse prevention. However, increased recidivism rates have also been associated with sex offenders who have participated in these treatment programs.

Poor results related to group-based treatment may have several explanations. One is that group participation is central to both therapeutic communities as well as cognitive-behavior /relapse prevention programs. A common phenomenon of groups, especially treatment groups, is a persuasive sense of group identity and cohesion. Tendencies toward individuality threaten group identity and cohesion. Within groups these behaviors are met with negative reinforcement and sometimes punishment. Another explanation is that psychopaths are able to obtain freedom through their deceptive abilities. Consistently, psychopaths demonstrate convincing compliance in treatment only to revert to core psychopathic behavior after release.

Legal implications stem from restriction of liberty for an indeterminate period after a prison sentence has been served. This is a persistent legal problem for sex offender civil commitment laws. The U.S. Supreme Court in *Kansas v. Hendricks*, 521 U.S. 346 (1997), determined society's needs were best served through detainment and mandated treatment after incarceration. Currently, 16 states have enacted civil commitment laws for predatory sex offenders. Ironically, approximately 10 percent of predatory sex offenders are psychopathic and may not be treatable. Detainment to protect society is consistent with the *Hendricks* ruling. However, treatment while in detainment, unless it is effective, is contrary to the *Hendricks* ruling.

Psychopathy as a taxon is a persuasive construct. Criminal psychopaths represent a relatively small percentage of sex offenders, but

account for a high percentage of violent offenses. Utilizing unique biological, developmental, and social characteristics of a taxon is the only way to increase understanding, recognition, and treatment of criminal psychopathy. As more information becomes available about psychopathy, multiple modal treatments, including medical and psychological interventions, can be refined to address deviant thinking and behavior of criminal psychopaths. To protect society from psychopathic sex offenders who cannot be treated and who have unacceptable rates of recidivism, longer prison sentences, rather than indeterminate civil commitment, are necessary.

Taxon, Psychopathy, Predatory Sex Offender

E10 Addressing Social and Legal Issues Associated With Police-Involved Shooting Incidents Through Forensic Investigation and Shooting Scene Reconstruction

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The goals of this research project are (1) to recognize the many complex, legal, social, and forensic issues associated with all police officer involved shootings, particularly incidents involving racial factors; (2) to examine the necessary components for a comprehensive investigation and reconstruction of a shooting scene, (3) to be aware of the legal issues and successful resolution of those issues commonly associated with police-involved shootings; and, (4) to share their experiences and concerns with the expert panel and to explore options that may enhance the investigation of police-involved shootings and public confidence in the system to ensure that justice is accomplished.

The multidisciplinary session will focus on the need to restore public confidence and trust in law enforcement following the aftermath of a police involved shooting, particularly when the shooting victims are members of a minority or underprivileged class. This goal is best accomplished by ensuring a comprehensive, objective legal, and scientifically sound investigation and reconstruction of the incident.

The proper recognition, documentation, collection, and preservation of physical and pattern evidence associated with shooting scenes will be discussed. The value of this process to a scene reconstruction and the ultimate successful and just conclusion of the incident cannot be overemphasized. Many high profile, police officer involved shooting incidents are further complicated by inadequate crime scene functions. Thus, the investigation is tainted with uncertainty and the public confidence is jeopardized.

Investigation and reconstruction of shooting incidents requires adherence to basic investigative and crime scene procedures. However, there are certain components specifically associated with shooting incidents. Several major components of shooting scene reconstruction will be discussed, including trajectory determination methods, shell casing ejection patterns, gun shot residue analysis, and glass fracture analysis. In addition, examination and analysis of gun shot injuries and wound patterns are valuable to the reconstruction.

The forensics and reconstruction must be looked at in the context of a future legal proceeding. The representation of the victims of police shootings places the civil attorney in the position of a criminal prosecutor. The attorney must understand when deadly force violates a citizen's civil or constitutional rights as the law is recognized by the courts under both federal and state law. The victim's lawyer must further understand what forensic evidence is important in order to successfully either prosecute a

civil proceeding and/or initiate or aid a law enforcement agency to conduct an investigation. Sometimes the actual criminal prosecutor will be perceived to be in an inherent position of conflict with both the police agency and the victims of the shooting.

Finally, all of these essential components will be discussed in reference to several high profile, racially charged, police office involved incidents of racial profiling in which the expert panel was significantly involved. Critique of these cases and the effect on public perceptions and confidences will be discussed in order to explore and develop strategies and philosophies to reduce the potential of future problems and shortcomings.

Police Shooting, Deadly Force, Racial Profiling

E11 A Death In or After Police Custody: The Exhumation of Carl E. Williams, Sr.— A Team Presentation

James E. Starrs, LL.M, Professor of Forensic Science and Law, The George Washington University, Washington, DC*

This paper will explain the necessities for conducting an exhumation, with Pennsylvania as the site, and will assess the utility of an exhumation and re-autopsy thirty-six years after burial.

On Tuesday, November 9, 1965, Carl E. Williams, Sr., a 38 year old Afro-American, left his York, Pennsylvania home and, according to all reports, never returned. He was found dead in a field with an adjoining baseball field in York two days later with a police blackjack lying near his body. Although the York police at first denied any involvement in the disappearance or death of Carl E. Williams, Sr., it was shortly learned that two police officers admitted to having picked up Williams on the evening of November 9, 1965 for being drunk and disorderly. Although at first these police officers made no record of this arrest, they later received police discipline for not doing so as well as for taking Williams to the York Armory, allegedly at his request, and leaving him there in his drunk and disorderly condition. The York Armory is adjacent to the athletic field where Williams was found dead two days later.

Subsequently, a York police officer claimed ownership of the blackjack found near Williams' body. This police officer explained that he had accidentally left the blackjack behind after using it to play fetch and carry with his retriever dog at the athletic field. His explanation for its presence next to Williams body indicated that it had no connection with Williams' death.

A postmortem was performed on Williams' body by a clinical pathologist at the York City Hospital. The record of that postmortem has been destroyed as a matter of course at the hospital. Following the postmortem, an inquest was held by the local Coroner at which hearing testimony was received. The inquest found Williams' death to have been caused by "myocardial failure" due to "massive myocardial infarction" with an associated "old myocardial infarction;" all findings corresponded to those given on Williams' death certificate. The records of the Inquest have since been destroyed in the regular course of the business of the Coroner's office in York, so it is said.

Dissatisfied with the investigations into their parent's death and the lack of any documentary evidence of these investigations, two of the children of Carl E. Williams, Sr. contacted this presenter for the purpose of securing an exhumation of the remains of their father and a re-autopsy of them. It was stated that Williams had been embalmed and buried at the Lebanon Cemetery in York, Pennsylvania but the funeral home preparing the body for burial has ceased doing business, eliminating the possibility of determining the nature of the preparation for and the conditions of the burial.

In addition, the Lebanon cemetery officials and the gravedigger there could not state with any degree of assurance whether Williams was buried in a vault, the construction of any such vault, the depth of the burial or the

type of coffin that would have been used to contain Williams' remains. However a personal visit to the burial place of Williams at the Lebanon Cemetery showed clear evidence of considerable soil subsidence in an east-west orientation from the plaque marking Williams' grave. The possibility, therefore, that the coffin had decayed and collapsed loomed very large.

After notarized consents were received from the surviving children, a Petition for Exhumation with accompanying legal documents was submitted to the York Orphans' Court in order to obtain a court order permitting the exhumation. The statutes of Pennsylvania and the regulations pursuant to them required that a court order be obtained in the first instance and, following the court order, a permit issued by the local Registrar. After an initial snag, the court order was duly issued but there was a delay in securing the permit for exhumation and re-interment since the permit for exhumation would only be valid for 72 hours after its issuance. Consequently, the date for the exhumation had to be cautiously and prudently selected to insure the presence of all scientists involved and the availability of a local funeral director to receive and transport the remains.

All the logistical details being in place, the exhumation occurred beginning at 8 A.M. on Sunday, July 29th, 2001 at the Lebanon Cemetery in York. A backhoe was employed to remove the top few inches of soil, whereupon the exposed soil was smoothed out in a search for the profile of disturbed soil marking a burial place. The need for care in locating the exact place of the burial arose from the proximity of adjoining graves immediately to the north and south of Williams' grave site.

After removing soil via the backhoe to a depth of about four and a half feet with probing using a metal rod not revealing the presence of a vault, the use of the backhoe was discontinued and digging proceeded by shovels until the decayed sides of the wood coffin were found. From that point on, spades, brushes and bamboo sticks were employed in what had then become an archaeological excavation rather than an exhumation. The remains were found fully defleshed, the skeletal features of the feet contained in intact socks, that being the only fabric which had survived intact.

The remains were removed bone by bone and logged in an inventory and on an anatomical chart as they were recovered and removed starting from the feet and moving upwards toward the head. The skull and portions of the chest were found to be under the partially decayed coffin lid, with the remains of the lid lying on the bones themselves. The skull was found lying on its right side with the left side (parietal and temporal regions) having collapsed into the intracranial region and the coffin lid pressing against the left side of the skull.

A modicum of pubic hair was recovered but no hair from any other part of the remains. (Williams was known to have very closely cropped head hair and no facial hair.) The few artifacts found included a pair of spectacles, at the foot end of the coffin, and a number of clothing buttons in the chest region as well as a few coffin nails and metal pins. In the search for a bag containing the organs, a search which was unsuccessful, a plastic sheet was found, apparently wrapped around the body from the pubic to the head area.

Thereafter, on Sunday, July 29, 2001, the excavated and separately bagged remains of Carl E. Williams, Sr. were removed by a funeral hearse to the York College's anthropology laboratory where they were kept under a secure locking system pending the initiation of an examination of the items recovered which was to take place on Monday, July 30th, 2001 at York College under the supervision of York College Professor John S. Levisky, Ph.D.

On Tuesday, July 31, 2001 at York College, under the medical supervision of Dr. Aronica-Pollak, a fingerprick of blood and a buccal swab was obtained from two of the children of Williams for later DNA analysis for identification purposes. Reburial in a marble-toned hard plastic vault, twenty-four inches in length, occurred at the Lebanon Cemetery at about 12 noon on Tuesday, July 31, 2001 following a religious ceremony with family and friends of Carl E. Williams, Sr. in attendance. An itemized list of bones retained for further analysis with the written consent of the family was prepared and given to Williams' family.

The examinations, by way of radiography and skeletal inspections, and the findings resulting from them will be presented by the scientific team's radiographer, Michael Calhoun, the pathologists for the team, Doctors Michael Baden and Aronica-Pollak and by the team's anthropologists Michael Warren, Ph.D and John S. Levisky, Ph.D. Dr. B.G. Brogdon will elaborate upon his follow-up analysis of the radiographs as well as his conducting CT scans and other scientific studies on the recovered and retained skull. Dr. John McDowell will discuss his analysis of the dentition of Williams and associated matters.

Exhumation, Legalities, Skeletal Examinations

E12 Natural and Anthropogenic Factors in the Preservation of Human Remains: The Carl E. Williams, Sr., Exhumation—A Case Study

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Geophysical conditions and burial circumstances are important signposts to the preservation of human remains as revealed in this case study.

The prospect of recovering skeletal material, soft tissue, or associated artifacts during exhumation of buried human remains is controlled by several interrelated factors. These include natural factors relating to the nature of the burial site itself and anthropogenic factors relating to the manner of burial. Among the natural factors are soil moisture content, soil pH, porosity and permeability of the soil, hill slope, depth to watertable, vegetation cover and the type of soil and related bedrock. Anthropogenic factors include type and extent of embalming procedure, type of clothes/wrapping, quality and construction of the casket, presence or absence of a burial vault, structural integrity of the vault, and depth of burial. Another factor of primary importance is the total elapsed time between burial (or in some cases reburial) and exhumation. Undertaking an exhumation of human remains involving other than a contemporaneous burial (i.e., length of time greater than five years between burial and exhumation) must be evaluated prior to exhumation in order to better predict the probable state of preservation of the remains. Such a prediction is needed in order to design the exhumation/excavation plan and to assess beforehand the general feasibility of the project.

Carl E. Williams, Sr. was buried in 1965 in the Lebanon Cemetery in York, Pennsylvania. Discussions with family members suggested that his was a modest funeral, that the casket was of plain wooden construction and that there likely was no enclosing burial vault. The remains were likely embalmed using standard techniques for 1965. Preliminary site mapping and soil borings suggested generally favorable conditions for preservation since the gravesite was on a well-drained, gently sloping hillside underlain by a rocky, clay-rich soil with a low soil moisture content. Although the soil at this site shows no thick weathering zones or prominent soil horizons, it is characteristic of soils produced by weathering of the underlying lower Paleozoic (Cambrian/Ordovician) metamorphic rocks. Numerous unweathered rock fragments are present in great abundance throughout the soil profile. A slight depression in the grass covered slope immediately above the presumed burial site suggested that the casket had largely disintegrated and collapsed around and upon the remains. In these circumstances, and given the 36 year burial interval, our prediction was that the remains would be largely skeletonized and that the subsequent exhumation would closely resemble an archeological/anthropological excavation.

On July 29, 2001 the Carl E. Williams, Sr. exhumation team successfully excavated Williams' remains. As predicted, no soft tissue remained; small bones, ribs and fingers, and the distal ends of the larger, more robust bones were somewhat spongy. The wooden casket had indeed collapsed and was in an advanced state of disintegration. Our preliminary site investigation had accurately predicted the location and state of the coffin as well as and most importantly the state of preservation of the human remains under consideration.

Human Remains Preservation, Carl E. Williams, Skeletal Examinations

E14 Preliminary Osteological Report on the Carl E. Williams, Sr., Scientific Re-Investigation

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This paper states the results of the osteological analysis on the skeletal remains of Carl E. Williams, Sr., emphasizing basic anthropological features as well as the evidence, or lack thereof, of antemortem, perimortem and postmortem trauma on the preserved skeletal remains.

The remains were exhumed from a marked grave of normal depth. There was no burial vault present, but remnants of a wooden casket containing several mortuary artifacts were identified during exhumation. The remains were completely skeletonized and devoid of the odor of decomposition, consistent with a time since death of many years. In general, the skeleton was well preserved; however, bones that were in close proximity with the coffin wood were degraded and many displayed typical "coffin-wear." All of the skeletal elements had been stained the color of the surrounding soil. Several elements had completely degraded and were not recovered, particularly the distal and intermediate phalanges of the hands and feet including all elements of the right hand and wrist. Of particular forensic importance was the absence of the hyoid. After analysis, using standard osteological methods, it was determined that the remains were those of a black male who was 35 to 45 years of age at the time of his death. His living stature was approximately 5'8. He possessed a relatively robust skeleton free from significant pathology or nutritional stress. No history of significant antemortem trauma is recorded in his skeletal remains with the exception of a minor fracture of the nasal bones. This biological profile was found to be consistent with the demographic data for Carl E. Williams, Sr., a black male who was approximately 5'8" inches tall and 38 years of age at the time of his death. Postmortem damage to the skeleton complicated trauma analysis and precludes a definitive statement pending further examination of several retained specimens. Additional analyses will attempt to rule out trauma to the left side of the chest, the left side of the cranium, and the cervical region of the spinal column. The remains exhibited very little age-related pathology and no evidence of significant pathology that might have contributed to his death. Individualizing traits or anomalies were noted in the vertebral column, particularly with respect to the number of cervical and lumbar vertebrae. The dentition showed a common pattern of postmortem tooth loss and antemortem dental pathology; however, no antemortem medical or dental records exist. The team's forensic odontologist will submit a dental analysis. Due to the relatively brief period between exhumation and re-burial, the following elements were retained for further anthropological analysis; the conclusions to be reported with the presentation of this paper:

The cranium and mandible were retained for re-radiography and microscopy to rule out perimortem fractures and sharp-force trauma. Further examination of the mandible will attempt to identify scalpel marks indicating removal of a neck organ block during autopsy. The cervical vertebrae and thoracic vertebrae numbers 1 and 2 were also retained for re-radiography and microscopy to rule out blunt force or sharp force trauma. Additionally, the severely degraded left ribs were retained to confirm exact inventory and rule out patterned injury and/or sharp force trauma via microscopy. Finally, all elements recovered of the left hand were retained to rule out defensive wounds and/or sharp force trauma via microscopy.

Anthropology, Osteology, Skeletal Trauma

E15 A Radiologist's View of Craniofacial and Mandibular Remains From the Carl E. Williams Exhumation

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This presentation illustrates the radiological examination and analysis of selected skeletal remains for evidence of trauma.

The historical events leading to the exhumation of partial remains presumed to be those of Carl E. Williams have been described above. Experts in several disciplines distributed portions of those remains for evaluation. Only fragments of the skull and mandible were provided for radiological evaluation.

The skull was divided into two major parts by the craniotomy done at autopsy. This produced a large skull-cap or cranial vault and another large fragment composed of the maxillo-facial area, the anterior, middle and posterior fossae, the base of the skull, the sella tursica and most of the temporal bones. There were two relatively large fragments from the squamous portion of one or both temporal bones, a few small flakes of bone of uncertain origin, and the mandible in two fragments.

The skull was reconstructed insofar as possible. Exact matching of fragments was impossible, apparently due to uneven shrinkage of fragments. The mandible was reconstructed easily but the mandibular condyles could not be fitted into their counterpart glenoid (mandibular) fossae in the temporal bones. Is this, again, related to shrinkage rates or to commingling? No attempt to force a fit was made for fear of producing a total separation of the mental symphysis or an additional fracture of a mandibular ramus.

Standard radiographic positioning was used to produce frontal (Caldwell's view), lateral and oblique basal (Towne's view) of the skull. Direct frontal and oblique views of the mandible were obtained. Finally, computed tomography (CT) of the skull in the axial plane was undertaken.

Visual inspection, conventional radiographs and computed tomography (CT) studies revealed the following findings with assumed pertinence to the problem at hand:

1. The overall configuration of the skull and facial bones shows male characteristics with mixed Caucasoid and Negroid features;
2. Fragmentation of the squamous portions of the temporal bones along sutural lines above the craniotomy cut;
3. Absence of the middle one-half of the zygomatic arch on the right;
4. Absence of the entire zygomatic arch on the left including a portion of the malar eminence;
5. Fracture of the angle of the mandible on the left through the socket of the third molar;
6. Diastasis or slight separation of the mental symphysis of the mandible without total separation; and
7. There may be an old healed nasal fracture.

These observations will be illustrated and discussed with respect to the possibilities of ante-, intra-, or postmortem occurrence on the basis of location, appearance and patterns of injury.

Radiology, Skull and Facial Bones, Trauma and CT

E16 The Value of Exhumation in Police Brutality Cases

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Many times allegations of police brutality arise after autopsy and after burial. The changes in the body after death as identified after exhumation will be distinguished from the injuries incurred during life and will be illustrated photographically and correlated with the postmortem X-ray findings. The value of these findings in evaluating the reliability of differing eyewitness accounts will be discussed.

Forensic Pathology, Exhumation, Excessive Force

E18 Digital Discovery in STR/DNA Cases

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Attendees will learn about the methods forensic laboratories use to record and retrieve digital data in STR/DNA cases, the need to preserve and produce such evidence in the discovery process, how to accomplish this through court proceedings, and new court rules, such as Rule 417 in Illinois, and how such evidence is used in case evaluation and litigation.

Discovery is a critical aspect of criminal practice, especially in cases involving scientific or other expert testimony and evidence, such as DNA. Full discovery is essential to evaluate evidence and to properly prepare for both the introduction of such evidence and for cross examination of an expert witness. DNA is but one form of scientific evidence, subject to the same concerns as many other types of evidence. Almost thirty years ago, Professor Friedenthal explained the need for expert witness discovery: "It is fundamental that opportunity be had for full cross-examination, and this cannot be done properly in many cases without resort to pretrial discovery, particularly when expert witnesses are involved . . . (Experts) may rely on entirely separate data . . . Before an attorney can even hope to deal on cross-examination with an unfavorable expert opinion, he must have some idea of the bases of that opinion and the data relied upon . . . The need for pretrial discovery regarding expert witnesses is further evidenced by the ever-increasing dissatisfaction with the honesty and reliability of expert testimony." Friedenthal, "Discovery and Use of an Adverse Party's Expert Information," 14 Stan. L. Rev. 455, 485 (1962 (emphasis added)). Courts must have access to complete scientific discovery if they are to fulfill their role of assuring that evidence introduced at trial is reliable. Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579, 589, 125 L. Ed. 2d 469, 113 S. Ct. 2786.

Forensic DNA evidence has become more commonly used as an identification tool. In part, this is because new automated analytical systems allow laboratories to test more samples, faster, and at a reduced cost. As this technology marches into the courtroom, will the lawyers keep pace? Most DNA casework today uses Short Tandem Repeat—or "STR" technology. In an STR case, you can see a visualization of the alleles found at each locus presented on a graph, called an electropherogram. While determining a profile from a single source may seem relatively straightforward, things become much more complex when a mixture of profiles is found.

Counsel should always make a specific written request for forensic test results and for exculpatory information before trial. Concealing exculpatory laboratory results violates the dictates of *Brady v. Maryland*. Indeed, the American Society of Crime Lab Directors recognizes that in the event of "the release of erroneous, misleading or incomplete results . . . the result may be a miscarriage of justice." (ASCLD Guidelines For Forensic Laboratory Management Practices, III. Responsibilities to the Public Interest. H. Quality of Work Product.) ("ASCLD Guidelines.") Counsel's ability to assess DNA evidence will depend on his or her ability to get access to all the data in the case. Since most of the actual analysis is done by a computer using specialized programs, it is imperative that counsel get not only all the "hard" data such as copies of the electropherograms, tabular data, typing sheets, phone logs, and chain of custody history, but also the electronic data as well. In most cases, these are the GeneScan and GenoTyper files, especially the GeneScan project files.

This is not always easy. Some labs destroy such data. This is fundamentally wrong as a matter of science and law. Illinois, for instance, now specifically requires production of electronic data. (Illinois Supreme Court Rule 417.) Such data are now provided as a matter of course, on CD ROMs, which cost a few dollars at most. In addition, laboratories should be aware that justification for the preservation and production of electronic data can be found in the "DNA Advisory Board Quality Assurance Standards For Forensic DNA Testing Laboratories." ("DAB.") According to these standards, followed by most government labs, the "laboratory

shall maintain, in a case record, all documentation generated by examiners related to case analyses.” DAB Standard 11.1.1. This should cover electronic data.

Federal Rule 16 of the Federal Rules of Criminal Procedure, local rules, such as Illinois Rule 412, provide for the disclosure of materials and information within the State’s possession. This includes test results. (134 Ill. 2d R. 412(a)(iv).) Sanctions may also be at issue when digital data goes missing. Illinois, Rule 415(g), for instance, provides for sanctions for missing discovery.

Materiality and not simplicity or standardization should be the guidepost. For instance, Federal Rule 16 of the Federal Rules of Criminal Procedure requires the disclosure of reports of medical and physical examinations, scientific tests, experiments, documents and tangible objects, if they are material to defense preparation or if they are intended for use at trial. This is a factual determination of what is material to be made on a case-by-case basis. While it may be rare that counsel needs information beyond what is noted in the specific language of a rule, such material information, which might be essential to the truth-finding process, should not be barred in the interest of simplicity for laboratory personnel.

A rule-limiting discovery to specifically noted materials has its drawbacks in this or any technical area. Flexibility is essential. What is material or sufficient has and will continue to evolve. The specific techniques and terminology may change tomorrow. Indeed, while “autoradiographs” were common a few years ago, soon they will be essentially obsolete.

Once digital data are obtained by counsel, they can be analyzed by counsel’s own expert, and, if counsel obtains the correct software and training, to some degree, by counsel. Indeed, if issues arise concerning the digital data or their interpretation, counsel could then, present the issue to the judge or jury directly, by running the software and data in court with a projector. This will be demonstrated during the presentation.

STR, DNA, Digital Information

E19 Preserving Evidence for Forensic Testing

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Attendees will learn about the new trend to require the preservation of evidence for forensic testing. This will include a review of what kinds of material are being preserved, including evidence for DNA testing, digital data, and records, the need to preserve and produce such evidence under the direction of the courts, how to accomplish this through court proceedings, and new statutory or court rules, such as the new statute in Illinois, and how such evidence has been used in litigation.

Illinois Gov. Ryan signed the first legislation in 2000, and revisions in 2001, requiring law enforcement agencies to preserve evidence, including DNA and fingerprint evidence for testing. The new Illinois law comes on the heels of the reversal of a number of convictions in Illinois and elsewhere. Scores of innocent men have been released from prison when DNA testing proved their innocence. In some cases, testing has caught the true perpetrator. In 1997, Illinois became the second state to pass a post-trial forensic testing law. Without evidence, however, there can be no testing. The truth will remain obscured. Yet, according to the Innocence Project, almost seventy percent of their post trial DNA cases cannot go forward because the evidence has been destroyed.

Under old policies, evidence was often maintained on an ad hoc basis. If space was available, it was retained. If not, or if the agency or custodian was inclined, the evidence might be discarded. In addition, courts looked to the vagaries of the “Youngblood” standard, to decide after the fact if evidence was wrongfully destroyed. Ironically, Mr. Youngblood, whose evidence had apparently been discarded, languished in prison for years after that Supreme Court decision. He was exonerated in 2000,

when a minute sample was finally found and subjected to DNA analysis. Under the new trend, a bright line is set giving agencies, litigants, and the public notice about standards for retaining evidence, founded on the judgments and priorities set by the legislature.

These issues formed the backdrop for Illinois’ new law to preserve evidence. With the benefits of this new technology at hand, policy makers decided to assure we must take steps to use it, and make sure the evidence is not destroyed through careless or malicious acts. This is why Illinois set forth guidelines for handling physical evidence in this new era of DNA testing. This effort is clearly the trend. California and Texas have recently followed suit. Legislation proposing federal standards and funds for preserving evidence has been introduced in the United States Senate and in the House. Representative Ray LaHood (R) of Illinois and Senator Patrick Leahy (D) of Vermont sponsored the latter bill.

The statutory right to test evidence necessarily entails a right to have that evidence maintained for forensic testing, and to have the documents necessary to find such evidence preserved. Illinois’ law aims to ensure testing is possible before and after trial, in serious cases. It requires law enforcement agencies and State’s Attorneys’ Offices to preserve, subject to a continuous chain of custody, physical evidence secured in relation to a trial and to maintain sufficient official documentation to locate such evidence. In Illinois, guidelines are set for how long evidence must be retained. Requests for destruction of evidence must be in court, on the record, making parties publicly accountable. The testing or re-testing of evidence may be done by the defense or the prosecution, both before or after trial. While some offenders have been exonerated before or after trial because evidence has been preserved, the police have also solved many “Cold Cases” by testing old evidence, which has been preserved. Beyond DNA and fingerprint evidence, other kinds of evidence might provide useful information, including the use of “IBIS” to search for firearms similarities to find out if a gun was used in another crime, or tied to another offender, pathology specimens for cause of death issues, poisonings, etc., toxicology and drug issues.

Preserving Evidence, DNA, Fingerprints

E20 The Educational Role of the Forensic Science Laboratory Director

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The goal of this research project is to explain the need for independence.

Operating a modern, public forensic science laboratory that equally satisfies the needs of the user agencies, courts, prosecution, defense and science presents a unique challenge without peer. Every stage of the criminal justice process, from assisting in the creation of criminal laws to the post-conviction phase of a criminal prosecution, requires objective input from the forensic science laboratory. The challenge to the laboratory director is maintaining this scientific integrity and objectivity in venues that by their mere nature are adversarial, whether they be the legislature or the courtroom.

But how much independence a laboratory director truly has depends greatly upon the organizational structure of the governmental unit and its placement within a state, local or federal government. In the U.S. today, the vast majority of public forensic science laboratories are organized under a local, state or federal law enforcement or public safety agency. The reason for this close association of forensic science professional investigators and prosecutors should be self evident: the effective and timely analysis of crime scene evidence requires close association and communication between the crime scene investigators, detectives, laboratory personnel, and the prosecutor. The most potentially probative and/or dispositive piece(s) of evidence must be identified, selected, and prioritized. With the ever constant obstacle of limited resources combined with increasing and uncontrolled demand for forensic evaluation,

informed decisions must be made as to which items should be first examined and by which technique or discipline. Given the unique set of circumstances presented in every case, these decisions should not be made in isolation. This is true today more so, not less so, than at any time in the past; the advent of electronic databases places laboratories much more in an investigative role than in the traditional prosecution phase.

If there is any down-side to this organizational structure within a law enforcement agency, it is that the laboratory director, if not a sworn law enforcement official him/herself, reports to one, and often to an official several levels removed from the chief of the law enforcement agency. Such a structure often places the laboratory director in a difficult position because the exercise of scientific objectivity may conflict with the interests and goals of law enforcement.

The laboratory director is ultimately responsible for assuring scientific integrity, accuracy, and impartiality throughout the process. The decisions on the order and priority of numerous and diverse examinations of evidence must be based on these same principles, despite opposing views of counsel. The language and data presented in a written report(s) or oral testimony must convey the results in a clear, concise and understandable manner without over- or understating the conclusion. Finally, through the appellate or post-conviction phases of the criminal justice system, the forensic science laboratory must be able to evaluate and/or conduct unfettered additional examinations with an independence that fosters confidence and trust in the results by all parties concerned.

Law enforcement agencies are responsible for public safety and successful criminal investigations. In pursuit of these goals, they want results, and they often want them quickly.

This potential for conflict does not require the separation of the laboratory from the agencies it serves. What is essential is that laboratory directors be provided with sufficient latitude and independence to ensure scientific integrity at all stages of the process. A first step towards this goal is the availability and willingness of the law enforcement agency, or its higher governmental authority, to listen to and understand the issues confronting the laboratory manager. Laboratory directors may need to take the initiative in this respect, and learn how to educate their law enforcement agencies on the importance of objectivism and integrity in the scientific process, and how, for example, an unassailable process contributes more to law enforcement than quick or questionable results.

Laboratory directors should understand, too, that their role may be more successfully implemented by educating the legislative bodies charged with drafting the criminal law and procedure. Whether it is a DUI bill, a drug law, creation of a DNA databank law, or a post-conviction statute, those making such decisions must be afforded the opportunity for accurate scientific input to make the bill or law technically correct and enforceable. Legislators may not appreciate the extent to which their legislation will require additional funding or staffing for a lab. More often than not, the only person who can provide this information when it is most needed is the laboratory director.

Laboratory directors must understand that their presence and voice will be increasingly important outside the laboratories for which they are responsible. They must seek to educate all participants in the criminal justice community on the nature and value of the scientific process and on the need for resources adequate for the tasks they are asked to perform.

Laboratory Director, Law Enforcement, Scientific Objectivity

E21 The Quest for Reasonable Medical Certainty

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The goals of this research project are to present a discussion of the medicolegal construction of standards of proof used in the courtroom.

In 1985 *The New York Times* in a series of articles accused the Chief Medical Examiner of New York City of cover-up in the certification of the

cause and manner of death in a number of police custody cases. *The Times* argued that the medical examiner had tainted the outcome of the investigation by refusing to certify the manner of death. He instead left the manner—undetermined. The outcome of five comprehensive investigations that followed suggested that the medical examiner's excessive conservatism and cautiousness in the certification of the deaths was "so excessive as to undermine credibility rather than enhance it." The medical examiner demanded, the report indicated, "the kind of medical certainty characteristic of an academic scientist in a field, forensic pathology, where that kind of certainty is almost unattainable."

The legal and medical professions use different language and levels of certainty for making decisions, for example, in the definition of homicide. The certification of the cause and manner of death, the primary role of the medical examiner or coroner, has profound importance for the family, insurance claims and legal proceedings. The medical examiner's judgment to determine the cause and manner of death is based, not merely on the examination of the body, but on education, experience, hearsay regarding the decedent and the circumstances of the death, medical records (not always complete), inferences and just plain intuition. The meaning of the manner of death is thus subject to wildly differing interpretations among medical and legal experts. The medical expert using a legal standard of "reasonable medical certainty" then delivers these interpretations to the jury. Just as the legal profession decries certainty, in a world of evidence-based medicine, the physician medical examiner or coroner may hold the last bastion of a subjective medical practice based on personal experience and practice.

In the highly contested adversarial American legal system, law and medicine co-construct one another during the scientist's search for truth and the lawyer's search for justice. At the center of this intersection between law and science is the issue of expert testimony and the standard of proof based on one's level of certainty. Is the medical expert's testimony to be representative of a settled consensus of opinion in the relevant community of scholars or to be simply reasoned and based on one's knowledge of the field? Although the courts have quantified the level of probability for differing standards of proof, medical experts are warned to refrain from assigning a percentage of confidence during testimony. Although authoritative consensus is what most lawyers desire, they pursue lesser standards of proof when they try individual cases. This paper will discuss the evolution of the reasonable medical certainty standard used in American courts during the twentieth century.

Reasonable Medical Certainty, Standards of Proof, Expert Testimony

E22 Identifying Digitized Handwriting

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The goals of this research project are to understand the different steps followed when conducting a handwriting examination. To be able to assess the limitations of handwriting evidence which may affect arriving at definitive conclusions. This information will assist lawyers in presenting handwriting evidence and getting the most value from such evidence.

In a recent Collaborative Testing Services, Inc. (CTS) handwriting proficiency test (Test No. 01-524), items were presented to examiners in the form of photographs of original documents. Photographs, which do not succumb to the limitations typically encountered with photocopied or digitized handwriting [1,2], are considered the best method of reproduction when originals are not available (CTS uses photos rather than originals because of the need to produce a large number of identical sample sets). However, the test items provided to examiners for this test were not conventional but rather digital photographs [3]. The original documents were

scanned using a high quality drum scanner, and the subsequent images were printed with a professional digital photographic printer. Thus, the examinations and resulting conclusions for this test were completed using photographically printed digital images.

Despite any limitations posed by such test items, over 80% of the participants arrived at the “correct” conclusion. Such inadvertent incomplete description of evidence items is not uncommon in real case scenarios, and proficiency tests should be designed to reflect such scenarios. How often has a document examiner received evidence described on the clue sheet (Request for Analysis form) as originating from a common source, only to find upon preliminary examination this was not the case. Preliminary tests are applied to all forensic evidence in the different disciplines before a forensic comparison is conducted. Such tests assess the evidence for limitations which might affect a proper forensic examination and the rendering of definitive conclusions. These tests are applied to evidence regardless of the information relayed in the clue sheet. A proficiency test should be approached no differently. Was a microscopic examination of line quality conducted on the photographs in CTS test 01-524 or was a visual examination adequate to confirm the handwriting to be naturally executed? Were the words *Digital Paper* on the reverse of the photographs adequate proof that the handwriting was digitally prepared or was a microscopic examination conducted to confirm this? How was the characteristic “stair casing” or “step and repeat” scaling in the line quality, features that in the past were considered to preclude a handwriting comparison of digital evidence, now resolved to assess natural execution and arrive at definitive conclusions?

These are some of the questions that must be answered to explain why so many participants arrived at the correct conclusion on digitized handwritten material, evidence that otherwise might not be accepted by some examiners for analysis or at the very best result in inconclusive findings. A recurring argument when examining digitized handwriting is that it is not possible to assess line quality and therefore comment on natural execution. Several works [4-10] address the limitations associated with handwriting examinations on photocopies and digitized images. Document examiners have been known to either identify photocopied

handwriting, refuse to conduct an examination until originals become available, conduct the examination but restrict conclusions to weak opinions, or conduct the examination but reserve the right to change your opinion upon receipt of original documents. Until now, there were no case studies where conclusive findings have been rendered based on a handwriting examination of digitized evidence.

The results of an open CTS handwriting proficiency test generated statistics supporting handwriting examinations of digitized evidence and arriving at definitive conclusions. The scientific examination of questioned handwriting will be presented identifying the tests used to assess evidence before the actual forensic examination is conducted. The issue of resolving line quality as it pertains to digital evidence will be discussed in regards to CTS Test 01-524.

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Digitized Handwriting, Proficiency Test, Line Quality

F1 Dental Identification in the Egypt Air Disaster

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At the completion of the presentation, the observer will understand the difficulties in recovering and identifying severely fragmented dental remains.

On Halloween evening October 31, 1999 EgyptAir flight 990 suffered an undetermined upset 30 minutes after takeoff from New York on a flight to Cairo. The upset caused a rapid descent from 33,000 feet to 19,000 feet in 36 seconds. Radar contact was lost at 19,000 feet and the aircraft impacted the Atlantic Ocean shortly thereafter. There were four flight crew, 10 attendants and 203 passengers for a total of 217 on board. The U.S. Coast Guard conducted a search and rescue mission for 35 hours. After the search and rescue mission was called off the search and recovery efforts began. There were no survivors.

The airplane was a Boeing 767 model 366 ER, a stretched and extended range version of the basic 767. Passengers were from Canada, Egypt, Germany, Sudan, Syria, United States, and Zimbabwe. Family assistance was coordinated through a task force led by the Department of State and the NTSB's Family Affairs Office, supported by the Red Cross, Disaster Mortuary Services of the Department of Health and Human Services, and Federal Emergency Management Administration for Communications.

The impact speed was close to the speed of sound which resulted in a debris field spread over a large area. The debris field was 300 feet underwater. The debris was composed of thousands of fragments. The recovery effort was challenging and was hampered by bad weather and the distance of the crash site from onshore facilities. Surface ships used a number of methods of recovering the debris. Remote controlled submergibles were used to collect the flight data recorder, cockpit voice recorder, and airframe and biological fragments.

A temporary morgue was established by DMORT in a gymnasium at Quonset Field in Rhode Island. A succession of dentists from various DMORT teams identified dental remains, radiographed the specimens, charted the dental features and entered the information into the WinID dental computer system. Antemortem records were collected by efforts of DMORT's Family Assistance Center and by the FBI. The antemortem records were studied, radiographs were digitally scanned, and information was entered into WinID.

After approximately six weeks of operation the temporary morgue was closed and an EgyptAir identification station was setup at the Rhode Island Medical Examiners facility in Providence. Elizabeth Laposada, MD of the RIME, was in charge of the identification effort.

The identification efforts used comparison of dental characteristics, fingerprint patterns, anthropological findings, medical features, and DNA to make the identifications.

This identification effort was challenging due to logistic and multicultural factors. The effort was a learning experience for all those involved.

Forensic Odontology, Mass Disasters, Computers

F2 Sella Turcica and Its Use in Body Identification

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After attending this presentation, participants will better understand the unique and relatively stable anatomy of the sella turcica as viewed on a lateral headfilm.

Positive identification of individuals after death is extremely important. Visual identification cannot always be done, but other methods can be used. Fingerprints are good, but only if post-mortem prints are obtainable and ante-mortem prints are available. Dental anatomy is extremely helpful, but only if antemortem radiographs exist and are locatable. Medical radiographs can also be utilized.

CT scans of the skull and mandible may be available. While it is not practical to perform a CT scan on an unidentified person, lateral headfilms are quite easy to take. The scout film which is taken to orient the CT scan also shows the mid-sagittal anatomic features. Sella turcica is usually evident and clearly demarcated. By comparing the antemortem CT scout film with a post-mortem lateral headfilm, a positive identification can frequently be made.

But how unusual is the morphology of sella turcica? And how does head position, during the taking of either the CT scout film or the lateral headfilm, affect the now two-dimensional presentation of this three-dimensional structure? And the age of the records, does sella turcica change shape over time, or is it a relatively stable anatomic feature? Can we really utilize a CT scout film taken years ago and compare it to a post-mortem lateral headfilm?

Sella Turcica, Lateral Cephalometric Headfilm, Scout CT Film

F3 Tooth Prints: Dentistry's Role in the Identification of Missing and Unidentified Children

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The goal of this research project is to introduce tooth prints as a reliable dental method in the identification of unknown remains in the absence of diagnostic dental records.

The disappearance and identification of missing and unknown children have received much attention in the national and local media. Dentists have historically helped in providing dental information on missing individuals when requested from law enforcement agencies and have continued to be a vital participant in the identification of unidentified human remains. Unfortunately, diagnostic dental records/radiographs are not available on all forensic examinations for comparative identification. Reasons for this increasingly common dilemma focus on the young age of the individual, length of time of non-active dental status of the person, or records which have been accidentally misplaced, or, even worse, destroyed. Because the human dentition continues to depict an individualized uniqueness, bite impressions provide a reliable method for identification purposes. This presentation introduces tooth prints as the bite impression technique in the establishment of a record of an individual's dentition at a given point in time, as well as providing a saliva sample for DNA identification.

Tooth Prints, Bite Registration, DNA

F4 Wound-Weapon Comparison of a Fatal Calvarial Injury—Using Computer Assisted Tomography

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The author will present a novel technique for matching weapons to wounds in bone using computer assisted tomography and describe the fabrication of weapon exemplars using conventional soft and hard tissue equipment materials. In addition the methods of specimen positioning and radiographic scanning will be provided in the course of the description of this case.

Computer assisted tomography (CT) has been used in medical diagnostics since the early 1970's and the mathematical principles underlying image reconstruction were first described in 1917. Since then, CT has been used routinely as a diagnostic modality in the medical sciences. The purpose of this presentation is to offer a case in which computer assisted tomography was used to assess the degree of fit of an axe butt to the skull of a deceased individual. The case involved the beating and exsanguination of a subject and was part of a multidisciplinary approach to the solution of this crime. Specific problems in the utilization of computer assisted tomography were identified and include the following:

1. suitability of the wound for the matching procedure is favored, in the case of cranial vault injuries, to those that are partially penetrating. Injuries, which grossly fracture the skull, may not be suitable for the matching procedure. Many injuries are not suitable for this procedure;
2. the fabrication of suitable exemplars for the purpose of the matching procedure is important since most weapons used are of an atomic weight which makes them unsuitable for use in the CT unit. The familiarity of the dentist with dental materials of atomic weight similar to human tissue (methyl-methacrylate, dental stone etc.) is an important aspect of this undertaking;
3. the positioning and stabilization of the exemplars in proximity to the wound is important since this may ultimately determine the quality of the resultant images; and
4. the selection of slice thickness on the CT scan is vitally important with thin slice thickness being preferred over thick ones. Excess slice thickness may result in an inability to assess the degree of fit.

In the authors' presentation, a single case will be put forward; however, illustrative material from similar cases will be included to show some of the strengths and shortcomings of the technique. The technique will be described in detail. Furthermore, a proposed method of qualifying the expert as an expert will be presented. Finally a practical method of obtaining images for evaluation by employing the services of a radiologist will be discussed.

The best chance for a meaningful assessment of the degree of fit of a wound to a weapon is gained when the weapon is stable, rigid, possesses unique or unusual features, and is well-preserved. The highest quality scans are obtained when an exemplar of said weapon is positioned adjacent to the underlying wound on the actual skull vault (as opposed to a model of one).

Computer Assisted Tomography, Radiographic Scanning, Wound-Weapon Comparison

F5 Odontological Identifications: The Profile of the Decedents

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The first objective of this presentation is to show the profile of decedents requiring odontological identification procedures in the western part of Switzerland. Its second objective is to present the results of the study; to establish links between the various parameters; discuss them; and to compare them with a similar study that was recently performed in the greater Houston, Texas area.

History has shown many examples of identifications requiring the needs of a dental examination. The first documented case of a dental identification was reported by the Roman Greek historian Dio Cassius in his *History of Rome* in which he described how Lollia Paulina was put to death on the orders of Agrippina and subsequently identified by her thanks to some characteristics of the victim's teeth. The dental remains of decomposed Charles the Bold were recognized by his page. Many other cases such as the remains of Joseph Warren, John Wilkes Booth or later, Adolf Hitler, were odontologically identified. The profile of all these decedents is that they were unrecognizable due to charring, fragmentation or/and decomposition.

Today, the need of a dental identification remains a prerequisite especially when the remains have been exposed to external factors such as heat, fragmentation, decomposition, skeletonization or a combination of these. The activity of the institute of forensic medicine of the University of Lausanne covers a population of approximately 800,000 people in the French-speaking part of Switzerland.

This retrospective study analyzes the cases requiring an odontological identification over a three-year period between 1998 and 2000. Out of a total of 1, 146 autopsies and external examinations, 65 cases required an odontological identification (6%).

Data concerning gender, age, cause of death, circumstances and conditions of the remains were collected and analyzed. 58% of the decedents needing an odontological identification were males and 42% were females. No case of gender was undetermined in this study.

The decedents were arbitrarily divided and ranked into 6 groups by age ranging between 0 and over 80. The majority of the identifications could be found in the 20 to 39 and 40 to 59 year ranges. The identity and the age of four cases could not be ascertained.

The most frequent cause of death was a traumatic lesion (32%), followed by undetermined causes (20%) and submersion (12%). Other causes of death included heat, intoxication, asphyxia, natural and unknown causes. The circumstances showed that 30% were linked with suicide, 27% with undetermined factors, 25% with accident, and, to a lesser degree, with natural death.

The conditions of the remains examined in this study could be defined as follows: decomposed 54%, charred 5%, skeletonized 3%, intact less than 2%.

The study also analyzed the environment in which the remains were found. 63% were found outside and 37% were found in the home where the deceased lived alone. The environment in which the remains were found could be associated and discussed with the different criteria of cause of death, circumstances of death, and conditions of the remains. Some of the results of this retrospective study were compared with those of a similar review analyzed in Houston, Texas by DeLattre V & Stimson PG which were presented at the AAFS Meeting in Seattle in 2001.

Parameters found to be similar in both studies included age in the 40s and 50s (Lausanne: 20%, Houston: 21%), death from gunshot wounds (Lausanne: 14%, Houston: 13%), and the percentage of decomposing remains (Lausanne: 35%, Houston: 32%).

Discrepancies were observed in parameters such as cases of homicide (Lausanne: 0%, Houston: 30%), suicide (Lausanne: 29%, Houston: 8%) and charred or incinerated remains (Lausanne: 3%, Houston: 40%).

The participant will finally learn that it was possible to study the relationships between various parameters: age and cause of death, age and circumstances of death, circumstances and conditions of the remains.

Forensic Science, Forensic Dentistry, Human Identification

F6 The Case of the Missing *Corpus Delicti*: Revisiting the Webster-Parkman Trial

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The goal of this research project is to familiarize the attendee with one of the landmark murder trials of the 19th century. This is believed to be the first American case admitting dental evidence to confirm the identification of the victim.

“Gentlemen of the jury” are reportedly the last coherent words of the Honorable Lemuel Shaw before his death in 1861. As Chief Justice of the Massachusetts Supreme Court, his (corrected account of the) charge to the jury in the Webster-Parkman murder trial has been cited through the generations as the classic definition of the requirements of circumstantial evidence.

The 1850 trial, conviction and hanging of Chemistry Professor John Webster for the murder of Dr. George Parkman in a basement laboratory of Harvard Medical College, caused an international sensation. Nearly sixty thousand spectators from throughout the country were ferried through the Boston courtroom in ten minute intervals. Journalists from as far away as Europe covered the trial with its grisly details of murder and dismemberment. Even Charles Dickens, on a visit to Boston, asked to see “the room where Dr. Parkman was murdered.”

Even by today’s sensationalistic standards the gruesome story is compelling.

Several days before Thanksgiving 1849, Dr. George Parkman, a physician and scion of one of Boston’s wealthiest families, was reported missing. Although he was last seen entering Professor Webster’s laboratory, a cursory inspection by the police revealed nothing untoward.

Dr. Parkman’s singular stride was a familiar image on Beacon Hill. The 59-year-old doctor preferred not to use a carriage, and he collected the rents from his many properties on foot. He was fond of telling the story that his only reprimand while a student at Harvard was for “excessive walking on the Sabbath.” Wealthy and eccentric, he practiced medicine, speculated in real estate and enjoyed rubbing elbows with the likes of Oliver Wendell Holmes and John James Audubon.

A week following the disappearance, Ephraim Littlefield, the janitor at the medical school discovered that human body parts had been dispersed and secreted throughout Webster’s laboratory. Following up on his suspicions, the janitor chiselled through a privy vault under the laboratory where he found a dismembered thigh and another partial leg. Further searching revealed a thorax in a tea chest and parts of a skull (with a partial denture) in the furnace. This later proved to be Professor Webster’s undoing.

First degree murder charges were brought against Webster and prosecutors proceeded without the *corpus delicti*. Accused of murdering Parkman during an argument concerning an overdue loan of \$400, Webster pleaded innocent and implicated the janitor, Littlefield. Ephraim Littlefield, who was known to supplement his income as a “resurrectionist” was experienced in the handling of cadavers. Nonetheless, his story remained unchanged and his testimony proved unshakeable.

An eleven-day trial ensued featuring some of the most prestigious names in 19th century American medicine, dentistry, and jurisprudence. Dr. Winslow Lewis, chief of the post-mortem committee, brought with him a diagram illustrating the different sections of the body found in the privy vault, the box, and the bones in the furnace. After completing his inventory he was forced to admit that he could not confirm that these were indeed Parkman’s remains. Neither Dr. Stone nor Dr. Woodbridge Strong, who testified at length about the difficulties of burning a corpse, could confirm that these were the remains of Dr. Parkman. Dr. Jeffries Wyman testified before the court with a life-size drawing of a skeleton, shaded and tinted to identify the separated and recovered parts. He too, however, was unable to positively identify the remains.

Then came the teeth, and with them, Dr. Nathan Cooley Keep. Dr. Keep, who was later appointed first Dean of the Harvard School of Dental Medicine, had recently made a partial denture for Dr. Parkman’s prognathic mandible. He had also previously provided care for Dr. Webster’s family. When shown the fused block of bone and teeth that had been removed from the furnace, he immediately identified them as Parkman’s dentures. Fabricated in sections, and connected to a gold plate by specially designed spiral springs, he testified that this was, without doubt, Dr. Parkman’s denture. Fitting of the dentures to previous casts of Dr. Parkman’s jaws was demonstrated to those in the courtroom. Pieces of Parkman were coming together.

Although Massachusetts law of the period actually forbade the defendant from taking the stand on the grounds of *potential* self-incrimination, the defense mounted a formidable proceeding. Seven citizens swore to having seen Dr. Parkman late in the afternoon, when according to the prosecution, he was already dead in the basement of the medical college. Most prominent was Dr. W.T.G. Morton, Boston’s most famous dentist, the man who had been the first in history to administer anesthetic for surgery. Dr. Morton took a directly opposite view to Dr. Keep. He saw nothing at all unique in the plate, the fused teeth and bone or the casts with which to confirm an identification. When pressed on cross-examination he stated that Parkman’s lower jaw, while peculiar, was not so unique that another’s plate might not actually fit him.

On the eleventh day, Chief Justice Lemuel Shaw gave his now famous charge to the jury. After highlighting the distinctions between murder and manslaughter he launched into the definition of circumstantial evidence. For over two and a half hours he became teacher, poet and philosopher. If that were not enough, he was also detective, including the weighing of the evidence. The *corpus delicti*, indispensable for any charge of homicide, was not proved with certainty by the pathological evidence alone *except* by the dentist’s testimony. Dr. Keep’s word was given weight; Dr. Morton’s dissent, while acknowledged, was treated very lightly.

The jury deliberations lasted only slightly longer than Justice Shaw’s charge to them. A guilty verdict was duly recorded and the sentence of death by hanging pronounced. An appeal, actually a writ of error, based entirely on technicalities was heard by none other than Judge Shaw himself.

Professor Webster maintained his innocence throughout these proceedings. Governor George Briggs, following the recommendation of the Council on Pardons, rejected a petition for clemency. Webster then confessed, claiming that he “never had the remotest idea of injuring Dr. Parkman until the moment the blow was struck.”

Herein lies the ultimate irony; Webster’s confession was strongly supportive of a temporary insanity defense. Had he told the truth at his trial he would likely have avoided the hangman’s noose. Instead he was executed on August 30, 1850.

Webster-Parkman Trial, Forensic Dentistry, Circumstantial Evidence

F7 Establishing Personal Identification Based on Patterns of Missing, Filled, and Unrestored Teeth

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The goals of this research project are to discuss the accuracy of past United States military dental charts and the utility of dental charts for establishing personal identification when radiographs are not available.

At the U.S. Army Central Identification Laboratory, Hawaii (CILHI), dental radiographs are not commonly available when performing antemortem/postmortem comparisons of individuals missing from past conflicts. Dental comparisons of antemortem and postmortem characteristics are often based on handwritten charts and notes derived from the individual's health records. While these charts are susceptible to human error (not generally a concern with radiographs), dental records that accurately document a missing individual's dental condition can be essential for establishing an identification. Obviously, records that are incomplete or inaccurate, on the other hand, will not assist in the identification process and could actually hinder the effort. The goals of the current study are to explore the accuracy of military dental charts from previous conflicts (WWII, Korean War, and Vietnam Conflict) and the subsequent utility of these records for the establishment of individual identifications of missing U.S. service members.

In order to gauge the accuracy of the dental records, the Decayed, Missing, Filled Teeth (DMFT) index was used to compare the records of missing service members from these past conflicts with published results from temporally and demographically similar populations. A sample of dental charts was gathered from missing service members from WWII, the Korean War, and the Vietnam Conflict. The sample sizes of each group were sufficient to generate reliable DMFT scores that were then compared with published results derived from oral examinations of compatible military populations. Distinct variation between the published DMFT scores and those derived from the dental records is likely indicative of incomplete/inaccurate recordation of treatment within the military dental records. Similar DMFT scores are interpreted as an indication that the charts accurately reflect the individuals' dental health status.

A second aspect to this research was to test the strength of a dental chart (without radiographs) for establishing an individual identification. In order to examine this, it was necessary to observe the uniqueness of the various adult dental health patterns (i.e., the pattern of missing, filled, and unrestored teeth) present within a large sample of individuals. Statistically, there are millions of possible combinations of missing, filled, and unrestored teeth within the adult mouth. This quantity of possible combinations suggests that an individual's dental health pattern should often be of sufficient uniqueness to be used for identification. As the statistical model of possible combinations is mathematically accurate, it does not necessarily represent reality. Each of the 32 teeth in the adult dentition cannot be considered to be at the same risk for loss or disease. Dental morphology will dictate that molars, based on their large surface area, will be more susceptible to decay than other teeth, such as canines or incisors. In order to observe the variation of adult dental health patterns, data were analyzed from two large dental health studies, one military and one civilian. For the military reference population, the raw data composed of detailed dental information for over 20,000 adults from the 1994 and 2000 Tri-Service Comprehensive Oral Health Surveys (TSCOHS) were utilized. For the civilian population, the raw data composed of detailed dental information for over 10,000 adults from the 1988-1994 National Health and Nutrition Examination Survey (NHANES III) were utilized. When radiographs are not available for comparison, these large data sets allow for a means to perform an empirical test that quantifies the relative strength of an antemortem dental chart that matches the dental health pattern observed

on an unidentified set of remains. For example, does a person with occlusal restorations on all lower molars and antemortem extractions of all first premolars have a relatively infrequent pattern that can be used as the basis for identification or is this a commonly observed pattern that is not overly discriminating? These results can be used to quantify the "rareness" of an observed dental pattern in the general population, and, in turn, potentially strengthen dental identifications based solely on dental charts.

Forensic Odontology, Dental Identification, DMFT

F8 A Cold Case/Still Frozen

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After attending this presentation, the participant will understand: 1) The national statistics involving missing persons and unknown remains, with specific data related to this problem within the State of Florida; 2) How information is placed into the NCIC System and the problems associated with inaccurate information; and 3) A case study: A cold case involving a missing teenager and the exhumation of a Jane Doe, buried for almost 19 years.

In this country, there are approximately 98,550 missing persons on record in the National Crime Information Center database (as of June 5, 2001), and only 4% of these missing persons have supplemental dental records included in their files. The number of missing persons fluctuates each day as some persons are located and others become missing. Florida accounts for 5,554 of these missing persons (adults and children).

Nationally, there are 4,688 listed as unidentified in the NCIC database, of which 90% are adults. Of the close to 5,000 unidentified, only 756 have dental information. In the State of Florida there are over 423 remains of unknowns that have been entered into the NCIC system, of which 260 have dental records included in their file.

Case Study/A Statistic: On Monday May 7th. 2001, Detectives from the Pasco County Sheriff's Office contacted me, asking if I would assist in reviewing dental information related to a teenager who had been missing for almost 19 years. They had reason to believe that the remains of a Jane Doe, buried in a neighboring County in 1983, may be those of their missing teenager. A review of the 1979 dental x-rays and chart for the missing teenager and the NCIC form that was submitted for her, showed inaccurate entries on the NCIC form submitted. Some similarities were noted when comparing the dental records of the missing teenager and the charted postmortem (1982) remains of the unknown. Dental x-rays, postmortem dental report and NCIC information for the unknown were not available for review, as they were lost. Several inconsistencies were noted in the initial comparison of the limited records available; however, the Sheriff's Department elected to proceed with an exhumation of the unknown female on June 13, 2001.

On June 13, 2001, the unknown from Manatee County was exhumed. The skull and dental structures were separated from the remains, re-examined, re-charted and x-rayed. A significant finding during the re-autopsy was that teeth originally reported as not present during the 1982 autopsy, were found among the remains. One of which, the Maxillary Left Central Incisor, had a unique pin retained porcelain restoration, previously uncharted.

This presentation will review the results of the dental comparison of the postmortem records with the dental evidence of the missing teenager, the problems associated with inaccurate dental charting, NCIC submissions, lack of proper dental records and radiographs, and problems when duplicate copies of the original dental findings and reports are not maintained.

Missing/Unidentified, Dental Records, Exhumation

F9 Orthodontic Clues in Forensic Identification

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Attendees will gain an orthodontist's perspective on forensic identification. The presentation will provide a systematic approach to evaluating orthodontic appliance, pre and post-treatment records, and residual evidence of past orthodontic treatment.

Forensic odontologists will find it increasingly necessary to apply their knowledge of orthodontics to the identification of human remains in the future. There are over 10,000 orthodontists in the United States. It is estimated that this group of specialists add 170 new cases per doctor per year. General Dentists add to this pool as well. At any given time, two to three million individuals in the United States are in the process of active orthodontic treatment, and tens of millions of individuals in the United States are carrying evidence of prior orthodontic care in their mouths. Forensic odontologists need to be able to identify the clues that are present in the active and past orthodontic patient. A systematic approach to classifying orthodontic appliances is useful when working on dental identifications where the deceased is still wearing orthodontic appliances. Specific identification of the appliance or appliance system is always the goal, but is not always possible. Treatment techniques and styles vary widely among practitioners and lead to the use of many different types of appliances. Competition for orthodontic supply dollars has created a multitude of manufacturers producing variations of the same basic product, and makes it difficult to identify them individually.

The first step in classifying an orthodontic appliance is to determine if it is a passive or an active appliance. Passive appliances are made to hold one or more teeth in a relatively stationary position, and may be designed to allow other teeth to grow or drift into more favorable positions. Active appliances are designed primarily for orthopedic (bony) or orthodontic (tooth) change. Both passive and active appliances can next be classified into either fixed or removable appliances. Fixed appliances are cemented to the teeth, while removable appliances are typically held in place with metal clasps or by close adaptation of plastic to the contours of the teeth. These appliances can be all metal, all plastic, or a combination of both. The most common active-fixed-orthodontic appliance system is called "braces" by the layman. Individual attachments to the teeth are designed as bands or brackets. Bands encircle the tooth and brackets are bonded to the facial or lingual surface. Begg and Edgewise are the two most common treatment approaches. Edgewise is by far the most commonly used system, but exists in two fairly evenly divided camps with slots in either .01 8" or .022". There are two types of bracket design for holding the arch wire into the bracket slot. An open faced bracket that uses elastic modules or wire ties for ligation is the most common. Self-ligating brackets have a gate integrated into the bracket design that clamps down over the wire to hold it in place. So-called prescription brackets began taking over the market in the 1980's. Tip and torque are built into the appliance by the way the slot is positioned within the bracket. A full set of twenty-eight brackets can include twenty-eight individual bracket designs, each with its own unique characteristics of size, shape, tip and torque. Multiple variations of tip and torque can exist for any one manufacturer's style of bracket. Bracket materials are another way to classify the appliance and include stainless steel, monocristalline and polycristalline porcelain, titanium, gold plated, plastic composites, and others.

Orthodontic records are an excellent source of antemortem information. These might include pretreatment, progress, and post treatment records comprised of chartings, models, photographs, and radiographs (panoramic, lateral and PA cephalometrics, bitewings, periapicals, tomograms, submentovertex, and other films). Evidence of prior orthodontic treatment may remain for the remainder of an individual's life. Some enamel decalcification patterns are pathoneumonic for past treatment with orthodontic brackets. Root resorption is a common side effect of

treatment. Removal of orthodontic appliances can leave clues in the form of incomplete adhesive removal; and, in tool marks left in enamel, from adhesive clean up.

Human Identification, Orthodontics, Orthodontic Appliances

F10 Effect of Image File Compression on Cross Covariance Correlation for Postmortem Identification

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The goal of this research project is to present research findings on the effect of image file compression on cross covariance correlation method for dental postmortem identification.

Results of a follow-up study on the original work performed at the Center for Education and Research in Forensics (CERF) in San Antonio, Texas to develop a new objective method for dental postmortem identification will be presented.

Current methods of dental postmortem identification are based on subjective comparisons of antemortem dental radiographs and postmortem radiographs produced by the forensic odontologist. Points of similarity or concordance are evaluated between the two sets of radiographs. Ultimately the identification is based on the number of points of similarity and the level of confidence of the forensic odontologist that the postmortem radiographic image represents the same individual as that of the antemortem record. Recently a more objective method of identification has been developed based on cross covariance correlation of antemortem and postmortem digital dental radiographs. Dental radiographs are first converted to digital images and the resultant postmortem digital image is compared with the antemortem digital image using digital image processing and a cross covariance correlation method. This computer-based method was presented at this meeting last year. The method showed perfect discrimination between similar and identical samples.

In order to facilitate transmission of digital dental radiographs over the Internet, image compression techniques are commonly applied. It is therefore necessary to determine the effect of image compression on the cross covariance correlation identification method.

Twenty digital periapical radiographs from the previous study were used as the sample. The sample was composed of two digital images of ten human hemi-mandibles with similar anatomic detail. One image from each of the hemi-mandibles was selected as the postmortem record; one image from each of the ten hem-mandibles served as the antemortem image for identification. The Joint Photographic Engineers Group or JPEG compression technique, based on a discrete cosine transform, and the new JPEG2000 technique, based on a wavelet transform, were used as compression schemes. The image chosen as the antemortem record was compressed at four different JPEG compression ratios (1:5, 1:10, 1:25, 1:50) and five JPEG 2000 ratios (1:5, 1:10, 1:25, 1:50, 1:100). Subsequently, each image was registered to the postmortem image and the cross covariance correlation determined for each comparison.

Cross covariance correlation (CCC) for similar images compressed with the JPEG method ranged from 0.898 – 0.993 while non-similar images ranged from 0.002 – 0.828. CCC for similar images compressed with the JPEG2000 method ranged from 0.862 – 0.993 while non-similar images ranged from 0.003 – 0.836. Using a threshold CCC value of 0.840, correct identification was determined with 100% accuracy.

These results suggest that neither the JPEG nor JPEG2000 compression algorithms affect the cross covariance correlation method of identification. Even at compression ratios of 50 to 1 no significant change was demonstrated. These findings support the use of image compression for the transmission of antemortem dental radiographic images via the Internet for forensic identification.

Image Similarity, Computer-Assisted Identification, Registered Images

F11 Digital Dental Radiography in Forensic Dental Identification: Benefits and Pitfalls With the Schick CDR System

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The goals of this research project are: 1) To review the scientific literature relating to digital radiography and the Schick CDR System; 2) To review specimen and sensor orientation problems and pitfalls in forensic dental examinations; and 3) To understand the limitations and the advantages of the Schick CDR System.

Background: For proper dental identification forensic dentists must have a thorough understanding of the radiographic techniques currently available to the dental community.

Advances in computer technology have opened new possibilities in recent years to the dental community with the advent of "filmless" radiography. The use of digital radiography in dentistry is a practice that all dentists should understand. It is likely that dental identifications by forensic dentists will involve digital images in either the antemortem or the postmortem records.

The Computed Dental Radiography (CDR) System from Schick Technologies, Inc. utilizes a digital CCD sensor. The available sensors are attached to the computer by a cable and are approximately the size of number 0, 1 and 2 dental analog film radiographs. The operator may then adjust the stored computer image by changing the contrast and brightness, the orientation of a captured image, zooming, measuring distances, colorizing, performing positive/negative enhancement, placing notes on the radiograph and importing and exporting images for evaluation.

With analog systems, film manufacturers provide a "dimple" system, which assists in the proper orientation of the film packet. With the CDR System an inverted pixel area marks the orientation of the sensor. With consistent orientation of the film packet or sensor, an examiner can determine the orientation of an antemortem specimen in an analog or a digital film. Improper orientation of the sensor in the CDR System produces flipped and inverted images that can be produced either in the clinical environment or in a postmortem situation. This is a direct result of the template selected in the CDR software and sensor positioning relative to the object. The CDR System requires the user to identify the image being captured prior to taking the radiograph. If this is function is not performed the resulting image will be disoriented both vertically and horizontally.

Materials and Methods: A radiopaque three-dimensional object with a distinctive configuration was embedded in an acrylic block. The block provided a means to rotate and invert the object for radiographic analysis. The Schick CDR software was used to capture radiographic images of the object as it was rotated and inverted around its axes. The resulting images were then compared to display the possible hazards

encountered with digital imaging. Postmortem and clinical examples of images produced by the Schick CDR system were also used to exemplify the possible manipulation to a digital radiograph that could lead to identification difficulties in forensic settings.

Results: This study displays some of the possible pitfalls of using a digital system for radiography. There can be complications with radiographic interpretation with this system if the object specimen is not properly oriented to the sensor or if necessary allowances are not made to reorient the image. If these factors are not addressed when using the CDR system, errors in identification of the specimen are possible. With a fragmented postmortem specimen, it is possible to orient the specimen in many planes in reference to the film or digital sensor surface. Thus, it is important for the forensic odontologist to properly orient the fragments in the same fashion as would be done in a living non-fragmented specimen to eliminate possible errors in radiographic interpretation. In practical use, the forensic odontologist is not always able to stabilize the specimen in the proper clinical orientation. In these situations, the sensor may be placed in "incorrect" clinical orientation to allow image capture without sensor cable interference. It is then necessary to assure that the appropriate steps are taken to reorient the resulting digital image to the proper clinical orientation.

Conclusions: Radiographic interpretative problems arise in analyzing digital images that are not viewed from the original data file. The original file provides the user with a history of any changes that have been made to the original image. In forensic examinations, the postmortem specimen may not be available for follow-up radiographic examination. It is, therefore, essential to ensure that the images collected at the forensic dental examination are made correctly the first time. A major advantage of digital imaging over analog imaging is the minimal amount of time required to produce excellent digital images versus the time required to produce analog images. A major disadvantage of a digital system is the initial expense involved. Additional advantages, disadvantages, and cautions will be discussed.

Forensic Odontology, Digital Dental Radiography, Dental Identification

F12 The Missing and Unidentified: How Can We Utilize the NCIC System?

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The goal of this research project is to educate all agencies of the important role dentistry should play in the successful use of NCIC Missing and Unidentified Programs.

In 1983, as mandated by Congress, the Unidentified Person Files were added to the Missing Children Act of 1982. The National Crime Information Center's (NCIC) Missing and Unidentified Program was established to assist and facilitate, on a nationwide level, the identification of deceased individuals.

The task of positive identification would be accomplished by the comparison of post mortem data to the unique physical characteristics including dental, DNA, fingerprinting and blood of those reported missing persons. All antemortem and postmortem data collected by ME/Coroners and investigative agencies would be filed on standardized forms. A centralized state agency would enter forms into a computerized program. Subsequently, the state would send this information to the NCIC which acts as the national repository for all missing and unidentified persons information. Reporting and filing of this information is mandatory for all states.

In 1990, Congress appropriated 17 million dollars for implementing changes that would improve the comparison process of antemortem and postmortem data. Since 1993, many forensic experts (Bell, Haglund, Silver, Cardoza, et al.) have written and spoken about the NCIC system problems and have suggested changes to the protocol to rectify those shortcomings. Finally, in 1998, a task force was sponsored by the FBI's CJIS Division. This task force included forensic odontologists, forensic anthropologists and medical examiners whose mission would be to review the NCIC protocol for collecting and entering missing unidentified person data. The goal was to ultimately suggest changes that would improve the accuracy of the system leading to increased identification on a nationwide scale.

In November 1999, both the Senate and the House of Representatives passed Jennifer's Law which was signed by President Clinton in 2000. The law appropriated 2 million dollars per fiscal year for state grants to improve the reporting of unidentified and missing persons for the years 2000 through 2002. Eligibility requirements for receipt of these grants include "state compliance with guidelines established by the Department of Justice for the NCIC Missing and Unidentified Person File including dental records, DNA reports, X-rays and fingerprints if available. While these grants are a step forward in supplementing inadequate state resources, many state agencies are not even aware that these monies are available from the federal government.

Over the past six years, as Forensic Odontologists for Suffolk County Medical Examiner's Office, NY, we have reviewed, through the NCIC System, hundreds of missing person reports as possible matches to our unidentified ME cases. We have never been able to make a positive identification based on dental data we have submitted or received. The most common problems we encounter are:

1. completely excluded or incorrectly charted antemortem-dental data, fingerprint, DNA and blood type;
2. incorrectly entered postmortem dental information;
3. the absence of other useful antemortem or postmortem information such as fingerprint availability or blood typing on the Missing and Unidentified record printouts; and
4. no preliminary screening to exclude obvious mismatches when matching by basic physical characteristics e.g., sex, hair, race, eye color.

With specific examples, we plan to illustrate these common problems which have frustrated forensic odontologist, medical examiners and other law enforcement agencies for the past ten years.

The purpose of this poster session is not to criticize the NCIC program, but rather the manner in which it has been used. We wish to encourage the forensic odontologist and other professionals to utilize the system correctly. Only when the user community understands the need for accurate and complete data entry (antemortem and postmortem) can we begin to improve the nationwide use of the NCIC Missing and Unidentified Program.

NCIC, Missing/Unidentified Persons, Jennifer's Law

F13 The Use of Amalgam Power and Calcium Hydroxide to Recreate a Radiopaque Image of a Lost Dental Restoration

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The goals of this research project are to present a method of using amalgam powder (radiopaque material) and calcium hydroxide (radiopaque material and transport medium for the amalgam powder) to recreate a radiopaque image on a tooth that has lost a dental restoration.

This radiopaque image may now be used as a comparison medium with any available antemortem dental radiographs.

This poster will present a technique that may be used by the odontologist to help assist in visualizing a radiopaque image of a dental restoration that has been lost. This recreated image may now be used as a medium for comparison with antemortem radiographs of the suspected individual.

The dental radiograph is an extremely important comparison tool in the identification process of recovered remains. A radiograph of a single dental filling may show enough characterization in its radiographic silhouette to confer uniqueness. A positive dental identification is established when the concordance between antemortem and postmortem data confers uniqueness and there are no incompatible inconsistencies. A problem exists when a restoration from a tooth is displaced (either antemortem or postmortem) resulting in the loss of the radiopaque comparison shape required for identification of the dental remains.

When a dentist prepares a tooth for a restoration, multiple factors will determine the result of the preparation: size/shape of tooth, size/shape and location of the caries, and resistance and retention form. Since all teeth exhibit a unique silhouette that can be used for radiographic comparison, the floor of a dental restoration preparation will also create a unique feature that could possibly be used as a comparative feature.

The materials used in this technique include amalgam powder, calcium hydroxide pulp capping paste, mixing pad, ballpoint applicator dental instrument, water, a fine tipped paintbrush, dental explorer, a dental carving instrument (Tanner #5) and a standard dental x-ray machine.

Extracted teeth with an existing restoration were selected for the illustration of this technique. Infectious control procedures were maintained while handling all freshly extracted teeth. Extracted teeth were disinfected by their placement in 5.25% sodium hypochlorite for ten minutes then rinsed in distilled water. Teeth were then stored in distilled water. All teeth were radiographed and photographed. All radiographs were produced on a digital radiography unit at 10 mA, 70 kVp for 6/60 second and a charged coupled device sensor. Restorations were then removed with a high speed dental hand piece being careful not to disrupt the floor and walls of the preparation.

Amalgam powder is carefully added to the floor of the preparation by using a small amount of water and a fine paintbrush. By completely covering the floor of the preparation, the clinician will help recreate the internal contours of the preparation. Amalgam powder can then be added to a mixture of calcium hydroxide base and powder until a uniform color is observed. This combination can then be placed in the cavity preparation. The working time for calcium hydroxide is approximately two to three minutes. If it is determined that an inadequate amount of calcium hydroxide/amalgam powder has been used, an additional increment can be added to the "provisional restoration." Upon the complete set of the amalgam powder/calcium hydroxide restoration, a dental carving instrument is used to recontour the external shape of the restoration.

The "provisionally" restored tooth is radiographed and compared to the pre-operative radiographs. External recontouring (addition or removal of the amalgam powder/calcium hydroxide mixture) of the "provisional restoration" can now be determined by the radiographic difference between the post-operative and pre-operative radiographs.

This technique is presented in a case report. In this case, the radiopaque restoration technique was instrumental in the identification of the remains of a U.S. service-member lost in an aircraft crash in Vietnam.

Odontologist, Postmortem Dental Restoration Loss, Radiographic Analysis

F14 The Kimmerle Anomaly (Ponticulus Posticus) of the Atlas Vertebrae and Its Utility in Forensic Identification

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The goal of this research project is to familiarize the forensic community with frequently unrecognized anomaly of the atlas vertebrae (C1) and its potential use in forensic identifications.

Kimmerle's anomaly, the eponymous designation named after the German radiologist who is first credited with its description in the medical literature in 1930, is also found in the literature referred to under a variety of terms to include: "ponticulus posticus," "arcuate foramen," "posterior atlantoid foramen," and "posterior bridging of the atlas." This anatomical variation is thought to represent an anomalous ossification of the posterior portion of the atlanto-occipital ligament forming a bridge or partial bridge over the sulcus through which transverses the vertebral artery and the suboccipital nerve. On dry specimens, a complete Kimmerle's anomaly is seen as a smooth osseous bridge or ponticle over the vertebral artery groove of the atlas connecting the posterior superior margin of the superior articular facet with the posterior lateral mass of the atlas forming a distinct foramen.

While the reported incidence of partial bridging is somewhat more frequent, the incidence of complete bridging in the general population reaches 15% in studies utilizing both lateral cephalometric radiographs and/or dry specimens. When presenting in a unilateral fashion, no predominant siding has been identified and a bilateral presentation is not uncommon. A slight male predilection has been reported in cases involving complete bridging. Studies involving racial variation have shown a slightly higher incidence of complete bridging in African Americans.

The etiology of Kimmerle's anomaly has been somewhat enigmatic. Studies have shown a tendency of complete bridging with increasing age, suggesting that Kimmerle's anomaly is the result of a degenerative process similar to osteophyte formation. Other studies, however, have shown that bridging with complete foramen formation can occur in children and adolescents with a similar frequency reported for adult subjects suggesting a congenital variation. Investigations into a possible familial nature of the Kimmerle's anomaly have shown that it is likely inherited as a Mendelian autosomal dominant trait with variable penetrance. Others have suggested that this anomaly is a remnant manifestation of an occipital vertebrae or a vestigial, atavistic, feature as it is commonly encountered in primates and other lower vertebrates.

The presence of complete bridging with or without persistent narrowing of the resultant foramen can, in some cases, restrict free movement of the vertebral artery. In such cases, especially during cervical flexion and extension, compression and traction of the vertebral artery and suboccipital nerve may ensue. These phenomena have been implicated in a variety of ischemic and pain syndromes of the head and neck to include transient vertebrobasilar insufficiency, chronic upper cervical syndrome, and Barre-Lieou syndrome. Kimmerle's anomaly has been recognized in chiropractic as a contraindication to high velocity manipulation of the cervical spine and, therefore, the presence of (or failure to recognize) this anomaly associated with the atlas vertebrae may have import in certain medico-legal settings.

The atlas vertebrae, as well as other components of the cervical spine, are well delineated on lateral cephalometric radiographs. Practicing orthodontists as well as oral and maxillofacial surgeons who commonly utilize this imaging study as an adjunct to treatment planning are in a unique position, within the dental profession, to appreciate this anomaly and may possess the only available antemortem records for comparison purposes. The recognition of this anomaly alone might be helpful as an exclusionary tool in forensic identification. The presence of this anomaly may also provide evidence in support of an identification and or help in the segregation of commingled remains.

A forensic case is presented whereby the finding of a Kimmerle's anomaly on postmortem examination was correlated to an antemortem imaging study allowing for additional support for an identification for which traditional dental radiographs were not made available.

Radiology, Forensic Identification, Atlas Vertebrae

F15 King Air Burst Into Flames at BNA Airport

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The goal of this research project is provide the forensic community with information and techniques used by a forensic odontologist to make a positive identification of remains from severely burned aviation victims.

On January 21, 2001, at 3:13 p.m. central standard time, a Beach BEF90, N17AE, lost right engine power shortly after liftoff from Runway 2 Center at Nashville International Airport in Nashville, Tennessee. The King Air was operated by a private pilot, Michael Andrew Pitney, age 44, under the provisions of Title 14 CFR Part 91, and instrument flight rules. Visual meteorological conditions prevailed and an IFR flight plan was filed for the cross-country flight to Waukesha, Wisconsin. According to the Nashville controller, shortly after takeoff at less than two hundred feet-above the ground, the pilot reported an engine failure and requested to return to the airport. The tower controller cleared the pilot to land on any runway and notified airport crash and fire rescue personnel. The controller saw the airplane in a right turn, descending, and observed the airplane level its wings just prior to impact with the tops of trees by Runway 20 Left.

On scene examination of the wreckage found the airplane upright, with the cockpit and cabin destroyed by the post crash fire. Part of the right outboard wing was found in a tree about 196 feet from the main wreckage. The tail was separated from the cockpit. John Doe 1, MEC 0 1-225, was lying prone on the ground near the back and to the right of the tail section. John Doe 1 had suffered from burns over his entire head and body. Hair and clothing had burned away. John Doe 2, NEC 0 1-226, was located to the right of the cockpit area, supine with his head pointing toward the plane. Extensive charring was present anteriorly and the deceased internal organs were partially revealed, external at abdomen. John Doe 3, MEC 01-227, was found seated in the right seat of the cockpit. John Doe 3 suffered extensive burning and charring over the entire head and body.

Officer William Dave Hodge, Nashville Airport Police K-9 unit 393, was first on the scene, seconds after the crash, and observed the fire. Officer Hodge observed Michael Pickney walking out of the woods, wearing only a necktie, underwear and shoes. His clothes had been burned off. Officer Hodge stated that victim said, "I killed three people." The fire and rescue personnel arrived on the scene and foamed the plane and fuel soaked area. Michael Pickney was life flighted to Vanderbilt Medical Center with 85% of his body burned. He arrived at VUMC still conscious and told doctors to tell his family that he loved them. Michael Pickney died a week later at VUMC from complications.

The twin turboprop was owned and operated by Amprite Electric Co., Inc. The people on board the King Air were Michael Pickney, CEO, Robert Lowrance, Jr., Treasurer, Gary Finney, Vice-President, and Edward Peach, Vice-President.

The antemortem dental records were obtained by the Davidson County Medical Examiner's Office on the three burned victims. Postmortem radiographs were taken on John Doe 1, 2, and 3 at the Forensic Science Center. By comparing the antemortem and postmortem dental charting, all three John Does were identified with reasonable medical certainty.

Radiology, Dental, Identification

F16 Mass Disaster and Forensic Odontology Protocol

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The goal of this research project is to explain the procedures followed by the Association Française d'Identification Odontologique for identify bodies in large disasters.

This team wants the intervention of several forensic odontologists for search of dental or denture fragments on the site. Trained dentists best carry out searches of this nature.

In the mortuary, two dentists examine each cadaver. Systematically, jaws are removed and photographed. The team prefers the photography to be carried out by a dentist photographer.

Then, jaws are cleaned and the postmortem dental record is made. Additional information from dental radiographs and dental panoramic tomographies or studies, such as age assessment, sex determination, or still specialized studies such as DNA analysis, are made if needed.

Postmortem and antemortem records are compared and the report is written when the positive identification is certain.

The dental report is distinguished from the medical examiner's report.

Forensic Odontology, Mass Disaster, Identification

F17 Forensic Application of Computer-Based Image Analysis for Postmortem Identification

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A computer-based image analysis system will be presented to aid in postmortem identification. The system provides an objective estimate of image similarity by first registering the postmortem and antemortem digital images and subsequently performing a cross covariance correlation between the two registered images.

Current methods of dental radiographic postmortem identification are based on subjective comparisons of antemortem radiographs and postmortem radiographs produced by the forensic odontologist. Points of similarity or concordance are evaluated between the two sets of radiographs. Ultimately the identification is based on the number of points of similarity and the level of confidence of the odontologist that the postmortem radiographic image represents the same individual as that of the antemortem record.

In a previous laboratory study presented at the AAFS Meeting in 2001, a computer-based digital imaging method provided perfect discrimination between the same specimen and different specimens regardless of the projection geometry used to acquire the images. A clinical study was performed to verify the accuracy of this method for postmortem identification.

Forty-seven dental records were selected from the University of Texas Dental School at San Antonio Outpatient Clinic. Inclusion criteria consisted of a minimum of two 20-exposure full mouth series taken over at least a three-year period. Posterior periapical films (8) and two

anterior periapical films from each full mouth series were digitized using an Epson Expression 1600 Professional flatbed scanner with transparency adapter. All x-ray films were digitized at 400 dpi (63.5 micron pixels) and 8 bit (256) gray levels. Patient information was redacted for patient confidentiality and a random patient number assigned to each set of digital images. Images from the same anatomical area (right maxillary molar, right maxillary premolar, left maxillary premolar, left maxillary molar, right mandibular molar, right mandibular premolar, left mandibular premolar, left mandibular molar, right maxillary lateral incisor, and mandibular central incisors) were grouped for analysis. A single image was selected randomly from each group to serve as the postmortem image and all other images in the group served as potential matching antemortem images. The image taken of the same individual at another date was the matching antemortem image in each group. The investigator performing all registration procedures and analysis was blinded as to the correct identity by assigning each image a coded number. This procedure was repeated three times for each group by randomly selecting another postmortem image. All image registration and analysis was performed on an Intel Pentium III personal computer using UTHSCSA ImageTool version 2.0 software. UTHSCSA ImageTool was developed at the University of Texas Health Science Center at San Antonio, Department of Dental Diagnostic Science and is available via the World Wide Web at <http://ddsdx.uthscsa.edu>. The mean cross covariance correlation for images of the same individuals and those from different individuals was calculated. Analysis of variance was used to determine if there was a significant difference between the two groups. This would indicate the ability of the method to correctly identify the matching antemortem record in a clinically relevant setting.

Preliminary results demonstrated that images from the same individual had a cross covariance correlation of 0.915 – 0.989, whereas, images that were from different individuals ranged between 0.108 – 0.797. Using a threshold of 0.840, correct postmortem identification could be made. This new method may provide the most objective and reliable method for postmortem identification using dental radiographic images. It may also be useful in cases with no dental restorations and minimal distinctive anatomical features.

Postmortem Identification, Image Similarity, Radiography

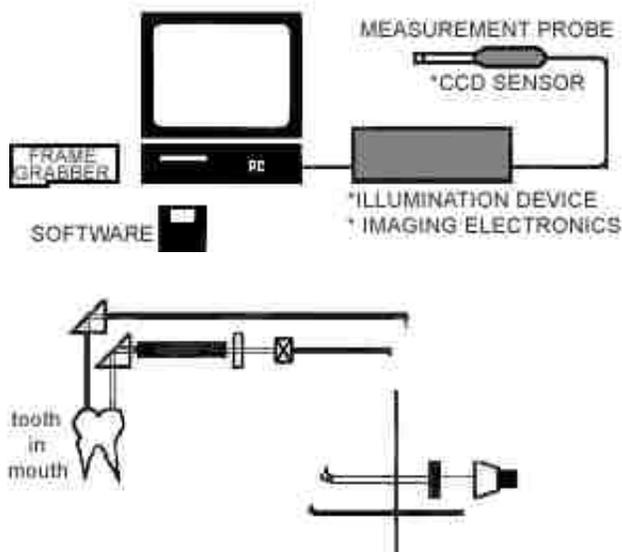
F18 The Use of Quantitative Light-Induced Fluorescence (QLF) for the Detection of Composite Restorations in Dental Identifications

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The goals of this research project are to become familiar with a) the use of light sources for the detection of composite (white) restorations in teeth, b) the effectiveness of this procedure versus normal visual identification, and c) the possible applications of QLF for the determination of composite material brand.

Introduction: Quantitative Light-Induced Fluorescence (QLF, Inspektor Research Systems, NL) is a new dental instrument (see below) for the assessment of dental caries (both enamel and root), tooth whitening, plaque, and secondary decay adjacent to restorations. Dental enamel will auto-fluoresce under certain conditions, and dental materials placed within enamel will either fluoresce more or less. Using the system, dental composites are easily visualized against enamel. Composite materials can be difficult to detect during forensic dental examinations for identification purposes. With the increased use of

these materials, the detection of these restorations is likely to become increasingly important. The purpose of this investigation is to determine if QLF increases the detection rate of composite materials on smooth surfaces versus normal white light visualization in an *in vitro* study.



Methodology: Twenty previously extracted human premolars were selected. Each was free of caries, stain and enamel defects on both buccal and lingual surfaces. Each tooth was gently pumiced and abraded with wet-and-dry paper to remove soft tissue remnants. The teeth were then randomly allocated to one of two groups: a) restored and b) unrestored. Each of the teeth in the restored section was further randomly allocated to one of two restorative materials, Dyract (a compomer) and Spectrum (a composite). A single drill hole was placed on either the buccal or lingual surface, and then the cavity was restored (following the manufacturer's instructions) with the selected material. Each of the twenty premolars was photographed using a mega pixel digital camera on a copy stand. Each premolar was also subjected to a QLF examination and the resultant image saved to PC. The images were then collated and arranged on two A4 pages; one of the white light images, the other of the QLF images. Each tooth was sequentially numbered. The sheets were distributed to ten dentists who were asked to indicate which teeth they believed were restored. Further to this, the images were presented on a website (www.forensidentistryonline.com) and viewers were asked to indicate their assessment of whether the teeth were restored.

Statistics: The data were entered into the PEPI statistical package and the Kappa agreement scores calculated for agreement with the known gold standard (restored/not restored).

Results: The results available at this time relate to the data collected from the ten dentists in the initial study; data from the website study will be presented. Agreement using the white light images was moderate, while the agreement between the QLF images was considerable.

Conclusions: QLF could be used as a reliable tool for the identification of composite restorations in dental identifications, both in single and multiple fatality incidents.

Odontology, Human Identification, White Fillings

F19 The Effectiveness of "Digital" Dental Radiographs for Human Identification

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Following this presentation, the attendee will be familiar with a) the accuracy of "digital" radiographic comparisons, b) the intra-and inter-examiner agreement of such comparisons, c) the effect of training and experience on these values, and d) the use of the World Wide Web in Odontological Research.

In the era of *Daubert* and other judicial rulings, it is imperative that forensic scientists are able to support their methodologies in Court through effective, empirical research. The need to present accuracy data and error-rates for techniques in odontology presents a particular dilemma, as there has been little research in this area. Two authors of this current study (IAP, DS) have published data on bite mark accuracy, and the current investigation continues this work by examining dental radiographic identifications.

Methodology: Ten identification cases were selected from the case files of the authors. The identifications in each case had been achieved using dental means, and then confirmed using alternate methods. Seven of the ten cases were positive identifications, three were exclusions, representing 70% prevalence. The radiographs were scanned into a computer and then edited. In some cases, to increase difficulty, certain radiographs were removed. All radiographs were orientated correctly. The completed cases were compressed using the JPEG algorithm and the cases were presented to examiners via a bespoke website (www.bobble.uklinux.net). Each case had four possible responses based upon the ABFO Identification guidelines: Positive, Possible, Insufficient Evidence, and Exclusion. These were selected using a drop-down menu. Participants were invited to participate via e-mails and advertising on forensic websites. Each participant was asked for brief demographic details and to complete the exercise twice following a one-month "wash-out" period. The identification cases were re-ordered for the second attempt. Participants were contacted by e-mail to remind them to revisit the site for their second attempt.

Statistics: The data were analysed using PEPE statistical software using an ROC methodology. Individual sensitivities and specificities for each of the four conclusion levels and the area under the curve (AUC) were calculated. Mean scores were calculated. Intra- and inter-examiner agreement was determined using the Kappa statistic.

Results: The data available at this time relate to 60 individuals who have completed their first attempt. The participants included Diplomates (12%), AAFS members (42%) and ASFO members (78%). The mean number of identifications completed was 170 (±478). The mean AUC was 96.2%, with all but two participants scoring significantly better ($p=0.05$) than 50% (chance). Kappa indicated that the mean agreement between examiners (inter) was substantial (0.82). Intra-examiner agreement will be presented. Mean specificities and sensitivities for each conclusion level were:

Conclusion	Mean sensitivity (SD)	Mean specificity (SD)
4 – Exclusion	100 (±0)	0 (±0)
3 – Insufficient evidence	100 (±3)	65.3 (±2.3)
2 – Possible identification	89.4 (±10.1)	68.2 (±16.5)
1 – Positive identification	34.6 (±12.8)	100 (±0)

Conclusions: The available data suggests that (digital) dental radiographs present a reliable, accurate, and robust method for human identification. Substantial agreement between examiners indicates that the

technique is objective and the specificity and sensitivity scores are in-line with many other forensic tests. Initial examination reveals that experience and training have no significant ($p=0.05$) effect on identification performance in this study. The World Wide Web presents a fast and economical method for involving odontologists in research projects.

Odontology, Accuracy, Human Identification

F20 Evaluation of a Digital Watermarking Software Applied to Digital Dental Radiographs

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This presentation will evaluate the application of a digital watermarking software to ensure the integrity of digitized dental radiographs.

Dental radiographs constitute important evidence in forensic dentistry. They are used in the evaluation of the age and racial affinity of victims. Restorations, extractions and anatomic structures can be used to compare ante-mortem and post-mortem dental radiographs. With the increased availability and demand for digital imaging systems, digitized dental radiographs are becoming a part of the evidence a forensic odontologist must evaluate. Potential medico-legal implications of digitized dental radiographs have been the subject of discussion in the literature. Digital and digitized conventional radiographs can be enhanced for contrast and brightness thus improving the diagnostic outcome. However, these radiographs can easily be modified through numerous photo-retouch or bitmap processing software, leading to falsification of evidence to the advantage of one or other party in a medico-legal case. Additionally, alternating could impact the comparison of ante-mortem and post-mortem dental radiographs.

Background: A digital watermark is an added signature to a digital or digitized image to offer proof of authenticity or integrity. These marks may be visible or invisible. Invisible watermarks are embedded in a way that they can be seen by a computer but remain imperceptible to the human eye. Yet they are durable and provide images with a persistent identity. The VeriData digital watermarking software (Signum Technologies) is purported to be a powerful solution to ensure high levels of integrity of digitized still images. The software has found many applications in fields such as scenes-of-crime recording, law-enforcement, accident investigation and medical imaging to identify and confirm the integrity of original material. It provides a unique solution to the problem of data authentication, enabling in the case of digital images subsequent modifications to be checked down to pixel level. To our knowledge this software has not been applied to digital dental radiographs.

Method: Six companies were identified as actively involved in the development of digital watermarking software of still images through a search on the World Wide Web. The software was chosen for convenience and for its known application to medical imaging. The VeriData digital watermarking software version 2.20 was downloaded on an IBM Aptiva personal computer (AMD K6-2 3D processor, 450 MHz, 96 MB RAM, 8 GIG) directly from the Signum Technologies web site for a 30-day trial period. Two panoramic dental radiographs were digitized using the Epson Expression 1600 Professional Series flatbed scanner with a transparency unit. The software allowed for direct acquisition of the dental images from the scanner. Dental images could also be retrieved from other existing folders in the computer. Once images were acquired, they were saved as Tagged Image Files (TIFF). Each radiograph was embedded with a visible or invisible watermark and saved as master images. These master images were given an image identifier and validated. The image were then altered using Adobe® Photoshop® 5.0 LE and revalidated for images changes.

Result: The digital watermarking software is easy to use and only minimal training is needed. Once a watermark is embedded, it can only be revealed and decoded by the detection software. During the validation process, the software “remembered” the appearance of the dental image and highlighted changes that were made to the image at a later date or time. This is accomplished by incorporating a secure algorithm making hacking impractical. Differences between the master and altered images appeared as a cross-hatched area on the altered image. The visible watermark and validation information are permanent and cannot be removed from an image once it has been applied. This software supports 8 and 12-bit RGB TIFF images, 8 and 12-bit greyscale TIFF and JPEG (JFIF) images. Some differences in the results may occur and are to be expected since the evaluation of the software is still underway. These differences will be projected and explained. Also advantages and disadvantages will be discussed.

Conclusion: the use of a digital watermarking software to “tag” digital dental radiographs is an effective way of overcoming the problem of image data integrity and authenticity, especially when they are used as evidence and subject to judicial or ethical scrutiny. The software used in this project enabled us to easily identify tampered digitized dental radiographs.

Digital Watermarking, Digital Image Manipulation, Forensic Dentistry

F21 Computerized Incisal Edge Tracing Using Different Dental Stone Colors

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The attendee will gain the knowledge on how the use of different color dental stone affects computerized incisal edge tracing for bite mark analysis.

There are numerous types of dental stone with different colors that can be utilized to make dental casts for bite mark analysis. This study was conducted to examine the effect of using dental stones of different on incisal edge tracing for bite mark analysis utilizing Adobe® Photoshop® 5.0.

Bite mark analysis has become a valuable tool when evaluating injuries caused by the teeth. Despite the fact that experts who argue that human error is unavoidable when the images are manually traced criticize conventional bite mark analysis technique, most conventional bite mark analysis techniques have not incorporated available computer technology. Recently Drs. Johansen and Bowers introduced a specific technique for analyzing bite evidence using a computerized tracing of incisal edges. Their technique utilizes a flat bed scanner to capture the image of a dental model and a specific tool to outline the incisal edges of the teeth. The purpose of this investigation is to determine if the color of stone in the dental cast affects the ability to scan the model and outline the incisal edges of the teeth.

Ten sets of impressions were each poured in dental stones of five different colors according to manufacturers’ directions: yellow (buff stone), white (orthodontic plaster), pink (silky rock), green (die stone), and blue (die stone). These models were scanned on a UMAX Power Look 2000® Scanner at 600 dpi and captured as a JPEG image. The incisal edges of incisors, canines, and first premolars were selected using the “Magic Wand” tool found in Adobe® PhotoShop® 5.0 with a pixel tolerance of 18. This tracing was repeated ten times for each set and each color of model. Then each subsequent tracing was subtracted from the original tracing. The mean and standard deviation of the histogram of the subtraction was compared using analysis of variance (ANOVA) at a $p<0.05$.

Analysis of the data indicates that the color of the stone does not significantly affect the accuracy of the incisal edge tracing ($p=0.15$). However, when each color was compared, some differences were noted. White stone demonstrated the smallest standard deviation, compared to blue, pink, green, and yellow. However, this finding may be misleading due to the difficulty in tracing white incisal edges against a white background. Differences in standard deviation (SD) and mean squared error (MSE) were noted with blue demonstrating significantly higher SD and MSE than the other colors. White demonstrated significantly lower SD and MSE. Green and yellow were not different from one another and demonstrated low SD and MSE. No significant differences were noted in repeated tracings ($p=0.71$) suggesting that tracings made utilizing the "Magic Wand" tool are repeatable.

The increased prominence of bite mark evidence and the rigor with which it is evaluated make it imperative that the most accurate materials and techniques are used when collecting evidence. The results of this investigation indicate that green and yellow stone allow accurate scanning of dental models and that the "Magic Wand" tool provides reproducible tracings of incisal edges.

Bite Mark, Color, Analysis

F22 Standardization, Automation, and Database Creation for Age Determination Reports

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The goals of this research project are: 1) To review the scientific literature for information relating to adolescent age estimation from radiographic evaluation of 3rd molar development; 2) To understand the need for standardization and automation of the age determination reports; and 3) To propose an automated means to create a database and standardized report approved by an ABFO sub-committee.

Background: Radiographic evaluation of third molar development has been widely used in estimating the chronological age of adolescents. In 1993, Harry H. Mincer, DDS, PhD, DABFO, et al., performed a study for the American Board of Forensic Odontology (ABFO) using the eight stages of crown and root formation to score third molar development proposed by Demirjian in 1973. This study resulted in the development of mean ages, standard deviations, and the empirical probabilities of an individual attaining at least 18 years of age for stages D through H based upon the residing arch of the third molar and the subject's sex. Although the subjects studied included 80% Caucasoid, 19% Negroid, and 1% "other" or "unspecified," the data produced are only significant for the Caucasoid. However, George G. Scott, Jr., DDS, et al. presented a paper entitled "Third Molar Development as an Estimator of Chronologic Age in Hispanics" to the AAFS in 1999 which demonstrated that 3rd molar development is variable and not linear. The study also showed that the data for age determination developed by Mincer was not significantly different for Hispanics in the 16 to 18 year age range. Further studies are needed to examine the accuracy of the statistical method used and to develop data on other races. With no other statistical data available, all individuals are currently evaluated based upon the Caucasian statistics.

Determining whether an individual has attained his/her eighteenth birthday has great significance in our legal system. Of particular interest to the field of forensic odontology is the Immigration and Naturalization Service's request for estimation of the age and evaluation of the empirical probability of an individual being at least 18 years of age. At the request of the Immigration and Naturalization Service, a committee was formed to establish uniformity in reporting age determination results during last ABFO meeting (Seattle, 2001). The goal of standard-

izing the report is to provide clarity in the report's interpretation by the reader. Further consideration should also be given to computer automation of the statistical data generated by the radiographic evaluation of third molars staging as well as report generation. This would result in eliminating inadvertent error in calculating the statistical data, simplify and expedite the process, while generating a uniform report. Furthermore, computer automation will provide a means of archiving the generated database on each individual.

Methods: A Microsoft Access (Microsoft Corp., USA) based pilot computer program, *C.E.R.F. Age Determination Program*, has been developed. The program archives data for age determination cases cataloging the case number, individual's name, race, sex, profile and portrait photographs, stated date of birth, and panoramic radiograph. After entering the estimated development stage of the 3rd molars present, the average mean age of the individual, the average age range to two standard deviations, and the average empirical probability of the individual having attained his/her 18th birthday is calculated. The program will then generate a report to the referring agency in accordance with the ABFO guidelines. Report editing is available for reports requiring supplemental information.

The *C.E.R.F. Age Determination Program* was tested to (1) verify ease of use and (2) establish the amount of time saved by using the program versus performing the calculations by hand and writing a report. A teenager who demonstrated basic computer skills was shown how to enter data into the program. He was then given the relevant data for eight (8) age determination cases and asked to enter the information into the database and print a report for each. Simultaneously, a forensic odontologist took the same data and performed by hand the calculations to determine the average mean age, standard deviation, age ranges to two standard deviations, and empirical probability that the subject was at least eighteen years of age. The odontologist then wrote a standardized report for each of the eight cases.

Results: The information was entered error free and without complication by the teenager taking on average, seven minutes to enter the data for each case and print out a completed report. The odontologist averaged forty minutes to perform the calculations and generate the same report by hand. A trained odontologist generated the same work product as the teenager using the *C.E.R.F. Age Determination Program* in six and one-half minutes.

Conclusions: The *C.E.R.F. Age Determination Program* provides a user friendly means to archive age determination case data, performs error-free age and probability calculations and generates template reports. The program expedites the process and thus reduces the odontologist's time required to complete an age determination case.

Forensic Odontology, Age Determination, 3rd Molar Development

F23 Reliability and Validity of Eight Dental Age Estimation Methods for Adults Used in Forensic Odontology

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The goal of this research project is to evaluate the reliability and validity of eight published dental age estimation methods that may aid in victim identification.

Age estimation is a critical part in the forensic identification of unknown persons and living persons who cannot provide acceptable identification documents. In these cases forensic odontologists can estimate age based on the person's dental condition. The simplest estimates are based upon clinical experience without using formal methods. Formal methods of calculation based on morphometric measurements and amino acid racemization have also been developed.

Morphometric measurements offer formal methods based on mathematical regression models. However, they have not always been subsequently validated in an independent material set or formally compared to each other. One notable exception was a study in 1980 by Solheim (Solheim, 1980). He evaluated five formal calculation methods vs. visual age estimation. Solheim found that Johanson's method (Johanson 1971) and visual estimation were the best. This paper updates this work by evaluating Johanson's method, the best morphometric method Solheim previously found, together with five newly developed morphometric methods. One of these is Lamendin's method, which is timely because of its recent use in Kosovo (Lamendin 1992). The paper also evaluates Bang's intact and sectioned methods (less accurate than Johanson's method in Solheim's earlier study but easy to apply in the field) for a total of eight methods. The study also indicates which methods are appropriate for teeth in situ (e.g., living individuals), for extracted teeth that can be sectioned, and for teeth that cannot be destructively evaluated, such as anthropological materials.

Materials and Methods: Twenty Caucasian teeth, intact or with superficial fillings and taken from 10 females and 10 males (ranging in age from 14 to 95 years), were selected for this study. Two teeth were selected from each tooth group, such as upper first incisors, with the exception that molars were excluded. The dental practitioners provided the reason for extraction (e.g., periodontal disease, denture, orthodontic, forensic autopsy).

Eight dental age estimation methods were chosen for this study according to the rationale described above:

1. Johanson's method for sectioned teeth (Johanson 1971). Six variables were chosen and seven assessment scores given in the Johanson's method. The variables included: attrition, secondary dentin, periodontal recession, cementum apposition, root resorption and root translucency. Only one formula was computed for all types of teeth.
 2. Kvaal and Solheim's (Kvaal 1994) first formula is for extracted but intact teeth. The following variables were measured in their formula:
 1. Length of the apical translucent zone (measured in mm, according to Bang's method (Bang 1970)).
 2. Extent of the periodontal retraction measured on the mesial root surface (mm).
 3. Ratios between the width of the pulp and root at the cemento-enamel (CE) junction and at the midroot level measured on dental radiographs.
 4. Ratio between the length of the pulp and root measured on dental radiographs.
- The authors had calculated individual formulas for each tooth group.
3. Kvaal and Solheim's (Kvaal 1994) second formula is for intact teeth in the oral environment. The formula includes all the variables above except for the length of the apical translucent zone of the root. Again, each tooth group has a separate formula.
 4. Solheim's method for intact teeth (Solheim 1994—in Norwegian). The formulas included eight variables: two color estimates, two periodontal recession measures, two attrition measures, crown length and sex. Separate formulas were created for each type of teeth.
 5. Solheim's method for sectioned teeth (Solheim 1993). Solheim used 14 different variables and had separate formulas for each type of tooth.
 6. Lamendin's method for intact teeth (Lamendin 1992). The formula includes two variables: the height of periodontal attachment from the CE junction and the root translucency. Only one formula was computed for all types of teeth.
 7. Bang's method for intact teeth. Bang and Ramm (Bang 1970) created a method that is solely based on the length of apical translucency zone. Two separate formulas were computed; one if the translucency was less than 9 mm and another if it was more than 9 mm. Every tooth had its own formula.

8. Bang's method for sectioned teeth (Bang 1970). Bang used only one variable, translucency, but computed separate formulas for each individual tooth.

Results: Method accuracy is a measure of reliability: how close a result comes to the true value. Method precision is a measure of repeatability: how good confidence one may have in the estimated result. These two measures were therefore assessed as key outcomes. The method accuracy was determined using statistical measures of central tendency, namely, the means of the Age Errors for each method. Method precision was described by the standard error (SE) of the mean. These results are shown in Figure 1.

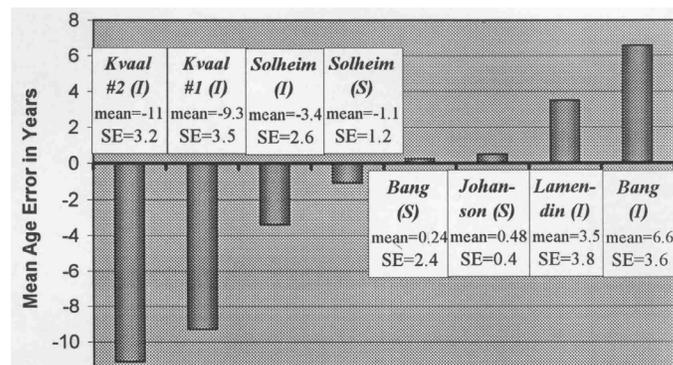


Figure 1. The mean Age Error and its standard error (SE) associated with the five intact and three sectioned methods. (I) = method for intact teeth; (S) = method for sectioned teeth.

The next analysis compared the mean age errors in order to determine whether or not the methods' accuracy differed significantly. An ANOVA and Fisher's PLSD post-hoc analysis (t-tests) were used to compare the mean Age Errors for each of the 28 possible pairs of methods (e.g., Bang intact vs. Lamendin). Given the present data, Fisher's method indicated that the critical significant difference needed in the present analysis to distinguish two methods from one another was at least 7.922 years. The results of the analysis showed that the Kvaal intact 1 and 2 methods were significantly different from all of other methods they were paired with (p values ranging from .0001 to .0498 and mean Age Error differences exceeding 7.922 years), except when tested in comparison with Solheim's intact method (p = .1587, mean difference = -5.680 years). The present data also showed that the remaining methods were not significantly different from one another (p = NS, error difference > 7.922 years) when compared pairwise, with the exception of Bang's intact method vs. Solheim's intact method (p = .0132, error difference = 10.055 years).

Method accuracy and precision is an important criterion when selecting a forensic method. However, in addition to the accuracy and precision, the author assessed the methods' simplicity ("ease of use"), including requirements for tooth preparation and special equipment, such as X-ray machine or stereomicroscope (Table 1).

Table 1. Criteria for selecting an age estimation method in forensic odontology.

Method	Accuracy (mean Age Error)*	Precision (Standard Error)*	Ease of Use**	Tooth Preparation	Measuring Equipment***
Kvaal 1	Low	Low	Moderate	Extraction	Dental X-ray Stereomicroscope
Kvaal 2	Low	Low	Moderate	None	Dental X-ray Stereomicroscope
Bang's Int	Moderate	Low	High	Extraction	Standard
Solheim's Int	High	Moderate	Moderate	None	Stereomicroscope Truebite® color scale
Lamendin Int	High	Low	High	Extraction	Standard
Johanson Sect	High	High	Moderate	Sectioning	Stereomicroscope
Bang's Sect	High	Moderate	Moderate	Sectioning	Standard
Solheim's Sect	High	High	Moderate	Sectioning	Stereomicroscope Truebite® color scale

- * The smaller the Age Error and Standard Error the higher the method's Accuracy and Precision.
- ** "Ease of use" relates to the minimum number of measurements and formulas required per method.
- *** "Standard equipment" includes a measuring caliper and a constant light source.

Discussion: When performing age estimation, accuracy and precision are of utmost importance. As Figure 1 graphically demonstrates, the present data indicate that the sectioned methods have a trend (albeit nonsignificant by an ANOVA done on method type, sectioned vs. intact) towards higher accuracy and precision (mean = -.139, SD = 6.98) as compared to intact methods (mean = -2.682, SD = 16.308). This trend might be because direct measurements on sectioned teeth, such as the amount of secondary dentin, are more precise than measurements taken on intact teeth or indirectly from dental radiographs.

The ANOVA and Fisher's PLSD t-testing data show the two Kvaal methods both significantly underestimated true age (Figure 1). They also exhibited high variability and low precision in the present materials. Kvaal's original data gave significantly better regression coefficients for the premolar teeth and to maxillary vs. mandibular teeth (Kvaal, 1994). The relatively small size of the present study (20 teeth) did not permit a subgroup analysis by tooth type, which might have given better results for the Kvaal methods in maxillary or premolar teeth. Therefore, dentists who are analyzing premolar teeth may wish to select Kvaal's method, since it gave regression coefficients in the range of 0.9 for upper premolar teeth.

Another reason to select Kvaal's second method, or Solheim's intact method, is that only these two are applicable to the study of intact teeth in living persons of unknown age, such as war refugees or immigrants without documents. On the other hand, if extracted teeth are available, the data indicate that the forensic scientist can choose a better method. For example, one might choose either Solheim's sectioned method or Johanson's sectioned method in this case. Both offer high accuracy (low mean Age Error) and high precision (high reproducibility and a narrow confidence limit). Fieldwork also imposes unique limitations. In the case of mass fieldwork in primitive conditions, such as a mass grave or battlefield, Lamendin's or Bang's intact method would have an advantage in not requiring a stereomicroscope, a special color scale nor tooth sectioning. In addition, sometimes one must perform age estimates on materials in anthropological collections. In these cases, there may be restrictions on sectioning or the use of other destructive methods. In these cases, high quality measuring equipment is likely to be available, and one might then reasonably select Solheim's intact method.

In all cases, the forensic scientist must remember the inherent imprecision and variability associated with age estimation measurements. Each age estimation method is based on a linear regression with associated confidence intervals. However, the formula only yields the predicted "population mean," in essence, the expected mean for repeated measurements on similarly aged teeth. For an individual tooth, often the focus of a forensic investigation, one must remember to include the method's standard error or confidence interval (plus or minus 1.96 SE) as part of the age estimate, e.g., "the tooth is 50 years old by Solheim's intact method, with an expected standard deviation of 11.5 years."

In conclusion, each presented dental age estimation method provides a different combination of accuracy, precision, procedure, and requires different equipment. The forensic odontologists should evaluate each age estimation case and, in addition to their visual age assessment, chose a method that would best serve their particular case, keeping in mind that accuracy and precision are the main requirements. Finally, it is important not only to generate methods for age estimation but also independently to test their reliability using independent data and examiners.

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Forensic Odontology, Age Estimation, Methods' Reliability

F24 Where Are We From? Using Bioarcheology to Determine an Individual's Residence—The Sequel!

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After attending the presentation, the participant will have: 1) a review and understanding of bioarcheology as it applies to forensic odontology; 2) a review of methods used in bioarcheology to analyze the isotopes found in teeth; 3) results of isotopic analysis of teeth; and 4) an opportunity to make conclusions regarding the teeth analyzed and their possible use as a forensic technique.

This program will review and expand upon the initial presentation of bioarcheology in forensics as presented at the Annual Meeting of the AAFS in Seattle, WA in February 2001.

Bioarcheology is used to analyze the chemical components of hard tissue (teeth and bone). The chemicals are stable over time and therefore offer a permanent record for archeologists to study. These chemicals are carbon, oxygen, nitrogen and strontium. The isotopes of these chemicals reveal information about an animal's diet, health, disease and residences.

Teeth develop in a predictable chronological order. As they develop, the forming enamel has carbon, oxygen, nitrogen and strontium deposited as isotopes of these elements. Food uptake provides these elements. Since food comes from local and distant sources, inferences and even firm conclusions can be made as to where the food and water originated from, hence, where a person may have lived. As new teeth develop and people move, the isotopes deposited in their enamel changes. As a result, a pattern of movement can be established for a person. This was the premise of the prior year's presentation.

In ancient archeological samples analyzed, the technique of isotope analysis is valuable in determining residence and movement since the samples are stable and unaffected by modern travel, import and export of food. This year's presentation will show the results of the isotopes present in teeth. The information will be used to determine if the premise of analyzing a person's isotopes found in his/her teeth in serial order of development can be used for modern forensic investigation to assist in tracing a person's residences and movement.

Bioarcheology, Isotopes, Identification

F25 Marketing Forensic Odontology— Educating the Public

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The goal of this research project is to present the fundamentals of a training seminar being instituted in the state of Wyoming. This seminar is being offered in each county to educate health care professionals, law enforcement officers, and social workers in the recognition of bite marks as a component of a crime.

Case example: Susie and Mark had been living together for a few short weeks. They decided to go out this particular evening. Mark apparently had a bit too much to drink, as was often the case. They went back to their apartment where Susie reported she was tired and went to bed. Mark followed and did not accept her rejections to his advances. Mark forced himself upon Susie. Not only was she sexually abused; she was also reportedly slapped and bitten. The emotional trauma she endured was tremendous.

Law enforcement officers were summoned, along with a representative of C.A.R.E.S. (the domestic violence and sexual assault task force). Following a "thorough investigation" by the police, it was concluded that no crime had been committed. Later, the C.A.R.E.S. representative overheard one of the officers say, "It was consensual sex. She probably deserved what she got."

Many social workers have admitted that they have witnessed what they thought might have been bite marks following domestic disputes. Yet, the forensic odontologists are not being utilized.

It was decided to plan a seminar to educate lay people regarding the recognition of bite marks. The plan is to market forensic dentistry by educating those people who might come in contact with a bite mark case. This would include sexual abuse, child abuse, and elderly abuse. The course will be offered to law enforcement officers, health care professionals (physicians, dentists, chiropractors, nurses, ambulance attendants), psychologists, coroners, social workers, and C.A.R.E.S. representatives. The seminar is planned for either single counties in the more populated areas or multiple counties in the more rural regions.

Continuing education credit is made available through the various organizations (POST training, American Medical Association, Academy of General Dentistry, local and national psychological, nursing, and social work associations).

The agenda of the workshop is as follows:

- I. Introductory remarks: Discussion of the American Academy of Forensic Sciences and the American Society of Forensic Odontology. Explanation regarding the role of the forensic odontologist in law enforcement and mass disasters.
- II. History of forensic dentistry: Ancient anecdotal evidence of "forensic dentistry" up through recent famous cases.
- III. Human identification: Explanation of the procedures used to identify humans through their antemortem and post-mortem dental records. This includes everything from the identification confirmation of a single decedent, to the unknown body, to the multiple casualties of a mass disaster.
- IV. Pattern injuries: Many law enforcement officers are familiar with this topic. However, it is quite often new material for the majority of attendees.
- V. Bite marks as pattern injuries: The main emphasis is recognition of a possible bite mark, especially in the abuse cases.
- VI. Classifications of bite mark severity: Case presentations including the component injuries and variations of the prototypical bite marks. In this manner, those attending the seminar are introduced to more examples than just the stereotypical double arch bite mark.
- VII. Statistics: Data regarding the incidence of biting in sexual abuse, child abuse, and abuse of the elderly. Statistics regarding location of bites in the various circumstances.

VIII. Bite mark workup: Case presentation including use of the computer for production of overlays.

IX. Protocol: Handling/documentation of the bite mark following the commission of an alleged crime. Also, the types of cases in which the forensic odontologist should be summoned.

X. Homicide case example: A college coed was brutally bitten three times on the inside of her left thigh and once on her left shoulder before she was slain. The murderer was arrested and confessed to the killing. A health care professional from the area commented after the arrest, "There were a lot of girls who have been to my office who told me that he had bitten them."

It is with the highest hopes that this type of educational seminar will aid in identifying abuse victims and possibly save a life in the future.

Bite Mark, Bite Mark Recognition, Abuse

F26 Mass Fatality Incident Training of Dental Identification: Applying the Gould Technique

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The goals of this research project are to promote the techniques, modifications, evaluations, and outcomes used for a new mass-disaster training workshop course.

This paper will discuss the application of Dr. George Gould's publication, "Graphic Mock Victims: A New Approach to Mass Disaster Training Programs" (Forensic Odontology News, ASFO, vol. 19, no. 1.) as a method to teach dental identification for a Mass Fatality Incident (MFI). Its objective is the establishment and preparedness of mass fatality teams, familiar and practiced with protocol and colleagues, in local jurisdictions across the country.

With volunteers from his district dental society, Dr. Gould conducted his program in four 4-hour sessions including topics and participation workshops for a) recovery methods, b) ante-mortem records analysis and construction, c) postmortem jaw fragment chartings, d) the comparison process, and e) tabulation of results.

A condensed version of Dr. Gould's program was presented in April 2001 at the University of Maryland Dental School in two 2-hour sessions. This introductory program in mass fatality dental identification was limited to second semester senior dental students. Prior to the first session, the nine enrolled dental students viewed the Discovery Channel's presentation of "Inside the Disaster Mortuary Operations Response Team - DMORT."

During the first session, an overview of forensic odontology techniques was presented concentrating on MFI recovery methods, computer coding protocol, and DMORT. In particular, guidance to continuing education in forensic odontology was emphasized. Sensitivity to human remains and attention to accuracy were detailed in a slide presentation from past MFI's. At the conclusion of the first session, the three dental teams, each composed of three senior students, were given a set of seven, mock ante-mortem victim records. Their assignment for the second session was to meet as a team and complete a construction of seven current ante-mortem charts from the initial examination charting and treatment progress notes, which were issued. The mock records included some intentional flaws representing mistakes frequently encountered in an actual MFI. Examples were tooth number errors, various numbering systems, left side/right side reversals, and filing errors due to similarly named patients/victims.

In Dr. Gould's terms, "Graphic Mock Victims" were constructed by first photocopying the correct ante-mortem dental charts. To simulate lifetime dental care, treatment procedures were added to this next-generation of photocopies, mimicking treatment rendered after diagnostic films and initial examination charting. The Gould method was modified to include both clinical & radiographic information on the chart of each mock victim.

Continuing his technique, jaw fragmentation was simulated by cutting, and therein, converting these next-generation postmortem charts into unknown jaw fragments and each labeled with a cryptic number for faculty tracking. For preservation and reuse of the graphic mock jaw fragments, all were laminated.

At the second session, the post-mortem laminated chart segments, simulating jaw fragments, were scattered in a classroom of 100 fixed and numbered amphitheater seats. The 3-member teams recovered the graphic jaw fragments, documenting grid locations, and charting the post-mortem data using computer-sorting codes. Due to the small number of “victims”, comparisons of the ante-mortem and post-mortem data were completed manually.

During this Senior Mini-Course, the students were successfully able to identify the mock victims, discriminate the flawed ante-mortem data, and recognize fragments that made no contribution to dental identification (i.e., jaw segments with no restorations or abnormalities). The program received enthusiastic endorsements from the students who hope to continue their forensic education and training after graduation.

All elements of Dr. Gould’s program, as applied at the University of Maryland, were found to be effective and easy to perform. As the latter fulfills the objectives, this program should be used in MFI training. Time, however, allocated for the program was evaluated as inadequate and an increase has been approved for the next academic year. Offering this program in the dental school setting has served to raise awareness among all dental students about the need for forensic dental teams and continued training in a small group environment. Regarding this awareness, it was interesting to note that, of the 20 Senior Mini-Courses offered in the basic and clinical sciences, this workshop course was the first to fill registration capacity, on the first day of enrollment.

Mass Fatality Incident, Training, Odontology

F27 The Crash of LOT Flight 007: Victim Identification

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The objective of this paper is to chronicle the contribution of dentistry to the identification of victims of one of the most significant aircraft tragedies involving American athletes—the March 1980 crash of a Soviet-made Ilyushin 62 Polish jetliner, which resulted in the deaths of 31 Americans, including a 22-member U.S. amateur boxing team.

The crash of LOT Airlines flight 007 near Okęcie Airport in Warsaw, Poland, on March 14, 1980, took the lives of 77 passengers and 10 crewmembers and, at the time, was the worst air crash in Poland’s history. The deaths of the 14 American boxers rank as the second worst foreign air tragedy involving American athletes. The loss was especially devastating to the American amateur boxing ranks because many were contenders for the U. S. Olympic team. The Ilyushin 62 exploded on its approach to the airport as a result of an engine-component failure and crashed and burned in an embankment and 40-foot-deep moat surrounding an old military fortification that was 950 meters from the approach end of the runway. The literature has no reports of participation of the Armed Forces Institute of Pathology (AFIP) identification team in this mass disaster. Therefore, this presentation will discuss the valuable role that dentistry played in the investigation and identification process with emphasis on the unique problems encountered and lessons learned.

At the request of the Polish government, the U. S. State Department directed an AFIP and Federal Bureau of Investigation forensic identification team to Warsaw, Poland, to aid in the identification of the Americans who perished in the disaster. The U. S. State Department

directed the AFIP Oral Pathology Department to assemble a six-member dental response team and to deploy within 24 hours. To accomplish dental identification, a U. S. Air Force dental team composed of four dentists and two dental technicians was assembled.

The nature of the crash and strict constraints that the government imposed caused a myriad of unusual and frustrating problems for the U.S. identification team. Authorities would not allow the U.S. team to inspect all of the remains. In fact, the dental team was allowed to examine only 34 victims. Of the 31 American passengers, 30 were positively identified. Dental, fingerprint, and anthropologic methods of identification were used whenever possible, but visual recognition and personal effects had to be relied on heavily to assist in the identification. Dental means identified a total of 11 (37%) of the 30 identified victims. Dental comparison was the only means of positive identification for eight (27%). Dental plus visual (2 victims) and dental plus fingerprints and visual (1 victim) accounted for three positive identifications or 30%. Dental findings were supportive in one positively identified victim. Fingerprint comparison was the most successful with 13 (43%) identifications.

The authorities also placed strict time constraints on the U. S. identification team, insisting it complete its identification efforts in a limited amount of time. Other problems that directly affected the AFIP dental team were poor identification-center facilities, extremely cold temperatures in the morgue, an inability to process dental radiographs on site, an inability to have complete control over chain of custody, and minimal time allowed in the ID center. Preparedness played a key role in the team prevailing over many of the unexpected problems and was directly responsible for the success that the dental team experienced.

This presentation will review the dental-team organization and methodology and problems that the team encountered including the lessons that it learned. The experience gained in this mass disaster has significantly enhanced the AFIP dental team’s knowledge and ability to prepare for and work under adverse conditions and circumstances when it is deployed to disasters outside of the United States.

Dental Identification, Mass-Disaster Investigation, Sports

F28 The Sharon Reynolds Case

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The goals of this research project are to categorize the differences between stab wounds and canine bite mark. Patterning on clothing, blood smears, skin, avulsed tissue and bone will be shown and discussed. The results of two autopsies will be reviewed and the forensic evidence addressed. Expert witness opinions and their legal ramifications will be reviewed.

On June 12, 1997 seven-year-old Sharon Ann Reynolds was found dead and mutilated in her basement. Her mother, Louise Reynolds, was charged with second-degree murder and denied bail.

A dentist was consulted and arrived at the conclusion that the marks on the body “are completely inconsistent with dog bite marks be they either domestic or wild.”

The pathologist summarized his findings and testified at the preliminary hearing as follows. There were:

- a. Multiple cutaneous abrasions and contusions,
- b. Exsanguination, and
- c. Excision of the scalp.

These findings attributed the cause of death to more than eighty stab wounds created by scissors and/or knives.

The prosecution halted judicial proceedings in 1999 pending the results of a second autopsy ordered by the coroner and consented to an application for bail for Louise Reynolds. As part of her condition for release to a halfway house, she was permitted no contact with her surviving four children or any of the witnesses in the case.

Sharon Reynolds' body was exhumed and another pathologist performed a second autopsy on July 13, 1999. Present at the autopsy were the original prosecution pathologist and odontologist and the defense counterparts. The second pathologist concluded, "a dog was responsible for at least some of the injuries sustained by the decedent, and the possibility that a weapon was also involved in the infliction of injuries is not excluded by this second post-mortem examination."

The prosecution consulted many other experts before the scheduled trial of February 7, 2001 including fiber expert, botanist, animal behaviorist and anthropologist.

The prosecution dropped the charge against Louise Reynolds on January 25, 2001. "The Crown no longer has proof that this death was caused by stab wounds and therefore no longer has a reasonable prospect of conviction."

Louise had spent almost four years awaiting trial. The following week a seven million dollar lawsuit was launched against the original pathologist, the odontologist, the law enforcement agency, and the prosecutor's office for malicious prosecution, false imprisonment, and gross negligence.

Bite Mark Recognition, Stab Wounds, Clothing

F29 Proper Patterned Injury Documentation... The Key to Accurate Bite Mark Analysis

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The importance of proper photographic documentation of patterned injuries will be emphasized as the key factor controlling accuracy in bite mark analysis.

As a general rule, the strength of an opinion in bite mark analysis is controlled by two key factors - the uniqueness of the dentition and the amount of detail in the bite mark. While accurate documentation of a suspect's dentition is usually not difficult, the same cannot always be said for accurate documentation of a patterned injury such as a bite mark. In fact, it is often the central issue of disagreement among experts in bite mark investigations. There are many methods of documentation of patterned injuries on skin such as photography, tissue excision, tissue transillumination, impressions of three-dimensional characteristics and scanning electron microscopy. Despite the many methods of documentation that exist, photography remains the principal method of documentation of patterned injuries on skin. Therefore, for the purpose of this presentation, only photography will be considered when discussing documentation of bite marks and other patterned injuries. Optimal patterned injury documentation is important not only as a factor that controls an opinion in bite mark analysis, but in some cases it can make the difference in the determination of whether a patterned injury is indeed a bite mark. Although subjectivity cannot be eliminated as a variable in bite mark analysis, it is important to minimize this factor as much as possible. Within the context of sound science, procedures that reduce subjectivity or increase objectivity should be emphasized. Certain factors that introduce subjectivity into patterned injury documentation can be controlled while others cannot. For instance, postural distortion of patterned injuries on skin surfaces such as breasts and buttocks cannot be controlled. On the other hand, photographic distortion of patterned injuries on skin can be controlled by means of proper photographic techniques. Therefore, the use of proper photographic techniques when documenting patterned injuries on skin is critical to the accuracy of any subsequent analyses. Unfortunately, in many cases, the individual documenting the patterned injuries is not the same person that will be conducting the subsequent analysis. This creates a recognition problem that often turns into a communication gap for the individuals involved. In other words, the person gathering the evidence doesn't know what the person that will analyze it needs. As a result, the Forensic Odontologist is all too often presented with evidence for analysis that is inadequate in varying respects. In some cases, the photographs may be missing something basic like a scale of reference. In other cases, the inadequacies may be something more subtle such as improper angulation of the camera. In any case, the usual

result is that an inordinate amount of time is spent trying to recover evidence that could have been documented properly in the first place. In order to avoid this dilemma, one of two things should be done: 1) personnel who will conduct the analysis should document the evidence; 2) personnel who document the evidence should be trained in proper photographic techniques based on the needs of the analyst. Although modern technologies have provided us with the ability to overcome some problems related to quality of evidence, in my opinion, this is not meant to be a substitute for proper evidentiary documentation. Image enhancement should be used to increase the quality of evidence that can stand on its own, not to prop up evidence that would "fall on its face" otherwise. We must recognize that the use of techniques like image enhancement introduce another variable into our analysis. If our goal is to minimize variables as much as possible, then we must determine whether the benefit of using this technique outweighs the risk of introducing another variable into our analysis. In either case, proper initial documentation of evidence should minimize subsequent disagreements about the quality of the evidence used in bite mark analysis. Examples of common mistakes in photography of patterned injuries on skin will be demonstrated.

Bite Mark Analysis, Patterned Injury Documentation, Photographic Techniques

F30 The Mother of All Multi Bite Marks

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This is an exercise for the attendee odontologist to select the appropriate level of identification terminology from the ABFO bite mark guidelines he or she would choose as compared to the choices of the present. Bite marks not only have their own forensic value, but also can prompt law enforcement creativity to use other investigative techniques to build a case.

This case is unusual in that there are multi bite marks on the victim, done over a multi-period of time, with multi-suspects, in multi-jurisdictions resulting in multi-criminal charges, and involving multi-forensic odontologists. At the time involved authorities called it the worst case of child abuse ever seen in Jacksonville.

A ten-month old black female was hospitalized in pediatric intensive care with multiple fractures, including skull and arm, cellulitis, particularly on the face, and a large number of patterned injuries, many superimposed over each other, in different stages of healing. With the infant on intensive care support, a team of nurses and police manipulated the victim to obtain reasonable bite mark photography under the circumstances. The infant eventually recovered and was placed in foster care by the State.

While the photographs were deemed suitable for comparison, the challenge was the decision making under ABFO guidelines as to the status of each injury pattern and whether each was suitable for comparison, and at what level. At the request of the odontologist, medical examiners viewing the photographs timed the bites as from six days to six weeks old, or more. None were timed as "recent," meaning over the last few days.

The only suspect at the time was the mother who had been in Florida for about a week, and who was being held on child neglect charges, having been seen by neighbors carrying the infant around for days in this condition. The mother's dental exemplars were taken by court order. No evidence of her peg upper laterals were seen in any curvature deemed a "possible" or a "probable" bite mark, so the odontologist ruled her out as a biter; charges against her, then, stood as "neglect" rather than "abuse."

While in custody, the mother maintained the abuser/biter was the purported father who remained in the adjacent state of Georgia, and whom she had left about a week before coming to Florida. Since the incarcerated mother remained in phone contact frequently with the father, detectives in Jacksonville began working with the Georgia Bureau of Investigation

agency in Adel, and, with the mother's cooperation, a legal phone recording strategy was initiated to help build probable cause for taking his dental exemplars.

To limit travel time and expenses, the Florida odontologist enlisted the help of a dentist in Adel, Georgia, and sent him certain dental materials for use in the protocol for taking evidence from the suspect. Having developed probable cause, the GBI served a search warrant on the suspect and the enlisted dentist obtained the inventory requested. The GBI delivered the inventory to the Florida odontologist via chain of custody through the Jacksonville Sheriff's Office.

The father's exemplars were compared to the only two certain human bite marks deemed suitable for comparison for a higher level of identification.

There was evidence of intentional alteration of certain teeth as seen in the models of the father's teeth, particularly the incisal embrasures of the lower anteriors.

The odontologist was not able to demonstrate a material difference between the real bite marks and test bites in skin using the models taken during the search warrant that would have been after intentional alteration.

Bite Marks, ABFO Guidelines, Intentional Alteration

F31 The Victim Bites Back

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Attendees will be able to understand and visualize the characteristics of bite mark patterns, analysis of the patterns, and use of information obtained to identify or exclude the suspected biter.

Bite marks on human skin are pattern injuries, usually a double arch pattern. Each one has class characteristics that identify it as a bite mark and individual characteristics, which can relate the pattern to a specific dentition. Individual characteristics may be used to include by points of concordance or to exclude by dissimilarities.

Properly analyzed and compared, these pattern injuries may be a very important and sometimes critical factor in the outcome of a case.

Mr. Grover Freeman, age 54, was an extremely successful, popular, and well respected attorney, specializing in representing defendants in medical malpractice cases. He resided in Carrollwood, an upscale area of Tampa, Florida, with his third wife of four years, Constance, age 51. His first wife had died of cancer in the early 1970s. In 1986 he married Katherine, now 41, and divorced her in 1996. It appeared to be an amiable divorce according to friends and he maintained a cordial relation with Katherine and their daughter, who lived only several blocks away.

All of this abruptly changed late in the evening of May 15, 2000, when Katherine, entered her ex-husband's house using her own key. Advancing to the upstairs bedroom, she approached Mr. Freeman, who was in his waterbed, and proceeded to shoot him 14 times with a 9 mm semi-automatic pistol. He survived long enough to reach for the telephone and call 911. Constance, witnessing the shooting from the bathroom, hid in the bathroom closet but was discovered by Katherine. Katherine attempted to shoot her but the pistol jammed and a physical battle ensued. Constance was choked and pistol whipped but managed to escape when the fight progressed to the bedroom balcony. Constance told investigators she had bitten Katherine on the face.

On May 16, 2000, at 6:00 a.m., Katherine's Cadillac was found abandoned on the hi-rise middle span of the Sunshine Skyway Bridge over Tampa Bay, where she had jumped in a suicide attempt. She was pulled alive from the water 200 feet below by St. Petersburg Fire and Rescue units about 40 minutes later and transported to Bayfront Medical Center. She underwent extensive surgery for two broken legs, broken pelvis and internal injuries, remaining in critical condition. Tampa

authorities charged her with first degree murder, armed burglary, and aggravated battery.

On May 18, 2000, under an "Order to Compel," Katherine Freeman was examined by Barry Lipton, DDS, in the presence of the attending physician and Det. Michael Willette of the Hillsborough County Sheriff's Office and Deputy Latta Parker of the Pinellas County Sheriff's Office.

The injuries were photographed with a Pentax camera using Konica VX 100 film and a Polaroid Macro 5 camera using Polaroid 990 film. An ABFO #2 scale was utilized. The soft tissue injuries in the region of the left eye were deemed to be a bite mark of human origin.

On May 25, 2000, a dental exam was performed on Mrs. Constance Freeman at the office of Dr. William Robinson of Tampa, Florida. The exam consisted of Polaroid and 35 mm color photographs, both intra and extra oral. An extra oral exam was performed for facial symmetry, temporomandibular joint function and maximum mandibular opening. All soft tissue was within normal limits and she had a maximum opening of 50 mm. Dental impressions were made using Jeltrate Plus Alginate and Coltane President Soft Base Putty. Models were poured using Type II Dental Stone (Alginate) and quartz die stone and orthodontic plaster (Coltene).

Acetate overlays were made of the contracting surfaces of the incisal edges of the models. These were compared with the 1:1 ratio photographs of the bite mark present on the left eye area of Katherine Freeman. This comparison revealed distinct incisal edge characteristics consistent with the most prominent incisal point contacts of Constance Freeman's dental arches.

On March 17, 2001, Mrs. Katherine Freeman changed her plea from Not Guilty to Guilty to avoid the death penalty, and is currently serving life in prison.

Odontology, Bite Mark Evidence, Homicide

F32 The Topographic Mapping of Teeth For Overlay Production In Bite Mark Analysis

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The goals of this research project are to present an innovative new technique for the pseudo-3D mapping of teeth for use in computer generated bite mark overlays. This technique will significantly decrease the subjectivity in bite mark overlay production, as it exists today, especially with computer-generated overlays.

The current methodologies for the fabrication of transparent hollow volume overlays, to be utilized during bite mark analysis, all involve some degree of subjective decision making by the forensic odontologist involved. Between them, the authors Bowers and Sweet have published the majority of information related to the fabrication of computer generated bite mark overlays. However, they are divided concerning the degree of subjectivity versus objectivity when using the digital method. The reduction, to eventual elimination, of such subjectivity is a continuing goal of forensic odontology.

This paper will present a systematic method for the topographic mapping of the teeth from casts made from the dentition of suspected biters. The fabrication process involves the sequential sectioning of the stone dental models made from any suspects, in a predictable, reproducible, and accurate fashion. The subsequent overlays are produced to have a topographic appearance, or pseudo-3D effect.

Often the wealth of information contained in the bite mark injury cannot be fully related back to the injury process and the teeth that created the mark. By utilizing the topographic mapping of teeth, more of this previously unused evidentiary information can be developed and interpreted by the examiner.

Bite Mark Overlays, Computer-Generated Overlays, Topographic Tooth Mapping

F33 Dynamic Courtroom Presentation of Bite Mark Evidence Via Digital Overhead Camera and LCD Projector

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The purpose of this presentation is to provide information to forensic odontologists that will allow them to testify in bite mark cases using a digital overhead camera projection technique. This technique allows a dynamic, “live” or real time comparative presentation to the court detailing the bite mark pattern as related to the dental arches in question.

The actual case related to this presentation involved a breaking and entering crime that resulted in the murder of one individual and the rape of another. The perpetrator entered the home of the victim through the back entrance wearing a stocking over his head. He then murdered the husband in view of his wife and child by gunshot wound to the head at point blank range. The wife of the decedent was then raped and sodomized at gunpoint. During this act, several bite marks were inflicted on the victim’s neck and shoulder. Bite mark testimony was given at trial and the accused was convicted of capital murder and given the death penalty.

Standard procedures were implemented to compare bite patterns on the skin of the victim to the dentition of the suspect. The comparison yielded many concordant points involving several distinctive dental conditions. However, the purpose of this presentation is not to debate the bite mark comparison procedures but to discuss the method used for courtroom testimony of the bite mark evidence. This involved the use of a digital overhead camera stand (Sony, VID-P100, Video Presentation Stand) in conjunction with a LCD data projector (Sony, VPL-CS1) allowing a dynamic or “live” demonstration.

The digital overhead camera has some similarities to the traditional “overhead projector” except that the digital version can capture live images of three-dimensional objects such as dental models. It also provides the projected image of photographic evidence and written text without the necessity of conversion to a transparency. This is done using reflective rather than transmitted light and by the use of a mounted video camera. Also, by changing the digital overhead’s light source from reflective to transmitted, radiographs of all sizes may be projected. The overhead also has a very robust zoom feature which can be quite useful in demonstrating small and detailed structures.

As the image is captured by the video camera, the digital signal produced by the apparatus is directly routed into the video input of a LCD data projector which projects the image onto a conventional slide-viewing screen. Since the digital camera is providing a continuous, live image to the projection screen, a dynamic rather static comparison of the evidence and/or exhibits can be illustrated to the court. This can involve any normal comparison technique such as placing bite mark transparencies and other types of exemplars onto bite mark photographs or even the dental models themselves. Or, dental models may be directly related to one-to-one bite photographs which can be observed by the court in real time.

In summary, the digital overhead camera in conjunction with a digital data projector, is useful in any type of evidence presentation in which a real time, three-dimensional comparison is beneficial. Further details of this technique and the case in which the technique was used will be discussed.

Odontology, Bite Mark, Digital Overhead Camera

F34 Bite Mark Analysis Utilizing the Computer—Pitfalls and Brick Walls

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After attending this presentation, the participant will gain an overview of several of the applications of the use of computers in the analysis of bite mark injuries.

The analysis of bite marks has generated a great deal of interest and concern in the forensic dental and legal community. The matching of a suspect’s dentition to a bite mark injury has been the pivotal piece of evidence in many criminal trials. Because of the impact of this type of evidence, the validity of the bite mark analysis has become a frequent target for defense attorneys. Questions regarding reliability, error rates and peer review of bite mark evidence are becoming more frequent. Many members of the forensic odontology community have attempted to address these concerns by developing standardized methodologies for the analysis of bite marks, some of which use computer applications. The purpose of this presentation is to demonstrate the author’s application of computerized analysis to four bite mark injuries and the technical considerations involved in these analyses.

Case 1: The victim was a deceased 18 month-old Caucasian male. Two injuries were evaluated, one was a mature scar on the forearm. The injuries were photographed using conventional film. Three suspects were identified and dental records were made for each of the suspects pursuant to a court order. Models of the suspects’ dentitions were photographed and tracings were made of the biting surfaces of the teeth. The tracings were superimposed over the photograph of the injury and then scanned into the computer.

Case 2: The victim was a deceased African-American male with a bite mark injury on his left shoulder. The injury was photographed using conventional film. Three suspects were identified and dental records were made for each of the suspects pursuant to a court order. Models of the suspects’ dentitions were photographed and the photographs were scanned into the computer. Tracings were drawn by hand using the pen tool in Adobe® Photoshop®. Photographs of the injury were also scanned and the images of the injury and suspects’ dentitions were superimposed using the computer.

Case 3: The victim was a deceased Caucasian male with a bite mark injury on his left shoulder. The injury was photographed using conventional film. Four suspects were identified and dental records were made for each of the suspects pursuant to a court order (one of the individuals was not presented with a court order; he voluntarily submitted to the dental evaluation; written and verbal consent were obtained prior to the examination). Models of the suspects’ dentitions were directly scanned and tracings of the biting surfaces of the teeth were traced using the magic wand tool in Adobe® Photoshop®. Photographs of the injury were scanned and the images of the injury and suspects’ dentitions were superimposed using the computer.

Case 4: The victim was a living 10 month-old African American male with a bite mark injury on his forearm. The injury was photographed using conventional film. Four suspects were identified and dental records were made for each of the suspects pursuant to a court order. Models of the suspects’ dentition were directly scanned and tracings of the biting surfaces of the teeth were traced using the magic wand tool in Adobe® Photoshop®. Photographs of the injury were scanned and the images of the injury and suspects’ dentitions were superimposed using the computer. One of the striking components of the bite mark injury was the presence of a large midline diastema. Three of the four suspects exhibited a midline diastema. This finding necessitated application of the measurement capabilities of the Adobe® Photoshop® software.

A different level of computer application was used in each of these four cases. Each of these cases presented different technical requirements as well as technical difficulties. The outcomes of these cases will also be presented.

Bite Mark, Computer, Analysis

F35 A Unique Way to Analyze Bite Marks Using 3-D Laser Scanners and Comparative Software

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The goal of this research project is to demonstrate a new way to analyze tooth mark pattern injuries also known as bite marks. This study is a continuation of the one we presented in 1995. At that time we attempted to use a three-D laser scanner to produce two cad-cam files, one of the bite marks and one of the teeth that produced the bite mark. We tried to meld the two files and visually match them electronically. The results were interesting but inconclusive. Now, we are taking this idea one major step forward by using comparative software commonly used by manufacturers, such as the auto industry, to check for accuracy of parts. The system can also show points of commonality between a pattern injury (bite mark) and the object making it.

Since the 1970s, the American legal system has accepted bite mark pattern injury comparisons, such as used in the Bundy case. However, with the Supreme Court ruling in *Daubert vs. Merrill Dow Pharmaceuticals*, the Court listed several factors that the trial judge should consider in evaluating of expert scientific testimony.

These include:

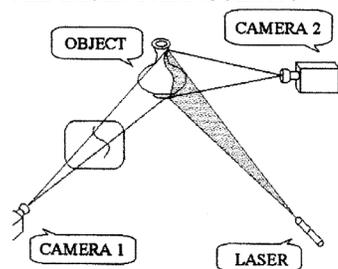
1. Whether the technique or theory can be tested.
2. Whether the technique or theory has been subjected to peer review and published
3. Whether the technique or theory's error rate is known
4. Whether the technique or theory is generally accepted within the relevant scientific community.

In the past, bite marks have not provided the strongest basis for scientific findings, rather they lead to interpretive findings that tend to be divisive. This study seeks to eliminate the subjective qualities from bite mark analysis, thus helping to meet the "*Daubert*" standards as set by the courts.

With the cooperation of Peter D. Frade, PhD, Interim Departmental Chair and Associate Professor, School of Mortuary Science at Wayne State University, Detroit, Michigan, the first phase of the study was completed. Utilizing an injection-molded model of a human dentition, mounted on a vice grip, we inflict bite marks on a cadaver. We documented the bite marks using the technique outlined in the ABFO guidelines for the collection of bite mark evidence. First, photographs of the bite marks were made in both color and black and white, with and without the AFBO ruler. Next, impressions of the bite marks were taken in a resilient dental impression material (i.e., Examix by GC Co.). All impressions were poured in Die-Keen Dental Die stone, per manufacturer's instructions, using a Vac-u-spat machine. A model of the deepest bite mark, as well as the model that inflicted the wound pattern injury, was sent to a third party for scanning. After scanning, commercially available software was used to see to what extent the bite and the original model correlate to each other.

Scanning Methodology:

THE LASER TRIANGULATION



The sensor projects a laser plane on the surface of the object to be measured. The section is sampled by a CCD camera, which supplies 600 points over a 25mm width. The surface is then digitized with laser lines by moving the sensor over the object. This creates a set of sections that characterizes the surface. Each point is referenced in the laser space. Knowing the position of the

sensor, through its software interface and installation on a CNC (Computer Numeric Control) machine, calculates the point coordinates.

Measuring accuracy is achieved by the registration of the laser plane with the machine space. A small sphere, approximately 10mm in diameter, is installed on the machine bed to align the sensor. Four available identifiers, -x, +x, -y, and +y, are used to establish positioning. These identifiers relate the sensor's orientation to the machine bed and its indexed position at 0, 90, 180, or 270 degrees. Moving the sensor over the sphere at all four identifiers through the CNC's control, captures it's position with the laser's software. The positions displayed by the CNC's control are checked against the displayed position of the software."

"Once the CNC mill and sensor are calibrated, an object can be digitized."

"Once the images are digitized comparative software by Imageware is utilized. Imageware takes your nominal CAD geometry, compares it to your measured data and tells if your part meets specifications." In our case, it shows which points of reference match and the degree of match.

Conclusion: We have taken the rigorous parameters required by industry and applied them to the needs demanded by our profession and the courts. These parameters require that subjective results be replaced by a more intense and easily reproducible method in which objectivity is paramount.

Odontology, Three-D-Scanner, Comparative Software

F36 Digital Analysis of Evidence Photographs (Bite Mark): Automated Rectification of Photographic Distortion, Resizing to Life Size, and Rotation of Images

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After attending this presentation, the participant will understand the methodology and value of automatically (1) digitally rectifying certain types of photographic distortion within evidence photographs, (2) resizing chosen portions of the image to life size or any other scale, and (3) rotating the image along any chosen axis.

It is of utmost importance that the evidence photographs used for forensic analysis are an accurate representation of the actual objects photographed. In many cases, photographic distortion exists within these images. Also, they are rarely scaled to life size. These problems can be overcome using digital technology that has been available for a number of years. One problem with these procedures is that some of the steps involved can be rather tedious and difficult to accomplish properly. Another problem is that each investigator's results may vary depending on his/her experience and expertise.

The authors have developed a software program that automates these three procedures. This program is a plug-in application to be used with the image-editing program Adobe® Photoshop®. Once the evidence photo is digitized and imported into Photoshop®, it is evaluated for photographic distortion, relative size, and rotational orientation. If discrepancies exist in these areas they must be corrected. Data points are selected within the image defining the portion of the image to be corrected. A dialog box is then displayed where real life linear dimensions and angular values of the known object are entered. The program will then adjust the image to the given parameters. The image can be rectified relative to either rectangular (scale or ruler) or circular (reference shape or coin) shapes within the image.

Images can be quickly and accurately rectified, resized, and rotated using this software and suggested procedures. More importantly, accuracy, consistency and reproducibility are increased when image rectification is carried out in this manner. Investigator subjectivity and other variables inherent with manual rectification methods are also reduced.

Digital Analysis, Rectification, Photographs

F37 Teamwork in Action—Integration of the Forensic Sciences During Bite Mark Investigations

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During this presentation, the participant will be taken through the steps involved in a thorough investigation with evidence collection and storage of a known bite mark patterned injury. The participant will learn the specific techniques available when working as a team with patterned injuries suspected to be bite marks including the fields of forensic dentistry, forensic photography, forensic trace evidence, DNA evidence, and forensic pathology.

Relatively recent advances in the forensic sciences have led to the ability to investigate bite mark patterned injuries with greater detail than ever before. Valuable evidentiary quality information can be gathered when the Forensic Dental Consultants work as a team with the Medical Examiners, Forensic Trace Evidence Experts, Forensic Photographers, and DNA Comparison Laboratories. We are fortunate at the Harris County Medical Examiner's Office to have all of these resources available in our Joseph A. Jachimczyk Forensic Science Center, where the county morgue is located. The presentation of the material outlined in this abstract will follow a "bite mark case" throughout the evidence collection process, with particular emphasis on the need for an organized team approach in order to fully gather information that will be of high evidentiary value.

The oral presentation and slide show will thoroughly cover the following aspects of the patterned injury investigation. The collection of patterned injury evidence and metric analysis will be demonstrated in a step-by-step manner, with suggestions for materials to be utilized in the procedures. A practical method for the fabrication and storage of impressions and models of the injury will be presented. Forensic photography methods will be reviewed and demonstrated, including the use of various light sources including white light and alternate light sources. Recommendations for camera types, film choices, and light sources will be presented. The collection and recommended storage of trace evidence will be detailed. The various types of trace evidence that can be found in a typical bite mark will be outlined. General guidelines for the age estimation of the patterned injury will be presented. And finally, a sample of the known biter's DNA will be compared to the DNA collected from the bite mark itself. A brief overview of the evidence preservation and collection follows.

At the scene, the deceased body with suspected bite marks is carefully placed in a sealed body bag and transported to the morgue. Radiographs are taken through the sealed body bag. The bag's seal is removed and opened in the presence of the Forensic Pathologist in charge of the case. Photographs are taken of all aspects of the operation. With the bag open, trace evidence collection begins with the hands and arms. All items collected are photographed in place. Unique items are placed in individual tri-folds. General collection items are placed together and labeled with the case number, date, and the initials of the collector. The tri-folds are sealed with evidence tape and placed in the trace collection bag. Diagrams of the body are used to identify the location and type of items on the body. The order of collection is hands and arms first, then the upper body and lower body. The initial collection uses white light and is followed with a collection at 460 nm using a 550 nm barrier filter. Fluorescing items are collected, cataloged and photographed. Areas that exhibit fluorescence associated with body fluids, including saliva, are collected using sterile water and are retained with DNA analysis in mind. The body is rolled on to the opposite side and the process of evidence

collection is repeated. Each tri-fold is given an alphabetical notation, and this is reflected on the evidence collection diagram. There is a separate collection diagram for the hands with anterior white light, hands with anterior alternate light, hands with posterior white light, and hands with posterior alternate light. The strong visual association between the graphic diagrams, the photographic records, and the evidence collection envelopes keyed to the diagrams are very easy for a jury to use in associating the collected evidence. Once the trace evidence and photographs are completed, the forensic pathologist in charge of the case will request that the forensic dentist proceed to collect forensic dental evidence to serve as further exhibits to present to the jury. It is up to the forensic pathologist to decide whether the dental evaluation should be conducted prior to, or after the autopsy is performed.

The integration of the above outlined Forensic Sciences during bite mark investigations will lead to a thorough collection of evidence and enhance the presentation of the information to the jury. The presence of experts in each field during the investigation can enhance the validity of the evidence presented to the jury and increase the opportunity for justice in the prosecution of the alleged perpetrator of a crime.

Forensic Science, Forensic Dentistry, Bites

F38 Dimensional Non-Contact Morphometric Comparisons of Human Dentitions With Simulated Human Bite Marks

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The audience will understand the value of comparison of 3-dimensional (3-D) images of dentitions and bite marks in a virtual environment.

Of all the tasks confronting the forensic odontologist, the recognition of bite marks, their recording and assignment of provenance are amongst the most problematic. Recently in Australia recurrent problems with bite mark cases have almost resulted in their inadmissibility as evidence. This unfortunate legal position has then been reflected in protocols for the taking of "intimate samples" from suspects in custody. One obvious problem to arise from this position is the unintended danger of excluding the often important exculpatory value of bite marks even in those cases where their inculpatory value cannot be relied upon "beyond reasonable doubt."

Central to the problem of bite mark analysis is the frequently technically insurmountable obstacle of comparing 2-dimensional (2-D) images of a presumptive bite mark with the 3-D replica of the dentition which might have caused it. At the very least, unless forensic odontologists are able to match a particular dentition to a particular set of indentations in a reasonably stable substrate under laboratory conditions, and are able to give some idea of closeness of fit or match, then our expert opinions in the real-world analysis of wounds are going to be legitimately challenged.

Odontologists at the University of Melbourne, together with colleagues from the National Research Institute of Police Science in Japan, have recently been extending the American Board of Forensic Odontology (ABFO) guidelines to include 3-D information of both the study models of the "suspect's" dentition and full color, textured, 3-D images of marks left by that dentition on various parts of the human body.

Scanning of the study models is achieved with conventional laser scanning (Modelmaker H-series laser) and scanning of parts of the body is done using a 3-D physiognomic range finder (Fiore, NEC Japan). Fiore projects a structured sinusoidal light pattern onto the body and by interpreting distortions in the wave form, is able to map the surface of the body to an accuracy of 0.2 mm. Color and texture information is recorded simultaneously. The scanning procedure takes approximately 2.5 seconds.

In a parallel series of experiments 50 study models taken from dental students were digitised by laser scanning and then compared with digitised silicone rubber models of bites made by the same subjects in wax registration rims. Wax was chosen because it is a slightly imperfect recorder of tooth shape, as is human skin. Qualitative comparisons of the 3-D datasets of the dentition and the 3-D datasets of the experimental bites were made using 3DStudioMax (version 3.1) which allowed the generation of dynamic quicktime movies. We hope that these manipulable models will help lay people such as jurors to understand the process of comparison. Fully quantitative 3-D morphometric analysis was performed using 3D-Rugle3, a companion software package used to interpret data obtained from Fiore.

Using the ABFO guidelines, a statistical matrix was developed that can be used both as a sieve to exclude those “suspects” whose dentition is very different from the marks recorded either in wax or on parts of the body and to give an objective measure of the degree of difference or similarity between bite marks left by one of a number of multiple “suspects.”

It is our long term intention to continue to develop our series of currently very basic “gold standard” experiments beyond our present capacity to measure teeth and wounds in 3-D. In addition, we aim to record regional distortion of the skin in different poses to the point where we will also be able to interpret different biting conditions.

Bite Mark, 3-Dimensional, Scanning

F39 Unusual Canine Injury Patterns in Australia

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The goal of this research project is to never underestimate the intelligence of the animal kingdom.

Australia is renowned for animal attacks, from great white sharks to deadly snakes and spiders. Dingoes too have had their share of notoriety. Perhaps the most famous of these involved the 1981 disappearance of 10-week-old Azaria Chamberlain from a campsite at the base of Uluru. In more recent times, a 10-year-old boy was mauled to death in May 2001, on Frazer Island, off the Queensland coast.

Dingoes are a wild form of dog found throughout Australia. In size they are midway between wolf and jackal, with a shorthaired coat, usually yellowish in color, bushy tail, erect ears and sharp muzzle. They are carnivorous, and hunt singly or in family groups, but rarely in packs. They are often found as a pure strain or crossbreed around Australian Aboriginal campsites.

The case study that will be presented occurred in 1996 following a fatal vehicle accident in the South Australian outback community of Amata. In accordance with state law, arrangements were made for a post-mortem examination to be conducted on the body of the 18-year-old. This required the body be taken to the Forensic Science Centre mortuary in the state capital Adelaide, a distance of 930 miles. Whilst waiting for transport to be arranged, the body was placed in a zipped body bag and left overnight in a galvanized-iron community shed. When the body was to be collected police were confronted with a distressing sight—the body bag was open and the face of the deceased was mutilated.

The post-mortem injury involved extensive defleshing of the facial tissues from an area extending from the forehead including the right eye

socket, both ears and upper neck. In addition the tongue and thoracic inlet structures were missing. Parallel scratches on the left chest may be associated with claw marks. The results of the vehicle trauma could be clearly distinguished from the subsequent injury, which exhibited no sign of a vital reaction. These facial injuries would have precluded a visual identification. However, since the deceased had already been identified before the mutilation, the chain of custody on the body bag allowed the coroner to accept the identification.

Investigation at the scene revealed dog hairs on the doorframe of the shed. The deceased’s cross-bred dog was discovered lurking in the proximity. An examination of the body bag showed teeth marks and saliva on the zip. There were a number of small puncture wounds on the body bag, consistent with teeth marks, but the bag was essentially intact. Pale hairs, obviously not from the deceased, were also present on the body bag and a possible paw print in dirt was noticed on the bag.

The circumstances indicate that the only explanation for the scene is that the dog 1) opened the shed door, 2) unzipped the body bag, 3) bit the exposed flesh, and 4) closed the door on exiting.

The authors are not aware of a similar recorded instance in the literature.

Dingo, Mutilation, Body Bag

F40 Suspect in the Deaths of Eighteen Prostitutes Convicted of Murder Using Lucis Digital Enhancement Software and Adobe® Photoshop® Software

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The goals of this research project are to apply two software programs to evaluate bite mark evidence and the implementation of scientific methods to identify bite marks.

A twenty-six year old female prostitute was strangled and left dead on a country road in 1991. The only forensic evidence found was a bite mark on the left breast of the victim. A suspect was arrested but was released because the medical examiner could not determine when the bite mark was made in relation to her death. In 1998, it was determined in order to solve this case, the time of death and the time the bite marks were inflicted had to be established. The suspect’s dental casts were used to make bite marks on a volunteer’s arm to determine when the bite mark was made in relation to her death. The Polaroid Spectra camera was used to photograph the arm in order to determine the longevity of the bite marks. Photos were taken up to two hours and then evaluated to determine the stability of the bite marks. The series of test bite marks proved that the healing and disappearance of the marks was consistent with repeated tests. This was done many times over twelve months. It was determined from the study that the victim was bitten approximately ten to fifteen minutes before she was strangled. The suspect was indicted and a trial was held in January, 2001. The bite mark photo was digitally enhanced with the Lucis software program. Both the dental casts of the suspect and the Lucis photo were entered into the Adobe® Photoshop® program. The opacity of the dental casts was adjusted and the teeth were positioned on the bite mark and printed out with the Adobe® Photoshop® program. The court accepted the computerized overlays over the objection of the defense attorney who objected that this is a new technique and no previous court cases were available to evaluate. The jury deliberated six hours and returned with a guilty verdict.

Bite Marks, Lucis, Adobe®

F41 Hammers and Homicides—Three Cases

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The goals of this research project are to familiarize forensic dentist with skull injuries and how they may assist medical examiners and law enforcement investigators.

Over a recent three-year period, the author was requested by law enforcement officers to participate in the forensic investigation of three homicides involving blunt force trauma to the skull, by a high-density object, which ultimately led to the death of each male victim.

In the first case, investigated by the San Diego County Sheriff's Department, Homicide Unit, the murder weapon, a hammer covered with the victim's blood, was found close to the victim's body. Using overlays, the striking face of the hammer was found to be highly consistent with fractures on the skull. Several exhibits were constructed to demonstrate the similarities at the pending Superior Court trial. The suspect was eventually found guilty of second degree murder and was sentenced to 15 years to life in a California state prison in October, 1997.

The second case was drug related and involved the taking of jewelry from the victim, as well as his murder. This crime occurred in San Mateo, California, very close to San Francisco, where his decomposed body was dumped. San Mateo Homicide Investigator Dick Dolan initially contacted the author in his quest for the nature of the weapon that was responsible for several depressed fractures of the victim's skull. One of the blows resulted in a punch-out of the entire thickness of the skull. The resultant fragment was found directly over the brain when the San Francisco Medical Examiner's pathologist performed the autopsy. The opening in the skull from whence the chip originated had the appearance of an old-fashioned keyhole. (An illustration of a hammer wound in the textbook, *Forensic Pathology* by DiMaio & DiMaio was almost identical to the wound in this case.) Since no weapon was ever found in this case, it was the author's mission to find an object that would have caused the skull perforation. Visits to several home improvement centers plus tool specialty shops led to the discovery of a claw hammer with almost the same striking face diameter as the depressed fracture. Furthermore, a slight notch below the round opening of the skull measured within fractions of a millimeter to the neck of the hammer. Not being able to secure volunteers for hammer trauma testing, a watermelon was employed, which produced almost an identical lesion to the skull perforation. The comparisons were made through the use of overlays. Eventually, the defendant was found guilty and received a life sentence without chance of parole plus 100 years.

The third case involved the suspect (a wife) and the victim (her husband) which occurred in February, 2000 in San Diego County. The suspect reported her husband missing and stated that he was wearing running clothes when she last saw him on a rainy afternoon, before she left to tend horses on their small ranch. When he did not return in the evening, she reported him missing to the San Diego County Sheriff's Department. The next day, members of a Search and Rescue Unit found his body several feet from an area where he was believed to have jogged on a regular basis. There was no blood under his body, and his shoes were not muddy or blood spattered. In addition, at the post-mortem examination a small segment of his scalp was found under his T-shirt. Also, a rectangular skull fracture was observed. Pursuant to a search order, investigators, who found blood spatter throughout the bedroom, examined the residence. Based on witnesses' statements and physical evidence at both the residence and the area where the husband's body was found, the suspect was arrested four days after she filed the missing person's report. A homicide investigator, Rick Empson, contacted the author. As in the second case, the author of appropriate sources made a search and two hatchets were selected. One was called a Shingle hatchet, and the other was described as a Drywall hatchet. Both had rectangular striking faces, and both were close to the dimensions and shape of the skull wounds. The use of transparent overlays was used in this case, as well as the other two cases, in

order to demonstrate relationships for the jury panel. She was found guilty and was facing a sentence of 25 years to life at the time of the submission of this abstract.

The author has presented cases in the past involving telephone cord ligatures, handcuff markings, and hair dryer burns among other objects. It is obvious that a forensic dentist has the experience, skills, and techniques for assisting medical examiners, as well as criminal investigators, in difficult cases. Just as pathologists rely on toxicologists and DNA experts, it is obvious that forensic dentists can be relied upon to perform intricate analyses, not only in body identifications and bite mark cases, but in the field of wound recognition as well. The presentation will consist of color slides illustrating the actual crime scenes, the autopsies, and weapons involved in these three cases.

Skull Fractures, Acetate Overlays, Hammers

F42 Evidence Collection and Retention for Unidentified Deceased—A Legislative Approach

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The attendee will learn how a forensic problem may be potentially solved through conceiving, sponsoring, and/or supporting a legislative proposal at the state government level.

Volunteer forensic odontologists have worked with the California Department of Justice Missing/Unidentified Persons Unit for many years to establish and compare databases of dental information for unidentified deceased persons and missing persons for the purpose of assisting in the dental identification process. Currently there are over 2,200 unidentified deceased persons in California. Critical to the potential identification of those individuals is the post-mortem examination, collection of records, and evidence. Over the years, evidence has been lost, destroyed or never collected, making identification of these persons difficult or impossible. It was noted early on that law enforcement jurisdictions appeared to vary widely in their protocols for general forensic evidence collection and specifically dental evidence collection. There was no statewide standard evidence collection protocol in place for cases involving an unidentified deceased person. Dental evidence was sometimes never collected, buried, or even cremated prior to a forensic odontological work-up. A 1999 study by the California Coroner's Association for a DNA pilot project confirmed and demonstrated the wide variations in evidence collection and retention in these cases.

Members of the California Society of Forensic Dentistry (CSFD) met with members of the California Coroner's Association and the California Department of Justice. A legislative proposal was drafted by members of CSFD and presented to California State Senator Richard Rainey (Republican)—a former Sheriff. He understood the problem and agreed to introduce the concept as California State Senate Bill 1736 in February of 2000 on behalf of CSFD. Senator Rainey enlisted the support of Democratic State Senator Jackie Speier. She became a co-author of the bill making this a truly non-partisan bill. SB1736 required that specific evidence would be collected from each unidentified deceased person and maintained indefinitely or until an identification was made. Among this evidence was the maxilla and mandible with their associated teeth. In addition, hair, body fluid samples, and tissue samples are to be collected for future DNA testing (if possible or necessary). Specific additional documentation including x-rays, photographs, and a dental examination are specified in the legislation.

Cooperation among the California Coroner's Association, the California Department of Justice, and CSFD insured that the needs and concerns of all parties were adequately addressed. Testimony was given in the California State Senate and the California State Assembly. Letters of support were written at many stages from many supporting groups. The bill was passed out of both houses of the state legislature and forwarded to the governor for his signature. The bill was passed into law on August 31,

2000 taking effect January 1, 2001. There was never a single vote by any legislator against this bill.

This effort demonstrates how forensic odontologists, coroners, medical examiners, and law enforcement agencies worked together to improve the possibility that an unidentified deceased person would ultimately be returned to his/her home. This legislation could become a framework and an example for other states that may have similar inconsistencies in how and what evidence is collected and retained when a deceased person cannot be identified.

Unidentified Deceased Persons, Evidence Collection, Legislation

F43 The Unique Role of Forensic Odontology in a Homicide Case

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The goal of this research project is to examine the unique use of dental knowledge to resolve issues in a criminal case.

It is generally acknowledged that forensic odontology has three areas of activity: identification of unidentifiable human remains, bite mark analysis in crimes against persons, and expert testimony in dental liability cases. The case being presented shows a unique use of forensic odontology in a criminal case. The ability of the forensic odontologist to examine the dental injuries of a homicide victim is shown. The issue resolved through dental knowledge was whether the suspect in a homicide should be charged with manslaughter in the first degree or second-degree murder.

Forensic Odontology, Dental Injuries, Homicide

F44 Recognition and Reporting of Child Abuse: A Follow-Up Survey of Texas Dentists

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The objective of this study is twofold: First, assess the level of knowledge and attitudes among dental professionals on the important issue of child abuse; and second, evaluate and compare the results of this study with a similar survey conducted in 1986.

Child abuse is a disturbingly common finding in society today. One-half of all Americans believe that child abuse is the most important public health issue facing this country, compared with other public health issues like drug and alcohol abuse, heart disease and cancer. An estimated 3,154,000 children were reported to child protective service agencies as alleged victims of child abuse or neglect in 1998, and approximately one million of these reports were confirmed. There have been substantial and significant increases in the incidence of child abuse since the last national incidence study was conducted in 1986. It has been reported that the number of physically abused children who were countable under the Harm Standard rose by 97 percent from an estimated 311,500 in 1986 to 614,100 in 1996. Because it has been reported that up to 65 percent of all physical abuse cases result in orofacial injuries, the dental profession is in a unique position to recognize and report suspected cases of child abuse. The under-reporting of child abuse in Texas by dental professionals is an established fact; a study by Kassebaum in 1986 demonstrated that only 19 percent of Texas dentists had reported one or more suspected cases.

Methods: A 24-question survey similar in format and content to the 1986 questionnaire was mailed to 1,046 Texas dentists. The names of practicing dentists were randomly selected from a membership roster provided by the Texas Dental Association. Both general dentists and selected

specialists (pediatric dentists, orthodontists, oral surgeons, dental public health, periodontists and endodontists) were included in the study group. The questionnaire consisted of multiple-choice and dichotomous yes-no questions. Participants were given a postage-paid envelope for mailing the results of the survey to the principal examiner. No identification was requested as to either the name or location of those completing the survey.

Results: There were 383 responses to the questionnaire, for a response rate of 37.7%. The majority (n=289) of the respondents were general dentists. The remaining respondents included 24 pediatric dentists, 34 orthodontists, 17 oral surgeons, 9 endodontists, 5 dental public health, 3 periodontists and 2 "unspecified dentists." 79.6% of the respondents were male, 18% identified themselves as female, and 9 respondents did not answer the gender question. The ages of the respondents ranged from 25 to 66 years or greater with the largest group aged between 46-55 years. The reported years of graduation from dental school ranged from 1942-2000 with the largest group by decade being those dentists graduating in the years between 1980-1989. The majority (n=370) of the respondents were private practitioners, with 245 practicing dentistry in a large metropolitan area-city or suburb. The remaining (n=3) respondents practiced in an academic or institutional environment.

Responses by dentists to survey questions:

Dentists' Responses:	1986	2001
Response rate	33.5%	37.7%
Have suspected patient victim of abuse	36%	49.7%
- General dentists	NA	45.2%
- Pediatric dentists	NA	96%
- Orthodontists	NA	55.9%
- Oral surgeons	NA	47%
Have reported at least one case to authorities	19%	25.1%
- General dentists	NA	21.5%
- Pediatric dentists	47%	79.2%
- Orthodontists	NA	23.5%
- Oral surgeons	39%	17.5%
Hesitancy to report		
- Lack of adequate history	62%	57.7%
- Lack of knowledge about abuse and dentist's role in reporting	22%	27.7%
- Concern on the effect on practice	2%	6.4%
Believe legal obligation is to:		
- Report suspected cases of child abuse	NA	83.7%
- Report only known cases of child abuse	NA	9.3%
- Did not know	NA	6.7%
Indicate that the survey had increased their knowledge or awareness of child abuse	66%	60.5%

NA signifies question was not answered.

Conclusions: Although the findings of this study indicate a small increase in the percentage of child abuse cases reported, the ratio of suspected to reported cases has not changed since 1986. This suggests that underreporting of child abuse is still a significant problem in the dental profession. Another interesting finding of this study was a tremendous increase in the percentage of reported cases by pediatric dentist, while at

the same time a decrease in the reporting rates of oral surgeons. A lack of knowledge about child abuse and the dentist's role in reporting continue to be major reasons for not reporting suspected cases. Further education and training are required for both the dental profession and the child protection agencies to improve the inter-agency working relationship. While over 80% of surveyed dentists indicated that they have a legal obligation to report all suspected cases of child abuse, only 25% surveyed do so. Continued efforts by educational institutions, organized dentistry, and government agencies should be brought to bare on this significant social and healthcare problem.

Child Abuse, Survey, Texas Dentists

F45 Data Collection by Law Enforcement, Medical, and Child Protection Professionals in Child Abuse With Head and Neck Injuries

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The goals of this research project are to present the forensic community with: 1) the availability of relevant data collected by personnel having primary contact with child abuse victims; 2) the inability to utilize that data to evaluate possible causative factors of child abuse; and 3) how these may affect forensic dentists' ability to design and implement programs in recognition, reporting and intervention in child abuse.

Dentists are uniquely positioned to positively impact child abuse intervention. Dentists have a responsibility to recognize the physical signs and symptoms of child abuse. There are currently no readily accessible organizational databases in Bexar County, Texas for analysis of child abuse cases with injuries to the head and neck region and the associated causative factors.

An earlier study was planned to determine the number of child abuse cases resulting from family violence with substance abuse as a causative factor, especially those cases involving injuries to the head and neck region. Dentists may encounter these types of young patients in their practice. There is national research and literature on the occurrence of child abuse, but there is no information correlating the causative factors and the involvement of head and neck injuries in Bexar County, Texas. The inability to obtain this specific data became the motivating factor to design this study on data collection. The purpose of this study is to identify the inherent problems in data collection, storage and retrieval and make recommendations for improvement.

In 1998, according to a recent report, there were one million confirmed cases of child abuse in the United States. Studies have shown that between 50-65% of injuries to children as a result of abuse are seen in the head and neck region. In Texas alone, a 2001 survey showed that 49.7% of dentists suspected child abuse, but only 25.1% reported at least one case of abuse. 83.7% of the dentists responded that they knew they had a legal obligation to report suspected abuse. These dentists attributed their main reasons for lack of reporting to a lack of patient history and a lack of knowledge of abuse and their role in reporting.

Organizations that have primary contact with victims of possible child abuse were consulted. Interview protocols were developed for the following types of organizations: Law Enforcement, Hospital Emergency Rooms, Emergency Medical Services, Sexual Assault Nurse Examiners (SANE) and Child Advocacy Groups.

During the interview, the following data were sought:

Head and Neck Exam:

1. Were extraoral face and neck areas examined for injury?
2. Were intraoral areas examined for injury?
3. Do the examiners know the types of specific intraoral injuries?

Reporting Methods:

1. What data are collected?
2. Who enters the data into a report? Is it the same person who collects the data?
3. Where is this data entered (i.e. hard copy or computer)?
4. Are data entered into a database so that it can be retrieved? If yes, what data are retrievable?
5. Are these data reported to any other agency either by written or oral report?
6. Is evidence of family violence or substance abuse documented? If yes, is it retrievable?
7. Is photo documentation performed?
8. Are there any laws restricting the release of information when children are involved as victims?

The information collected by the organizations varied depending upon the specialized field of the organization and the aptitude and training of the person on site with the victim. The level of knowledge of intraoral injury types differed among the groups. Law Enforcement Agencies often report only the most severe charge in specific cases and not necessarily details of the specific injury. The presence or suspicion of substance abuse or other risk factors by the perpetrators are also underreported. Medical personnel may report information relating to the specific injuries but not necessarily the details of the causative factors leading to the injuries.

This specific information may be helpful in analyzing the patterns of violence leading to injuries of the head and neck. The information may also be useful for emphasizing to dentists their responsibility in recognizing and reporting abuse and neglect and aid the development of a curriculum model for students in medical and dental schools. At the present time, none of the organizations had adequate databases for associating causative factors with injury to children in the head and neck region.

Child Abuse, Forensic Dentistry, Data Collection and Retrieval

F46 The Role of Psychological Debriefing Within Forensic Odontology: Critical Issues and Views From the Field

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After attending this presentation, the participant will understand: 1) the nature and purpose of psychological debriefing, in particular Critical Incident Stress Debriefing (CISD); 2) the debate surrounding the effectiveness of CISD; and, 3) the experience and perception of psychological debriefing among forensic odontologists who have attended mass fatality incidents.

Due to its nature, the work of the forensic odontologist is often undertaken in difficult, stressful and traumatic circumstances e.g., the dental identification of victims of mass fatality incidents. In response to the potential damage that this type of experience can have on a person's well-being, psychological debriefing has become an increasingly common therapeutic tool.

Psychological debriefing is designed to alleviate the primary distress caused by exposure to traumatic events. In addition, it is employed

to inhibit the development of chronic responses, most notably Post Traumatic Stress Disorder (PTSD). The most influential model of psychological debriefing is Critical Incident Stress Debriefing (CISD). Originally developed for use with emergency service personnel (1), CISD consists of seven clearly defined stages.

Table 1. The seven defined stages within CISD

Introduction stage	The purpose of debriefing is explained.
Fact stage	Participants describe role/position during incident.
Thought stage	Initial thoughts during incident are explored.
Reaction stage	Emotional responses/feelings are explored.
Symptoms stage	Cognitive/physical/behavioural reactions exhibited during and since incident are elicited.
Teaching stage	Information provided on the normalcy of exhibited distress, stress management and additional reactions that may follow.
Re-entry stage	Open discussion and summary

Research into the efficacy of CISD is at best contradictory; whilst many studies advocate its use and effectiveness, an equal number of studies can be found that claim it is no more effective than informal discussions with colleagues or that it may do more harm than good. In order to evaluate the prevalence and perceived value of CISD among forensic odontologists, participants from a previous study were recruited (2), as they were known to have direct experience of mass-fatality incidents.

Participants' experiences and opinions of psychological debriefing were canvassed by way of interview, structured questionnaire, and e-mail correspondence. It is envisaged that the analysed data will be operationally useful insofar as informed decisions can be made as to the most appropriate form of debriefing intervention for the forensic odontologist.

Not only is this important to help safeguard the psychological health of individuals but it is also a timely evaluation for the profession given that potentially distressing work of this kind is likely to increase. As a case in point, the National Transportation Safety Board (NTSB, U.S.) and the Civil Aviation Authority (U.K.) are anticipating an increase in the number of major aircraft incidents over the next ten years as a result of increased air traffic volume. With this in mind it is imperative that the psychological needs of the forensic odontologist are elicited, documented, and appropriately met.

Psychological Debriefing, Critical Incident Stress Debriefing, Mass Fatality Incidents

F47 Dogs Bites in the Living: A Survey of 236 Cases in a French Hospital

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The goals of this research project are to present the results of this survey performed at the time of admission in a university hospital is to get more knowledge about dog bites in order to discuss the efficiency of the new French law against dangerous dogs.

In France, dogs bites present an important public health problem where the clinical forensic team is daily involved, drawing up certificates for prosecution. In 1999, after several mediated cases, the French government attempted to reduce the number of dogs bites by a breed specific legislation against dangerous dogs, though the prevalence of dogs bites is not well known in France. The main objective of this study is to estimate the prevalence of dogs bites in the city of Lille. Usually, animal bites ini-

tially lead the victim to the emergency department for care and then to the forensic department to get a certificate to prosecute against the owner of the dog. The forensic odontologist is involved for bite mark analysis and comparisons. Previous studies often investigated one or the other of these fields. The interest of this study is to collect data from both departments : emergency (adults and pediatrics) and forensic clinical medicine.

Methodology: This prospective study has been performed during 18 months (January 99 to June 2000). Assessment forms have been performed and data collected about the location of the wounds, the nature of the lesions, the number of bite marks, the treatments, the circumstances, the victim's age and sex, the breed of the dog, the victim's familiarity with the dog, etc.

Results: 236 cases of dog bites have been collected. The major anatomical locations is the upper member (43%) and the face (42%). The lesion is often a bruise (68%). The mean age of the victim is 30 years. Children less than 10 years are victims in 30%. The victim is a man in 72% of the cases. There is only one bite in 84% of the bites. The wounds need a treatment in 94% of the cases. And a hospitalization is necessary in 14%. The victim wants to prosecute in 22%. The event occurs at home in 33%; at work in 4% of the cases. The dog has a familiarity with the victim in 30%. The breeds more often involved are the German Shepherd and the Labrador.

Discussion: The results are applicable to the previous forensic studies about the anatomical locations (Vale and Noguchi -1983, Pretty and Sweet - 1999). The results are also applicable to the pediatrics studies about the number of bites (Greenhalgh and all -1991), the victim's treatment and the breeds involved. The forensic, pediatrics and epidemiological studies agree on the sex and ages of the victims. The French law against dangerous dogs attempted to ban, by sterilization, pit bulls, rottweillers and Staffordshire terriers, considered as dangerous. Surprisingly, few cases involving these breeds have been collected in this study. The breeds targeted in the law are genetically dangerous but many breeds like german shepherds may become dangerous because of bad training and the legislation has forgotten this point of view. This work shows that, in Lille, the Labradors, reputed as friendly pets, are among the most numerous biters. Bite mark analysis and comparisons of some cases included in this study are also discussed.

Conclusion: This study is applicable to the previous works for the variables linked to the victims. The results show that the French law would require an adjustment. The law would also have a look to the future and prevent the development of new dangerous crossbreeds.

Bite Marks, Odontology, Legislation

F48 Executive Airline Crash—A Combined Pennsylvania Dental ID Team (PADIT) and DMORT Response

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The goals of this research project are to understand that in any transportation disaster, a state dental identification team will most likely be faced with working with a regional DMORT team. This relationship could be adversarial or complimentary. This presentation will deal with the problems and solutions that occurred during a three day combined PADIT-DMORT activation for a charter airline crash in Northeastern Pennsylvania.

On Sunday, May 21, 2000, a chartered Executive Airlines Turbo-prop was returning to the Wilkes Barre – Scranton Airport from Atlantic City, NJ. The plane carried 17 passengers and a crew of two. The aircraft missed its initial approach and went around for a second landing attempt. The crew reported engine problems. At approximately 11:43 AM the plane

disappeared from radar. The aircraft was located at 1:30 PM in a heavily wooded area. It was determined, by first responders, that there were no survivors and dental identifications would be necessary. The services of the PADIT team were requested at 6:30 PM.

By 9 AM on May 22, eleven PADIT members were on site. This was in anticipation of a possible 24-hour identification process. PADIT has the manpower and equipment to handle a large number of dental identifications; however, it soon became evident that not all victims could be identified by dental means. At that time (noon), the local coroner requested the DMORT 3 team in order to have access to their excellent pathology and anthropology services and equipment.

PADIT team members had done a triage on the victims and discovered that at least 11 victims could be identified by dental means. However, the team was advised that no dental identifications could be started until DMORT arrived.

Equipment from DMORT arrived early on May 23 and the morgue was operational shortly after 2 PM. The DMORT set-up team is extremely well organized and the equipment is outstanding.

Administrative problems began to arise early on May 23. The National DMORT administrators insisted that all non-DMORT dentists on PADIT must leave. At this point, liability became an issue. This presentation will discuss how this issue was favorably resolved.

The policy on photography was also a stumbling block. PADIT documents all dental identifications with photographs taken by dentists using state of the art equipment. The team photographer hands over all film to the incident director who in turn hands it to the coroner in charge. The DMORT policy on photo control is necessary and has merit. We will discuss options.

The NTSB and National DMORT policy on obtaining ante mortem dental records also became an issue. The best way to get all the dental information needed is to have dentist-to-dentist dialogue. Family input is necessary, but does not always result in all dental information being forwarded to the Forensic Odontologist. Valuable time can be lost. This presentation will discuss this issue in depth and it will provide several possible solutions.

State Dental Identification Teams will face these and other issues in the future. Hopefully, this presentation will give team directors and members insight into resolving potential problems before they arise.

DMORT is an excellent resource that can supplement the expertise and equipment of organized Dental Identification teams. The PADIT – DMORT activation had many more positives than negatives. The key is to be able to work as partners.

DMORT, NTSB, PADIT

F49 Bite Marks: Injuries to Dentition and Metacarpophalangeal (MCP) Joints in Fighting Injuries—Forensic, Dental, and Medical Implications of Importance to Odontologists

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The attendee will be familiar with: a) the appearance of “bite” injuries caused to MCP joints following a strike to the teeth; b) the appearance of injuries to both the hand and dentition; c) the forensic significance of these marks; and, d) the medical and dental implications of such injuries.

Few studies have considered marks left on the hands (and in particular the MCP joints) following a strike (punch) to a victim’s mouth as bite marks. It is unlikely that such marks could be used to identify a particular victim, but these injuries may be able to confirm or refute an individual’s version of events. Little research is available on such injuries either from a forensic, medical or dental perspective. Odontologists may be required to examine the victim, attacker, or both, and may be called to recommend advice beyond that of the forensic examination. They should, therefore, be aware of the medical complications such injuries can involve. In this presentation a case report will be described in which two versions of events were described by the “victim” and the “attacker.” Medical and dental experts were asked to determine, from the appearance of the injuries sustained to the victim’s dentition and the attacker’s hand, which version was most likely. In addition to this, medical and dental aspects of these injuries will be described.

Case events: In the northeast of England a complaint was made against an individual for assault. The victim of the assault claimed that he had been punched in the mouth by the accused. This had resulted in multiple fractures of his maxillary anterior teeth, requiring extensive (and costly) dental treatments. The accused stated that he had not hit the individual; instead, the victim had repeatedly slammed his hand in a car door, resulting in an injury to his hand. The accused further stated that accuser had fallen on a pavement curb, and it was this, rather than a strike, which had caused his dental injuries. The police asked for dental and medical experts to examine photographs of a) the dental injuries and b) the injuries to the hand to determine which version of events was the most likely. In this case the medical and dental experts agreed that the most likely cause of the injuries to the victim’s teeth was a strike to the mouth. They determined that the most likely cause of the injuries to the attacker’s hands was a strike to a hard, sharp object while the hand was clenched. It was thought that the injury was unlikely to be caused by a car door. Details of the case will be illustrated.

Medical implications: Of all potential bite sites, the hand is the most likely to have infective sequela, especially if the injury involves the MCP joint. This kind of injury is most likely to occur in a “clenched fist” situation. This typically occurs when an attacker strikes and hits a victim in the mouth and causes a laceration from the teeth. In the clenched-fist injury, a laceration of roughly 5-10mm occurs, typically in the third (middle) MCP joint (normally the most prominent). The laceration usually looks superficial and benign. Typically the individual extends his or her hand to examine the injury and in the process creates a deep inoculum of oral bacteria that enter the wound. An immunologically protected site, infections of the MCP joints can be difficult to treat and advice should be provided for anyone presenting with such an injury. This presentation will provide details of the complications of such injuries and the treatment modalities for them.

Dental implications: Fist strikes to teeth can cause a variety of injuries, varying from incisal chips to avulsion. Teeth may fracture at coronal or root level, may become devitalised (even if not obviously traumatised), and may discolor. Such individuals should undergo a thorough dental examination including radiographs and must be advised on appropriate treatment. Evidence of the injuries should be collected through photographs and study models prior to the provision of any treatment. This should be performed even if there is no impending complaint.

Conclusions: Injuries to hands and teeth may provide an important forensic link establishing that two individuals have been in violent contact. Both the victim and the attacker must be advised on the appropriate medical and dental treatments to prevent infection and further complications. Evidence should be collected before any initial treatment (bar emergency remedies) is provided.

Odontology, Bite Marks, Tooth Injuries

F50 Appropriateness of Using Visual Line-Up Guidelines in the Preparation of Bite Mark Analysis

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The goals of this research project are to demonstrate the need to establish guidelines for dental line-up use in bite mark analysis to ensure the accuracy and fairness. Established guidelines for visual identification line-ups can be a useful basis for these guidelines, but their limitations in the field of odontology must be explored before they are implemented.

The concept of the line-up in forensic investigation has been used for time immemorial, but the idea of using a line-up for bite mark analysis is relatively new (Sweet, 2001).

The purpose of this paper is to review some of the historical data regarding the conduct of eyewitness line-ups, identify a set of guidelines for eyewitness line-ups, and make recommendations regarding the appropriateness of using these guidelines for bite mark investigation.

Fairness in the construction and administration of line-ups is an important aspect of the judicial process. The fairness of the line-up has been a concern of research and policy development in the area of eyewitness identification. Quality of fairness, the construction of fairness indices, and the development of evaluation procedures started in the 1970s and continue to this day.

There are three aspects of fairness in the line-up. These are size, composition, and administration.

The probability of false identification is inversely related to the number of line-up members but there is a diminishing return on this probability with the addition of each line-up member. Levi, in real-world identification, found that there is around a 60% chance of misidentification from culprit-absent lineups. This means that the chance of an innocent suspect being identified in a six-person line up, even when properly constructed, is 10% far higher than what is acceptable to the justice system.

The second component of the line-up is bias or quality of foils within the line-up. Recent writings have made clear that distracters should not necessarily be selected so as to look like the suspect, but instead should be selected so that they fit the description that the eyewitness had and be a plausible choice. Selecting distracters so as to resemble the suspect is not a desirable practice.

Lastly, there is the phrasing of the question, Should the procedure be forced choice or should the mock witness be permitted to state that no line-up member appears to be a good fit to the description? Should mock witnesses be instructed to select the suspect, the person they think committed the crime, the person they believe the witness was describing, or perhaps the person who best fits the description?

The early attempts by individual police agencies or legal bodies were generally incomplete, failing to address some of the more serious and subtle matters involving identification. Later attempts were either too vague or sometimes too specific or detailed to yield any practical effects on police practice.

One of the first attempts at setting guidelines for eyewitness line-ups was a 1967 article in the *American Criminal Law Quarterly*. It included 15 items. Since that time a variety of agencies have attempted to improve on this up to Wells who published *Eyewitness Identification: A System Handbook* (Wells, 1988) that contained nine chapters with a series of 131 specific procedural recommendations, along with research evidence and rationale for each.

Malpass and Lindsay (1998) derived four recommendations that will relieve the criminal justice system of its role in contributing to eyewitness identification problems including: the person who conducts the line-up or

photo spread should not be aware of which member of the line-up or photo spread is the suspect, the eyewitnesses should be told explicitly that the person in question might not be in the line-up or photo spread and they should not feel that they must make identification. They should also be told that the person administering the line-up does not know which person is the suspect in the case. The suspect should not stand out in the line-up or photo spread as being different from the distracters based on the eyewitness' previous description of the culprit or based on other factors that would draw extra attention to the suspect. A clear statement should be taken from the eyewitness at the time of the identification and prior to any feedback as to his or her confidence that the identified person is actually the culprit.

The major problem in using guidelines for visual recognition for bite mark analysis is that the guidelines were devised to enable professionals in law enforcement to verify the validity of observations by a lay person that may have only seen the suspect for a short amount of time, often in less than ideal circumstances. The forensic odontologist is a professional who is trained in the comparison of bite mark evidence and potential perpetrator. He or she has the advantage of conducting the analysis over a virtually unlimited amount of time in his or her own facility.

"Utilizing the Federal Bureau of Investigation (FBI) directives for preventing a photographic line-up from being impermissibly suggestive, certain tenets of that policy are breached by virtue of requiring a forensic odontologist (expert) to conform to a system (the line-up) created to elicit identifications from the lay person. One FBI recommendation is that the suspect exemplar should be grouped with a minimum of five other reasonably similar exemplars. A concern is that the forensic odontologist is considered an expert. In that regard, it is not necessary to present additional exemplars (or distracters), originally intended as a confirmation of a lay witness' observations. Much in the same way that expert latent print examiners are not required to view distracter prints in order to make an identification, a forensic odontologist selecting from a false universe of dental exemplars could elicit a stipulation to same from the defense with an eventual counter utilizing numerical equations mathematically, proving that one ID out of six exemplars does not eliminate millions of other similar identifications not viewed by the expert.

Another FBI recommendation is that the line-up should not be repeatedly shown to a witness. As previously stated, the forensic odontologist has a virtually unlimited amount of time to revisit dental casts, radiographs, etc., during his or her analysis.

A third FBI recommendation, targeted to preclude suggestive aspects of line-ups with respect to lay witnesses, is that no comments as to the validity of the line-up, the status of the case, etc., should be made or alluded to. Typically the forensic odontologist works in concert with law enforcement and may participate in the impression stage of incarcerated suspects, obviously giving a hint as to the status of the case. Additionally, if one forensic odontologist prepares the dental line-up for another, they would, in effect, create a joint work product not precluding comments as to the validity of the line-up between 'unsworn' expert witnesses.

Finally, the FBI advises that no witness should view the line-up in circumstances that would permit other witnesses to ascertain the first witness' ability to identify the subject. This would preclude consultations or confirmations with other forensic odontologists – presumably unacceptable as collegiate consultations are encouraged within the forensic odontology community."

The guidelines for a visual identification line-up have been evolving over a period of over thirty years. The concept of using a line-up in bite mark evidence is relatively new. It can be helpful to employ aspects of established guidelines in the analysis of bite marks, but given the quality of skin as an impression material, and the circumstances involving the bite mark investigation, the guidelines for eyewitness visualization of subjects in a line-up are unrealistic in the general analysis of bite marks.

Bite Mark Analysis, Guidelines, Dental Line-Up

G1 Overview of Suicide Cases in Geneva, Switzerland During a Twenty-five Year Period (1971-1995)

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The goal of this research project is to provide demographic information regarding people who committed suicide in Genève.

The purpose of this study is to provide demographic information regarding people who committed suicide in Genève between January 1, 1971, and December 31, 1995.

In this period (25 years), the forensic institute of Genève, Switzerland examined all the cases of suicide (2,074) committed in Genève by individuals, who were between 13 and 97 years of age.

The average number of such cases per year is 83. The mean annual suicide rate is 22.52/100,000 population, and the rate has remained relatively stable over the years. The average age of the decedents is 48 years. The sex ratio is 1.5 : 1 (1,261 males and 813 females).

The most common cause of death is by firearms (19 %). A high incidence of men (91 %) could be explained by an easier access to weapons (In principle, every Swiss man must enrol in the army; furthermore, he is asked to keep his gun at home.) Entry wounds are most frequently localised within the cranium and the face (78 %). Jumping from height is the second most common cause of death (18 %). This method (43 % of men) doesn't require any special material and is frequently chosen by the elderly. Hanging (17.5 %) is chosen especially by men (73 %). The weak proportion of women could be explained by a misunderstanding of the exact cause of death ("soft" death by vascular compression and not suffocation). Intoxication (16.5 %) is a well-known cause of death predominant in women (only 42 % of men), because it's a soft death and because women often have easier access to drugs such as benzodiazepines or anti-depressors. Drowning (16 %) is chosen by men and women in the same proportion (50 %). It's the principal means of suicide of women exiting a psychiatric hospital. Suicides by carbon monoxide poisoning is relatively rare (4.5 %). In 1978, town gas, which contained carbon monoxide, was replaced by natural gas (methane without CO). Therefore, carbon monoxide poisoning, previously a suicide method of choice, has now become very rare and completed especially by men (72 %) in their car. The other causes of death (train fatalities, asphyxias, electrocutions,) are very rare. Women predominantly commit attempts by cuts on wrists. Death by cuts on wrists (2 %) are predominantly committed by men (73 %).

In conclusion, we can say that the incidences of suicide cases in Genève, Switzerland, which are among the highest in Europe, are, of course, underrated since an unknown number of these cases are mistaken for deaths of another nature (mostly accidental and natural deaths).

Suicide, Death, Genève

G2 An Unusual Presentation of a Rare Entity: Exsanguination by Ruptured Left Subclavian Aneurysm

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The goal of this research project is to present an unusual case of a ruptured left subclavian artery aneurysm with formation of a subclavian-esophageal fistula, and to review the associated literature.

The case presented represents an unusual entity with an even more unusual history. The decedent, an 88 year-old white male, lived at home with his wife of 70 years who suffered from severe Alzheimer's disease. The decedent's past medical history was only significant for hypertension. Police records indicated a number of calls to the residence in the recent past because the wife had mistaken her husband for a "proowler" in the yard. On this occasion, the wife left her residence to cross the street and tell her neighbor that she had seen the prowler and "hit" him. The decedent was found face down and unresponsive on his front porch. He was noted at the scene to have small incised wounds of the hands and wrists, but no other injuries were noted at that time. The neighbor called 911, and resuscitative efforts were initiated at the scene by EMS. On arrival to the emergency room, resuscitation was still in progress, but continued efforts were unsuccessful.

Scene investigation revealed the decedent's blood on the door handle leading into the residence. The wife told officers at the scene that she had tried to hit the "prowler" with a candy bowl, and that he had blocked it with his hands. A fragmented glass candy bowl was found at the scene, also with the decedent's blood. Questioning the neighbors revealed that a similar incident had occurred one week prior, but the incident had not been reported. At that time the wife had confronted the husband within the house with a kitchen knife, but he was apparently uninjured and the authorities were not notified.

At autopsy, the external examination confirmed superficial incised (defense) wounds of the hands and wrists. Also noted were scattered, healing superficial incised wounds of the left chest, presumed to be related to the previous unreported knife incident. Examination of the scalp, skull, and brain was unremarkable. Internal examination revealed moderate to severe atherosclerotic disease of the aorta and its main branches, as well as mild narrowing of the coronary arteries by atherosclerotic plaques. There was also marked narrowing of the vertebral, basilar, and internal carotid arteries. Examination of the heart showed a single focus of fibrosis in the posterior wall of the left ventricle which suggested a small remote infarct. The most notable finding was a mildly dilated left subclavian artery that contained a large intimal defect near the aortic arch. This defect opened into a saccular aneurysm, surrounded by thin adventitia and periaortic tissue. The aneurysm contained a large thrombus, which abutted the posterior aspect of the esophagus. Examination of the esophagus demonstrated an associated rupture site through an area of ulcerated mucosa, forming a subclavian-esophageal fistula. Greater than 1500 cc of clotted blood was discovered within the stomach, suggesting acute exsanguination into the gastrointestinal tract.

Aortic aneurysms as a complication of severe cardiovascular disease are frequently seen at autopsy, but aneurysms of the arch vessels exclusively are uncommon. Of the cases reported, the majority of subclavian-esophageal fistulae present as a complication of aberrant subclavian arteries. One of the few reported cases of subclavian-esophageal fistula associated with normal subclavian vessel distribution occurred as a result of an esophageal foreign body. In our case, the arch vessels were appropriately positioned, a history of previous trauma or surgery was not elicited, and no foreign bodies were discovered. This suggests that this case was exclusively related to the decedent's cardiovascular disease.

Under certain circumstances, the manner of death in a number of cases of myocardial infarction has been ruled a homicide. If we were to assume that in this case, the decedent's aneurysm finally ruptured due to an acute stressful event (the assault), then this case could be considered a rare case of homicide by subclavian aneurysm. Given the circumstances, the manner of death in this case was eventually called natural. We present this case and review the associated literature.

Subclavian Aneurysm, Subclavian-Esophageal Fistula, Atherosclerosis

G3 An Unusual Cause of Sudden Death in Infancy: Histiocytoid Cardiomyopathy, Report of an Autopsy Case

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The goals of this research project are to remind participants of the following: 1) be aware of an unusual form of cardiomyopathy which may cause sudden death in infancy or early childhood; 2) know the clinical features of histiocytoid cardiomyopathy; 3) recognize the gross and microscopic features of this rare cardiac disease; and 4) be able to select the appropriate special stains to differentiate this entity from glycogen storage disease and from infiltrates of inflammatory origin.

Methods: Report of sudden death, autopsy findings, and histopathologic examination, including special stains and immunoperoxidase studies.

Clinical History: An otherwise healthy, full-term 22 month old female was at home in her crib when she began to cry. Her father picked her up and noticed that she was having trouble breathing. She subsequently became unresponsive and stopped breathing. EMS was called and the father began CPR. Upon arrival of EMS, the child was found to be in agonal respirations and without pulse. A cardiac monitor was placed, and it showed ventricular fibrillation. She was intubated and transported to the hospital. CPR was continued, and upon arrival to the Emergency Department, she was pulseless and not breathing. The cardiac monitor showed agonal rhythm, and ACLS was begun. Despite medical intervention, she displayed extended periods of asystole without pulse, and her pupils were fixed and dilated. Resuscitative efforts were discontinued and she was pronounced dead.

Autopsy Findings: At autopsy, the body was that of a well developed and well nourished 22 month old white female, who weighed 27 pounds and measured 34 inches in length. Her growth and development were appropriate for age. There were no signs of trauma. All internal organs were in their normal anatomic relationship. The heart, in the fresh state, weighed 70 grams (average weight for age = 56 grams), and it was structurally unremarkable. Upon sectioning, the myocardium was red/brown, without fibrosis, hemorrhage or distinct lesions. The interventricular septum was intact. The atria were unremarkable, and no interatrial defects were present. The coronary ostia were normally located, and the distribution showed right dominance with a circulation pattern within normal limits. The valves were thin and unremarkable. Microscopic examination of hematoxylin and eosin (H+E) stained sections of the heart revealed multiple myocardial and subendocardial clusters of clear histiocytoid cells with an associated minimal chronic inflammatory cell infiltrate. Special stains and immunoperoxidase stains were performed, and the histiocytoid clusters showed focal PAS positivity, weak positivity for actin, and negative staining for the histiocyte marker CD68. Based on these results, a glycogen storage disease (which would show diffuse PAS positivity) and a histiocytic process (which would show CD68 immunopositivity), were ruled out. The positive immunohistochemical staining for muscle actin supported a myocytic origin of the clear cells. The remainder of the autopsy, including microscopic evaluation, was unremarkable.

The clinical data together with the results of the autopsy, including H+E, PAS, and immunohistochemical microscopic examination of the heart, support the diagnosis of histiocytoid cardiomyopathy.

Discussion: Histiocytoid myocardiopathy is a rare cardiac disorder of infants and young children, presenting under two years of age, and it generally affects females. The clinical presentation is characterized by severe and eventually fatal, cardiac arrhythmias. Less frequently, the

presenting feature is sudden death. Gross morphology of the heart shows hypertrophy, tan/yellow myocardial nodules, but it may be grossly unremarkable. In most cases the heart weight is increased for age. Characteristically, the microscopic examination reveals focal collections of rounded, pale, vacuolated, or granular cells with centrally placed, round nuclei. These cells can be found in a diffuse or focal pattern throughout the myocardium, but they have been described to follow the course of the conduction system. Ultrastructural studies in reported cases demonstrate myofibrils, consistent with cardiac muscle origin, and abundant mitochondria. In some reported cases, malformations of the nervous system have been described. These have included hydrocephalus, agenesis of corpus callosum, malformations of cerebellum, and microphthalmia. In extracardiac viscera, some patients have had prominent oncocytes in glandular tissue. Rare other associations have included ovarian or renal cysts, and renal calcinosis.

The etiology of this disorder is uncertain. The ultrastructural observation of numerous mitochondria has raised the possibility that this is a mitochondrial cardiomyopathy, associated with abnormalities of the oxidative phosphorylation system. However, there are reported instances of successful surgical excision of histiocytoid foci, with survival to at least 6 years after surgery, and such a cure would not be expected in genetic mitochondrial disorders, which are usually characterized by steady degenerative changes. Another leading hypothesis is myocardial or Purkinje cell hamartoma, which is supported by the observation that the histiocytoid cells occur in locations in the heart where myocytes are normally found, and by the fact that the cells morphologically resemble muscle. These findings may also suggest that this entity is caused by a developmental anomaly of the conduction system of the heart. Some pathologists favor the consideration of postviral injury, either limited to the heart or systemic, which could explain the rare associated extracardiac abnormalities. Finally, it has been proposed that this disorder may have a genetic basis. The higher incidence in females suggests that it may be an X-linked dominant trait. This is an important consideration as genetic counseling may be indicated for affected families.

This condition should be considered in the differential diagnosis of SIDS, necessitating a careful cardiovascular examination in every case.

Conclusion: Histiocytoid cardiomyopathy is a rare cause of cardiac arrhythmia of uncertain etiology, affecting infants and young children, and it may lead to sudden death. The recognition at autopsy of the characteristic histologic appearance of the histiocytoid cells and the selective use of special stains and immunostains permit correct diagnosis.

Sudden Death, Arrhythmia, Cardiomyopathy

G4 The Changing Faces of the Medico-Legal Autopsies at the Office of the Chief Medical Examiner of the State of Maryland—A Decade of Experience

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The goal of this research project is to review the autopsies performed at the Office of the Chief Medical Examiner of the State of Maryland in the last 11 years.

A review of the autopsies performed at the Office of the Chief Medical Examiner of the State of Maryland, in the last 11 years, is presented to the forensic community to share our experience.

This poster will present the work of a team from the Office of the Chief Medical Examiner (OCME), State of Maryland and the National Study Center for Trauma and EMS.

Over the last eleven years the number of the medico-legal autopsies increased significantly, especially after 1997, from 2,997 autopsies performed in the year 1997 to 3,757 autopsies performed in the year 2000, a 25% increase. The increase is in comparison with the other types of cases performed by this Office, such as field inspections, OCME inspections, and approvals, which all showed a decline.

None of the protocols governing which bodies are autopsied vs. inspected have been altered during this time frame.

A look at the manner of death in our cases shows a dramatic increase (49%) in the autopsies classified as natural (from 959 in the year 1997 to 1,431 in the year 2000) and a significant increase (31%) in those classified as undetermined (from 531 in the year 1997 to 698 in the year 2000). The cases classified as accidents showed an increase of 22% and the suicides showed an increase of 5%. The homicides showed a 30% decrease after the peak from the early 1990s (641 cases in 1993 comparing with 473 cases in 2000). Because the most significant increase was in the cases classified as natural and undetermined, we further examined these categories.

In the cases in which the manner of death was classified as natural, the most significant increase was from 1997 to 2000, especially for atherosclerotic cardiovascular disease (from 313 in 1997 to 396 in 2000), hypertensive cardiovascular disease (from 6 in 1997 to 186 in 2000) and cardiac arrhythmia (from 53 in 1997 to 94 in 2000). There were no significant age, race or sex related differences. When we compared the data for all the counties that form Maryland, we noted that the greatest increase was in the cases from the most populous counties, Baltimore County, Prince George County and Montgomery County and the independent City of Baltimore.

We continued our study with a detailed view of the cases classified undetermined as manner of death. There were no significant age, sex or race related differences. Looking at the causes of death in this category we saw an increase in the cases related to drug use, drowning, and sudden death of an infant. Comparing the counties, the largest increases were in the City of Baltimore and in Baltimore County.

In conclusion, we consider that the significant increase in the number of the medico-legal autopsies in the State of Maryland is due to an increase in the number of the cases classified as natural and undetermined. The most important contribution to this increase is due to the death toll taken by the cardiovascular diseases, without respect to age, sex, or race.

Maryland, Autopsies, Increase

G5 Malaria Deaths in the United States: Case Report and Review of Deaths, 1979-1998

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The goal of this research project is to review the deaths in the United States caused by malaria and, through a case report, raise awareness to the potential of malaria-related deaths in the forensic setting.

This poster will review all the deaths due to malaria in the United States between 1979 and 1998 paying particular attention to epidemiological factors provided by the Centers for Disease Control (CDC). Through a combination of both gross and microscopic images, it will then present a unique case of malaria diagnosed only at the time of medico-legal autopsy.

Malaria is the world's most important parasitic disease, accounting for an estimated 300-500 million new cases and between 1.5 and 2.7 million deaths annually. The majority of these deaths occur in sub-Saharan Africa where malaria is endemic and are the result of infection with *Plasmodium falciparum*. The number of deaths related to malaria in the United States is comparably much lower and involves so-called "imported" cases in which U.S. travelers acquire the infection upon travel

to endemic areas and subsequently return to the U.S., or in which infected foreign citizens travel to the U.S.

There were a total of 115 deaths due to malaria in the United States between 1979 and 1998 with an average of 5.8 deaths per year. Specific epidemiological data provided by the CDC regarding the 40 deaths that occurred between 1992 and 1998 revealed the following: Deaths occurred in patients ranging from 9 months to 85 years of age (median, 53 years). Thirty-eight (95%) of these were due to *P. falciparum* and two (5%) to *P. vivax*. Anti-malarial chemoprophylaxis was used in 40% of cases, not used in 45% of cases, and unknown in 15% of cases. Twenty-four (60%) of the cases involved U.S. travelers to endemic regions, of whom 59% traveled to Africa, 25% to South America, 8% to India, 4% to Haiti, and 4% to unspecified areas. The remaining cases included 11 foreign travelers to the U.S. (27.5%), 3 induced cases (7.5%), and 2 undetermined cases (5%). Thirty-nine (98%) of the cases were diagnosed ante-mortem and only one case was known to have come to the attention of the medical examiner/coroner.

An illustrative case report demonstrates many of the features associated with fatal malaria infections in the United States. The case involves a U.S. student who was studying in Ghana and who, by report, had not taken anti-malarial chemoprophylaxis. Despite being seen at the student health clinic upon returning to the U.S., the diagnosis of *P. falciparum* infection and cerebral malaria was not made until the time of medico-legal autopsy where the classic gross and microscopic features of cerebral malaria were identified.

This case represents one of the few cases of *P. falciparum* infection not diagnosed ante-mortem. Given the worldwide prevalence of the disease, increasing international travel, and rapidly developing drug-resistance, malaria will continue to be an important disease and should be considered in cases of sudden, unexplained deaths. By reviewing the major epidemiological features of malaria deaths in the United States and by presenting the major gross and microscopic findings of cerebral malaria, an attempt is made at raising the awareness of the forensic community to the potential of malaria related deaths.

Malaria, Plasmodium Falciparum, Deaths

G6 North Carolina's Death Investigation Database

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The goal of this research project is to demonstrate the ease of use of a centralized statewide database to compare selected data fields with the US Census data to determine homicide victim profiles with shifts in population.

Searchable databases have long allowed for the comparison of data fields relating multiple groups. The North Carolina Office of the Chief Medical Examiner (OCME) maintains a database concerning its investigation of all deaths in North Carolina that fall under its jurisdiction. The database is maintained "in house" which allows quick and reliable information retrieval on cases in contrast to actual case files which may be archived in distant locations. The OCME database has case information dating back to 1973 and stores greater than thirty data fields on each case allowing for detailed comparisons within a group of interest. The data search can be restricted to specific fields thereby tailoring the search to data of interest and reducing the volume of data to be retrieved and compared. The ease of use and the ability to provide specific data of interest is demonstrated by the following search, which compares homicides in North Carolina in the years 1990 and 2000.

Six data fields are selected for comparison: Age, Race (including Hispanic), Sex, Date, Cause of Death (fifteen categories), and County of

death. This information is then compared to the US Census for North Carolina for the same years. The objective is to determine if shifts in population are reflected in the homicide victim profile.

The results demonstrate that the homicide victim profile tracks along with the shift in population. For example, the typical homicide victim in 1990 was a 27 year-old Black male who was shot, representing 55% of homicides while the population of Black males in 1990 was 22%. In 1990 the Hispanic population was 1.04% while the Hispanic homicide victim represented 1.34% of all homicides. In the year 2000 the typical homicide victim was a 27 year-old Black male who was shot, representing 51.4% of homicides while the population of Black males was 21.6%. The Hispanic population in 2000 was 4.7% while the Hispanic homicide victim represented 8.11% of all homicides. The actual number of homicides decreased by 141 cases while the percentage of homicides by gunshot rose from 63% in 1990 to 71% in 2000. Blunt force trauma cases remained about the same while sharp instrument cases decreased from 158 (19.3%) to 67 (10%).

The OCME database is a reliable source of information concerning death investigations in North Carolina, thereby allowing statewide comparisons within a group of interest to be compared to general census data.

Searchable Database, Homicide Victim, North Carolina

G7 “Homicide by Heart Attack” Revisited

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The goal of this research project is to review the criteria for ruling a death as “homicide by heart attack,” with illustrative examples from a metropolitan medical examiner’s office.

The term “homicide by heart attack” is used by some persons to describe sudden death due to underlying cardiac disease with an arrhythmia precipitated by the physical and/or emotional stress associated with the criminal activity of another person. Physical contact and/or injury may or may not occur in such scenarios. “Homicide” is an acceptable and appropriate manner-of-death ruling in such cases. Davis has published a set of criteria for pathologists to use when attempting to establish cause-of-death and manner-of-death rulings in cases where physical injury or contact does not occur. The criteria are as follows: 1) The criminal act should be of such severity and have sufficient elements of intent to kill or maim, either in fact or statute, so as to lead logically to a charge of homicide in the event that physical injury had ensued. 2) The victim should have realized that the threat to personal safety was implicit. A logical corollary would be a feared threatening act against a loved one or friend. 3) The circumstances should be of such a nature as to be commonly accepted as highly emotional. 4) The collapse and death must occur during the emotional response period, even if the criminal act had already ceased. 5) The demonstration of an organic cardiac disease process of a type commonly associated with a predisposition to lethal cardiac arrhythmia is desirable. Although Davis’ criteria specifically deal with cases in which there is no physical contact or injury, the authors apply similar criteria to all cases where sudden death due to heart disease is precipitated by the stress associated with another person’s criminal activity, whether or not physical contact or injury occurs. This is easily accomplished by leaving out the phrase “in the event that physical injury had ensued” for those cases where physical injury actually does occur. In this report, the authors present a series of five cases ruled as homicides using these criteria.

Case 1: A 40-year-old male was arguing with his girlfriend outside of his apartment when she started to strike him with a 2-3 foot long, light-weight, carved wooden statue. He was reportedly struck multiple

times in the head prior to his escape into the apartment, where he locked the door. Witnesses immediately called 911. Emergency Medical Services (EMS) personnel found him dead, in a chair in the living room. Autopsy revealed multiple superficial abrasions of the face and chest, along with a left periorbital contusion and two small lip lacerations. No skull, brain, neck or other internal organ injuries were identified. Other significant findings at autopsy included cardiomegaly (685 grams) with left ventricular hypertrophy, moderate coronary artery atherosclerosis, severe nephrosclerosis, and a remote pontine infarct. Toxicology tests revealed the presence of cocaine and its metabolites. Cause of Death (COD): Part 1: Cardiac arrest associated with stress and physical assault; Part 11: Cardiomyopathy; end stage renal disease; cocaine abuse; remote pontine infarct. Manner of Death (MOD): Homicide.

Case 2: The wife of a 74-year-old man arrived at his place of business just as an intruder was fleeing from the location after having robbed and assaulted the man. The man had sustained a punch to the jaw and was noticeably shaken, but refused transportation to the hospital via ambulance because he felt his injuries were limited to his jaw, which he presumed was broken. He went into the bathroom to clean-up and was then found unresponsive by his wife. She summoned EMS, who transported him to the emergency department, where he was pronounced dead. Autopsy revealed a fractured mandible, but no intracranial injury. The heart, which weighed 350 grams, had mild to severe coronary artery atherosclerosis, with near-complete occlusion of the right coronary artery. Toxicology was negative for drugs of abuse. COD: Blunt force head injuries associated with coronary artery disease. MOD: Homicide.

Case 3: A 66-year-old woman with a history of remote coronary artery bypass graft (CABG) surgery was suddenly awakened from sleep by an intruder who had broken into her home and was demanding money. After the woman became emotionally upset, the burglar fled. The victim was able to phone for help before she collapsed. She did not mention if the intruder had assaulted her. At autopsy, the decedent had multiple areas of senile purpura on her arms, as well as contusions of the right chest and left temple. No other injuries were identified. All resuscitative efforts failed. Autopsy also confirmed the presence of severe coronary artery atherosclerosis, with remote CABG surgery. Her heart weighed 510 grams. COD: Cardiac dysrhythmia due to atherosclerotic cardiovascular disease during an emotionally-stressful event (victim of robbery). MOD: Homicide.

Case 4: A 67-year-old woman was walking in a parking lot on her way from her car to the grocery store when she was stopped by a teenage male who demanded her purse. She refused, and the boy struggled with her for the purse, threatening to kill her if she did not comply. She was able to break away from him, run into the store, and relate what had happened to her prior to collapsing to the floor. All resuscitative efforts failed. At autopsy, there was no evidence of acute injury other than that which was considered related to resuscitative efforts. Other findings included hypertensive and atherosclerotic cardiovascular disease, with cardiomegaly (565 gm), severe coronary artery atherosclerosis, and a remote anterior left ventricular myocardial infarct. COD: Cardiac dysrhythmia due to hypertensive and atherosclerotic cardiovascular disease during an emotionally stressful event (victim of robbery attempt). MOD: Homicide. Adjudication: The teenager and an accomplice were charged with and tried for **, at which time they were found guilty of **.

Case 5: An obese, 52-year-old, diabetic man was involved in a physical altercation with a younger man. During the fight, the older man “acted as if he was having a heart attack.” He subsequently fled from the other man and attempted to drive himself to the hospital, but was so debilitated, that he stopped his car and had to ask for assistance. EMS responded and transferred him to the Emergency Department, where resuscitative efforts continued but eventually failed. Death occurred 30 minutes after EMS initiated treatment. Autopsy revealed rare superficial abrasions of the face, hemorrhage of the left sclera, and a small occipital contusion, but no other injuries. Hypertensive and atherosclerotic cardiovascular disease was present, with marked cardiomegaly (660 gm), severe

coronary artery atherosclerosis, and histologic evidence of remote, subacute, and acute myocardial infarcts. Well-developed coagulation necrosis with associated neutrophils was present focally. COD: Part I: Myocardial infarct due to hypertensive and atherosclerotic cardiovascular disease; Part 11: Obesity, diabetes mellitus, and stress associated with a physical altercation. MOD: Homicide.

In each of the cases presented, the modified Davis criteria, as described above, were fulfilled. In most of the cases, physical contact definitely occurred, although in some, no injury was inflicted, and in none were the inflicted injuries considered life threatening in and of themselves. Case 3 is the best example in the series of a case where no definite physical contact occurred between the assailant and the victim. Although she had some minor injuries, none could be clearly associated with the criminal activity. In each case, the victims clearly feared for their safety, and the events were of a highly emotional nature. Also, in each case, the collapse and subsequent death occurred shortly after the initiating event, but it occurred during the emotionally volatile period of time immediately following the event. Finally, autopsy revealed significant underlying cardiac pathology in each victim, such that each was a prime candidate for experiencing a stress-induced cardiac dysrhythmia.

Cardiac deaths precipitated by physical and/or emotional stress occur frequently. When the stress is precipitated by criminal activity directed against the victim by another person, it is appropriate to consider these deaths as homicides. In order to appropriately certify such deaths, strict criteria as set forth by Davis should be satisfied. Complete autopsy, including histologic examination and toxicology, coupled with detailed reconstruction of the events with particular attention paid to their timing, is essential in order to appropriately certify such deaths. Appropriate certification may lead to successful prosecution of criminals. Failure to appropriately certify such deaths may result in failure to appropriately adjudicate such cases.

Homicide, Heart Attack, Manner of Death

G8 The Significance of Pulmonary Interstitial Emphysema in Fetal and Infant Autopsies

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The goals of this research project are to provide participant with the capability to distinguish “florid” from “equivocal” pulmonary interstitial emphysema on routine H&E-stained lung sections and to understand the value of the histologic finding of florid pulmonary interstitial emphysema in distinguishing live born infants from stillborns.

The most commonly documented cause of pulmonary interstitial emphysema (PIE) is the mechanical ventilation of infants with respiratory distress syndrome, but known causes also include vigorous resuscitation efforts by those not accustomed to small infant lung volumes, forceful respiratory efforts against inspissated mucus or a foreign object, and spontaneous PIE related to cystic lesions or infection.

We have previously commented on the importance of the histologic finding of PIE in the determination of live birth in two infants whose bodies were discarded shortly after birth. Because of the implications of the distinction of live birth from stillbirth in criminal proceedings, we undertook the current study to further elucidate the importance of the microscopic finding of PIE.

Sixty-five cases of infant deaths were retrieved. The infants ranged in age from birth to 11 months (mean 2.4 months). The causes of death in these cases included sudden infant death syndrome (28), sudden unexpected death, manner undetermined (8), homicidal or accidental asphyxia (3), congenital anomalies (13), infection (5), prematurity (1), head injury (2) and non-asphyxial trauma (5). Microscopic sections of the lungs were

compared with those of 21 third trimester stillborn infants ranging in gestational age from 28 to 40 weeks (mean 35 weeks). The number of lung sections ranged from 1 to 10 per case (mean 4). The slides were examined for evidence of PIE, defined as the presence of non-endothelial-lined spaces in the interstitium and subpleural zones. “Florid PIE” was defined as the presence of expanded and dilated interstitial spaces coalescing with subpleural cystically-dilated areas. This finding was distinguished from the more subtle finding of focal distinct but non-distended interstitial and subpleural spaces, which we termed “equivocal PIE.” Immunohistochemical stains utilized to highlight endothelial cells (Factor VIII and CD 31) have been previously reported as being useful in the distinction of dilated lymphatic spaces from PIE. However, because of the cellular disruption frequently seen in postmortem bronchial and endothelial structures which can compromise the interpretation of these immunohistochemical studies, we relied upon conventional H&E-stained sections to evaluate the morphologic presence or absence of PIE.

Sixteen cases of florid PIE were identified. All were live born infants. An additional 46 cases of equivocal PIE were seen, including 35 live born infants and 11 stillborns. In 24 cases, no PIE was identified, including 14 live born infants and 10 stillborns. The causes of death in the cases of florid PIE included sudden infant death syndrome (9), homicidal asphyxia (1), hemorrhage and inattention at birth (1), congenital anomalies (2), and sudden unexpected death, manner undetermined (3). Twelve of these infants had received cardiopulmonary resuscitation and/or mechanical ventilation. In the cases of homicidal asphyxiation and hemorrhage and inattention at birth, no resuscitation attempts were made. In the remaining two cases, information concerning resuscitation was unavailable. Equivocal PIE was seen in 32 live born infants, all but 3 of whom had been resuscitated. Eleven resuscitated live born infants had no evidence of PIE. Of the 11 stillborns with equivocal PIE, resuscitation had been performed in two cases. Causes of death in both live born and stillborn cases with equivocal PIE were widely variable, as were the cases in which PIE was not identified. We attempted to correlate the presence of PIE in live born infants with sleeping position and with co-sleeping or non-co-sleeping. No consistent association was found.

In conclusion, the finding of florid PIE supports our previous observation of the association of PIE with live birth. However, no direct correlation between the presence of PIE and cause of death could be determined.

Interstitial Emphysema, Live Birth, Stillbirth

G9 Motor Vehicle Collision-Related Death Due to Delayed-Onset Subarachnoid Hemorrhage Associated With Anticoagulant Therapy

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The goal of this research project is to describe a death related to delayed-onset subarachnoid hemorrhage following craniocerebral trauma in a person receiving anticoagulant therapy, and to alert the medical and forensic communities to this potentially lethal complication related to trauma and therapy.

Death due to craniocerebral trauma sustained in vehicular collisions remains a common cause of unnatural death in the United States. In many cases seen by forensic pathologists, death occurs at or shortly after the injuries are sustained. In some individuals, death occurs following hours, days, or weeks of medical intervention. Others die as a result of complications of their injuries months or even years following the initial

trauma. Various medical interventions may be considered contributing factors in these and other deaths. In this report, we present a case of a death due to delayed-onset subarachnoid hemorrhage associated with anticoagulant therapy which was administered to the victim of a motor vehicle collision because of an underlying prosthetic aortic valve.

On a sunny Texas afternoon, a restrained, 40-year-old woman was driving a late- 1980's model automobile on a dry, 2-lane asphalt, rural highway when an oncoming pick-up truck turned in front of her, resulting in a head-on collision. The woman was conscious, but required prolonged extrication, as she was pinned in her vehicle. She was transported to the nearest hospital, where she was found to have fractures of the right tibia, fibula, and calcaneus, as well as a laceration of the chin and multiple cutaneous contusions of her trunk. Past medical history was significant for a remote aortic valve replacement (at age 16 years for rheumatic heart disease), for which she was receiving chronic anticoagulant therapy. During her entire hospitalization, she remained on anticoagulant therapy for her underlying prosthetic heart valve. A cardiology consultation with echocardiography revealed no acute problems. She underwent surgical fixation of the tibia and fibula fractures at the local hospital prior to being transported to a metropolitan trauma referral center, where she was to undergo repair of the calcaneus fracture. Ten days after the accident, the victim developed altered mental status and agonal respirations, requiring emergency intubation. A computed tomography scan of the head and brain revealed acute basilar subarachnoid hemorrhage. The clinical impression was that the patient had suffered a possible ruptured cerebral artery aneurysm. Since brainstem function was absent, "do not resuscitate" status was established, and the victim died, 11 days after the automobile collision. Because of the nature of the incident, the case was referred to the medical examiner's office where an autopsy was performed.

Autopsy revealed the presence of surgically-fixed tibia and fibula fractures, cardiomegaly (450 gm), a prosthetic aortic valve, multiple cutaneous contusions, and a healing laceration of the chin. Head examination was significant for the presence of approximately 15 ml of patchy subdural hemorrhage over the cerebral convexities and in the posterior fossa, as well as moderate to extensive subarachnoid hemorrhage, most prominent over the cerebellum and inferior right temporal lobe. No cerebral artery aneurysms or vascular malformations, skull fractures or subscalpular hemorrhage were identified. Sections of the formalin-fixed brain revealed a hemorrhagic discoloration of the right medial temporal cortex which, on microscopic exam, proved to be a cerebral contusion. The subarachnoid hemorrhage was most voluminous immediately overlying the contusion. Histologic exam revealed no evidence of fat or bone marrow embolism. The cause of death was ruled "complications of blunt force injuries." Based on the autopsy findings and the clinical history, the final mechanism of death in this case was related to the subarachnoid hemorrhage. Since no grossly-evident vascular abnormality could be identified, the hemorrhage was most likely related to the underlying brain contusion with anticoagulant therapy contributing to the hemorrhage.

Deaths related to complications of traumatic injury are not rare. The causal relationship between the initial trauma and death may or may not be readily evident in such cases. In fact, clinicians and others may initially attribute the death to an unrelated natural disease process, as occurred in this case. The present case serves to remind clinicians and pathologists that any death following a traumatic injury must be considered a possible injury-related death. It also serves to remind physicians of the potentially deleterious effects of anticoagulant therapy, particularly in persons who have been injured.

Forensic, Complications of Therapy, Subarachnoid Hemorrhage

G10 A Comprehensive Analysis of Forensic Science Training in Forensic Pathology Fellowship Programs

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The goal of this research project is to summarize current forensic science training in the nation's forensic pathology fellowship programs.

The forensic sciences are significantly impacting criminal investigations more and more each year. The advances in DNA identification technology alone have revolutionized the daily practice of forensic pathologists. For example, it is now commonplace for forensic pathologists to spot blood standard cards from all bodies for possible future DNA analysis. Other specialized fields in the forensic sciences, such as toxicology, arson analysis, firearm analysis, trace evidence and fingerprint examinations, also aide the forensic pathologist, as corroborative studies, to finalize the cause and manner of death in a wide variety of cases. Therefore, fundamental training in the forensic sciences is necessary to appreciate the complexities inherent in each field. To what extent are the trainees in forensic pathology fellowships around the country obtaining forensic science training?

This presentation will outline survey results regarding forensic science training from the 44 Accreditation Council for Graduate Medical Education (ACGME) accredited forensic pathology fellowship programs under the auspices of the College of American Pathologists (CAP) Forensic Identity Committee. The survey will assess the extent of training in the forensic sciences that fellows in forensic pathology are currently receiving. A formalized survey such as this has not yet been conducted and should provide a wealth of useful information about forensic-specific graduate medical education. The information gleaned from the study may aide members of the National Association of Medical Examiners (NAME) Ad Hoc Committee of Forensic Pathology Training in subsequent revisions to their recent training program guideline recommendations.

The first component of the survey pertains to the characteristics of the forensic pathology fellowship. How many fellows does the program train each year? Is the fellowship affiliated with a medical examiner or a coroner system? Is the medical examiner's or coroner's office accredited by the National Association of Medical Examiners? Is the office affiliated with an academic university or teaching hospital? This section is simply to obtain general information about each training program.

The second component of the survey is geographical. Is the medical examiner's office physically connected with the crime lab, or if not, how far from each other are they located? Specifically, with which components of the region's crime lab (i.e., DNA, toxicology, etc.) is the medical examiner's or coroner's office associated? The purpose of this section is to gain an understanding of the extent to which forensic pathology training programs are integrated with the crime lab.

The third component of the survey is qualitative. Questions in this section pertain to the nature of the involvement of the forensic pathology fellow in each of the areas of the crime lab. How much time is spent in each discipline? Is the exposure to the forensic laboratories simply a tour or does the fellow actually spend time training in each lab for a defined period of time? Are fellows encouraged to undertake independent research projects in the forensic sciences other than forensic pathology? These inquiries will further define the nature of education in the forensic sciences that today's forensic pathology fellows receive.

The presentation will summarize the results of all participating forensic pathology fellowship programs and discuss any trends that are

observed. The information gained from this study should prove valuable for assessing the current state of forensic pathology training with respect to the crime lab, and for formulating goals to strive for in the future as forensic pathology continues to become increasingly more integrated with other disciplines of forensic science.

Crime Lab, Forensic Pathology Fellowship, Training Program

G11 Postmortem Microbiology: Friend or Foe?

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The goal of this research project is to give participants a heightened sense of the various modern-day postmortem bacterial organisms, their relevance and their presence/absence based on sample site.

Introduction: Postmortem microbacteriological culture results are frequently difficult to interpret. Many organisms are cultured but the significance in the postmortem state is unknown. This can create dilemmas for forensic pathologists, particularly in those cases where a distinct anatomical cause of death is lacking. Many different culture techniques have been employed over the years and many different sites have been cultured, all with varying results. The emergence of new and resistant strains of bacteria prompted the investigators to establish what contaminants are present in the modern day and to compare the organisms cultured based on specimen site, relevance when compared to tissue sections and their presence based on time since death.

Methods: In this study, the authors obtained microbacteriological cultures from autopsies over a two-month period in the spring in a south-eastern state. Bodies in a state of advanced decomposition were excluded from the study, resulting in a total of 34 cases. Five sites were sampled in the majority of the cases: subclavian blood, heart blood, spleen, right lung and left lung. Sterility was obtained either through searing of the tissues or the use of betadine, depending on the site being cultured. In addition, microscopic sections of the lungs were taken directly adjacent to the culture site to enable correlation of organisms cultured to the presence/absence of inflammation seen histologically. Pediatric blood culture bottles were utilized for both the subclavian and heart blood samples. Culturette swabs were utilized for the lung cultures and a small portion of spleen was removed *in situ*, and then ground with a tissue grinder. The latter three specimens were streaked onto three types of agar: 5% sheep blood, chocolate and MacConkey. Positive blood cultures (as determined in the BacT automated system) were also plated onto these three types of media. Gram stains were performed on every organism grown and then additional testing was instituted to further identify the organisms as needed.

Results: As one would expect, the majority of postmortem bacterial organisms cultured are contaminants. However, many common ante-mortem pathogens are also frequently cultured in the postmortem state, but are without histologic evidence of inflammation and are therefore felt to represent contaminants as well. Tissue sections are absolutely critical in determining the relevance of these particular organisms. In the cases where organisms were cultured that were felt to be a contributing factor in the person's death, there was histologic evidence of inflammation. All specimen sites sampled within a single case produced similar findings. Therefore, postmortem microbacteriological cultures can be useful tools in the process of death investigation, when used appropriately and in the full context of the case.

Microbiology, Bacterial Organism, Postmortem

G12 Sufentanil Toxicity in Healthcare Professionals

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The goal of this research project is to provide to the forensic community an awareness of two recent cases of sufentanil toxicity involving healthcare professionals.

We have observed two deaths involving sufentanil toxicity in healthcare professionals in a period of less than two months. This presentation demonstrates two autopsy cases from the Harris County Medical Examiner's Office involving sufentanil toxicity among healthcare professionals. Sufentanil citrate is available under its generic name of sufentanil and is often used in the surgical suite by anesthesiologists as an adjunct to general anesthesia. Sufentanil is available in Dosette ampules of 50-mcg/1 ml, 100-mcg/2 ml, and 250-mcg/5 ml. It is a Class II controlled synthetic narcotic, which is about 5 to 7 times as potent as fentanyl and 500 to 800 times as potent as morphine. The usual adult dose is 1 to 2 mcg/kg. Supplemental doses of 10 to 25 mcg may be given as needed. Profound analgesia is achieved with doses of 2 to 8 mcg/kg. Deep general anesthesia is achieved with doses of 8 to 30 mcg/kg. Sufentanil easily crosses the blood-brain barrier and is quickly routed to body tissues. After 24 hours, approximately eighty percent of the drug dose is excreted in the urine. Sufentanil is metabolized into N-desmethylsufentanil and O-desmethylsufentanil. Approximately thirty percent of a dose metabolizes as conjugates in both urine and feces. Sufentanil has a number of toxic effects including respiratory depression, acute respiratory arrest, seizures, hypotension (also sudden hypotension), euphoria, dizziness, muscle rigidity, drowsiness, nausea, vomiting, bradycardia, and irregular heartbeat. The literature reports of two deaths in adults after self intravenous administration of sufentanil indicating blood levels of 1.1 and 7.0 mcg/L and liver levels of 1.8 and 3.4 mcg/L. It is not clear if these adults were healthcare professionals.

The following are details of two cases involving sufentanil toxicity which have occurred in less than a two-month period. Case One is a 41 year-old Caucasian male anesthesiologist who was found in the bathroom, sitting on the toilet with his pants on and unresponsive. An empty syringe was found inside a dry beer can. A small vial of sufentanil 50 mcg, three-fourths empty, was found in the bathroom. The autopsy findings included a recent injection site in the left antecubital fossa with a 3/8 inch hematoma, cardiomegaly (450 grams) with moderate atherosclerotic cardiovascular disease, bilateral pulmonary edema and congestion, hepatomegaly (2550 grams), and erosions of the gastric mucosa.

Case Two is a 34 year-old Caucasian male registered nurse who was found at work in the ladies' bathroom face down on the floor with his pants and underwear down around his ankles. Fifteen (15) different ampules, vials, and bottles of medications were found in the bathroom which included one opened ampule of sufentanil. In addition, one previously used syringe with needle and cap was found at the scene. The autopsy findings included bilateral injection sites on the medial thigh, cardiomegaly (550 grams) with right ventricular dilatation and concentric left ventricular hypertrophy, and hepatomegaly (2400 grams).

Sufentanil can be assessed in the laboratory by multiple methods including gas chromatography with nitrogen specific detection, radioimmunoassay, and gas chromatography-mass spectrometry (GC-MS). The blood analysis for sufentanil was identified and quantitated by GC-MS method. Biological specimens were made alkaline (pH 13) using 2N, NaOH. Sufentanil was extracted using a mixture of hexane:ethanol (19:1). D5-fentanyl was used as an internal standard. The dried extracts samples were injected onto the GC-MS and the ions 250, target ions, 194, 195, 151 for D5-fentanyl and 250 (target ion), 290, 291, 140 for sufentanil were monitored. Postmortem blood in Case One was positive for ethanol

0.12 g/dL and sufentanil 2.95 mcg/L. The syringe wash was also positive for sufentanil. No other drugs were identified. In Case Two, sufentanil was the only compound in concentration of 2.63 mcg/L. The cause of death was sufentanil toxicity for both cases. The manner of death was ruled as accidental for both cases.

In conclusion, these two deaths resulting from sufentanil toxicity in Harris County Medical Examiner's Office in less than two months are warning signs of the popularity of this potent, narcotic substance among healthcare professionals with substance abuse problems.

Sufentanil, Healthcare Professionals, Harris County Medical Examiner Office

G13 Oxycodone (OxyContin) Related Deaths in Maryland 1998-2000

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The goal of this research project is to examine the prevalence and features of oxycodone-positive deaths in the State of Maryland over a three year period from 1998 through 2000.

Oxycodone is an opioid agonist with a high oral:parenteral potency ratio relative to most other opioid analgesics. This is due to the presence of a methyl group on the aromatic hydroxyl group, which prevents its conjugation by glucuronic acid in the liver. Because oxycodone is less potent than morphine in its analgesic properties and has adverse effects that limit the maximum tolerated dose, oxycodone is frequently employed clinically in formulations containing aspirin or acetaminophen. In recent years, the number of deaths related to the abuse of oxycodone has appeared to be increasing.

We examined case records at the Office of the Chief Medical Examiner of the State of Maryland (OCME) over a three year period from 1998 through 2000, where toxicologic studies showed the presence of oxycodone in the samples submitted. The laboratory identifies oxycodone as part of its routine abused and therapeutic drug testing procedures.

The number of oxycodone-positive cases investigated by OCME has increased steadily from 1998 to 2000. In 1998, there were a total of 27 oxycodone-positive cases; in 1999 a total of 41 oxycodone-positive cases, and in 2000 there were 69 oxycodone-positive cases. Of these, the large majority of cases were in individuals between the ages of 32 and 49. In 1998, 67 percent; in 1999, 68 percent; and in 2000, 69.6 percent of oxycodone-positive deaths occurred within this age range. Most cases were in white individuals: In 1998, 85.2 percent; in 1999, 85.4 percent; and in 2000. Oxycodone-positive deaths in men outnumbered those in women. From 1998 through 2000, the percentage of oxycodone-positive deaths occurring in men were 70.4 percent, 70.1 percent, and 60.1 percent respectively. 41.6 percent of all oxycodone-positive cases were in the urban areas of Baltimore City or Baltimore County, while the remaining 58.4 percent occurred in Maryland's suburban and rural counties combined.

Of all oxycodone-positive cases from 1998 through 2000 (n=137), 41.6 percent of deaths (n=57) were attributed to oxycodone. Of the latter, 35.1 percent of deaths (n=20) were attributed to oxycodone alone, while the remaining 64.9 percent (n=37) were attributed to oxycodone in combination with alcohol and/or one or more other drugs.

This data suggests that oxycodone, especially when used in combination with alcohol and/or other drugs, contributed significantly to the number of deaths in Maryland from 1998 through 2000. Moreover, the use of oxycodone has increased significantly over this brief time period.

Oxycontin, Oxycodone, Death

G14 Deaths Related to Conduction System Pathology

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The goal of this research project is to inform the forensic community of fatal cases related to conduction system pathology.

It is not rare for pathologists to be confronted with the apparently natural deaths of young subjects without any prior medical history. Sometimes the exact cause of death remains unknown even after a complete autopsy and full toxicological analyses. In some of these cases examination of the cardiac conduction system can demonstrate pathological lesions which are described in the literature as a possible explanation of the fatal issue. On the other hand, rhythm disturbances are not always lethal. But, according to the circumstances in which they occur, they can lead to death. For example they can have dramatic consequences if the victim is driving or swimming. For these reasons the evaluation of the cardiac conduction system cannot be overlooked in forensic medicine.

Since 1998, the conduction system of the heart is systematically analyzed in our institute. A simplified and evaluated method is used. Samples of the conduction system are collected from the left approach to the ventricular septum. The initial block is cut into 5-7 blocks about 2-3 mm wide. From each block (always sectioned from the anterior face) at least 1-2 histological sections are prepared and stained with hematoxylin-eosin or with Masson trichrome. If suspicious lesions are noticed, more sections are made.

In this presentation, 25 cases are reported: 12 cases of sudden unexpected death and 13 cases of fatal accidents.

In the group of sudden unexpected death, the ages ranged from 11 to 52 years. For most of them the reports of the very last moments of life suggested a possible cardiac origin of death. Most of the time clinical data was unknown or insignificant. In the group of the lethal accidents which included cases of drowning, paragliding and road accidents, the police investigation strongly suggested a sudden sickness. The ages of the victims ranged from 15 to 70 years.

In the 25 cases, the macroscopic study of the heart (heart weight, examination of valves, coronary arteries, cardiac chambers and great vessels), as well as histological examination of working myocardium, were normal. The toxicological analyses were negative. However in all the cases, microscopic examination of the cardiac conduction system allowed to detect different pathological changes. Thus, lesions such as an abnormal small muscle entrapped into the bundle branches or in the interventricular septum, fatty infiltrations of the bundle of its branches, a replacement of the conduction tissue by empty spaces, the accessory pathways between conduction structures and myocardium, a stenosis of the arteries supplying the conduction system, and fibrosis of the septum with occasionally compression of the branches were detected. Such findings are described in the literature and reported as possible causes of rhythm disturbances and death.

Nevertheless, in cases of deaths which seem to be conduction system related, conclusions should be prudent, especially in forensic practice. Even if histological examination reveal pathological lesions, the death can be attributed to cardiac rhythm disturbances only if no other cause is found after a complete autopsy and toxicological analyses. Moreover, it is not possible to exclude that the pathological findings of the conduction system are not responsible for the sudden death, and that the cause of death is related to another unknown origin.

Microscopic examination of the cardiac conduction system, even with a simplified technique, is laborious. Moreover, the interpretation of the histological findings is difficult. However, the evaluation of the conduction system should be more systematically carried in routine forensic practice as it can explain not only the cause of sudden unexpected deaths, but also it can help to elucidate the circumstances of fatal cases initially supposed to be accidental.

Cardiac Conduction Systems, Sudden Death, Accident

G15 *Commotio Cordis Intermedius: Digital Interposition Between Projectile and Thorax*

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The goal of this research project is to present the forensic community with a description of novel variation of a recognized mechanism of sudden cardiac death.

A 21-month-old male child along with his father and uncle were attending a stock car racing event on a somewhat muddy track. The vehicles repeatedly splattered hardened chunks of the dirt into a short protective wall at the curved edge of the roadway and, on occasion, into the spectators sitting in the adjacent bleachers.

As the uncle, who was sitting in the top row, was passing the child to the father who was in the seat below, a “whoosh” sound followed by a “pop” was described by the two adults. The uncle was struck in the dorsum of the third left finger at the proximal joint, having his hand placed over the chest of the child while transferring him to his father. The finger showed a “black, grainy” area as well as a “red mark”, both gone when he reached the hospital. X-rays revealed no fracture. Upon later scene investigation, several irregular, hardened mud clods were found in and under the nearby seats, some approximating the dimension of a golf ball. The uncle had commented that the object that struck him felt about this size.

Following the “pop”, the child immediately let out a cry, jerked his head back, appeared to have lost consciousness, and became limp. Breathing was said to be irregular with a rapid pulse noted. EKG initial rhythm showed approximately 270 beats per minute. The respiratory rate varied between 3 and 10 breaths per minute and the pupils were dilated. Soon the pulse weakened and efforts to resuscitate him at the field and continuing in a nearby hospital were unsuccessful. Agonal vomiting had occurred and some was present on the clothing. A small “red mark” was seen on the left side of the baby’s lower ribs when his shirt was removed by the paramedics, and was also noted at the hospital. EKG now revealed asystole and he was pronounced dead one hour following the incident. There was a previous history of asthma with medications prescribed. He had been hospitalized two months earlier for otitis media and pneumonia, which cleared after antibiotic treatment.

Postmortem examination two days later revealed no bruising of the chest skin, underlying musculature, ribs, sternum, pericardium, or heart. The “red mark” on the chest observed at the track was not now evident. Microscopic examination of multiple heart sections and other tissues were essentially normal. There were no pulmonary changes indicative of asthma. Evidence of gastric aspiration was not observed. The only other injury was a small, patterned bruise on the lateral left forehead, noted on the day following the autopsy. The underlying skull and brain were grossly and histologically unremarkable.

The interposition (“intermediate object”) in this instance may have accounted for the lack of a discrete injury on the chest or in the musculature of the child, although “hyperemia” of this area as well as on the uncle’s finger were initially documented. A relatively high velocity impact to the thorax, however, remained as the lethal mechanism to a presumably vulnerable heart. Additional studies attempting to clarify the cardiac status will be described. The possible distribution of forces due to the interposed digit will also receive comment.

Sudden Death, *Commotio Cordis*, Intermediate Object

G16 *Genetics of Sudden Cardiac Death: Prothrombotic Mutations of Blood Platelet Glycoprotein Receptors are Common Among Men Who Die of Prehospital Myocardial Infarction at Early Middle Age*

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The goal of this research project is to present new insights into the pathology of sudden cardiac death and to draw attention to the importance of genetic prothrombotic factors as predictors of sudden prehospital coronary death.

The knowledge on predicting and predisposing factors of sudden cardiac death (SCD) at early middle age has remained limited: only smoking and family history are known to be associated with SCD. Following the decline in the rate of myocardial infarction worldwide, sudden cardiac death has remained the most important unresolved factor in the mortality of coronary heart disease (CHD). As much as 90% of CHD mortality in individuals under 55 years occurs out-of-hospital. A key event in the development of acute myocardial infarction and sudden cardiac death is the rupture or erosion of a thin-walled atheromatous plaque distant from the site of the culprit stenosis leading to the development of fibrin-rich occluding thrombosis. When an atheromatous plaque is fissured or its fibrous cap is ruptured, platelet glycoprotein GpIb-DC-V (HPA-2) receptors are activated and start the binding of platelets to subendothelial collagen. At the same time, GpIIb/IIIa (HPA-1) fibrinogen receptors are also activated and begin binding fibrinogen, connecting platelets to each other, leading ultimately to the formation of coronary thrombosis. A mutation (CM) in the leucine-rich region in the GpIb receptor gene binding site leads to an alteration in the amino acid sequence (Thr/Met) and alteration in the binding activity. Another mutation (pIAI/A2) in the exon of Gp Ila gene with replacement of one amino acid (leucine with proline), resulting in a change in the protein conformation and in the spatial orientation of the fibrinogen-binding region of the receptor, affects the efficacy of platelet aggregation. There have been no detailed autopsy studies on the occurrence of these mutations among victims of sudden cardiac death.

The aims of the present project were to study the associations of the Thr/Met mutation of the Gp Ila-DC-V collagen receptor and the pIAIA2 mutation of the Gp IIb/IIIa fibrinogen receptor with coronary thrombosis and MI in a carefully characterized autopsy series and to examine the possible age-dependency of this association.

The study series comprised 700 men (mean age 53.1 yrs, range 33 to 70) of the Helsinki Sudden Death Study (HSDS) subjected to a detailed medicolegal autopsy in 1981- 1982 (n=400), and in 1991 - 1992 (N=300). This series comprises all sudden unexpected cardiac deaths of men below 55 years living in the Helsinki city area (500 000 inhabitants) and also all violent deaths within this area during 2.5 years. Life style and various risk factors were ascertained by interviewing the spouse, a relative, or a close friend of the deceased. The interview succeeded in 500 (71.4%) cases. The presence or absence of acute MI and/or coronary thrombosis was confirmed by macroscopic and histological examination of the myocardium. The Thr/Met and pIAUA2 polymorphisms were detected by PCR and restriction digestion.

The genotype frequencies of the Thr/Met polymorphism were 77.1% for ThrThr, 21.3% for ThrMet and 1.6% for MetMet genotype.

Respectively, the genotype frequencies of the pAIIA2 polymorphism were 73.1% for pAIIA1, p₁AIIA2 24.2% for and 2.7% for pAIIA2A2.

Men with an acute MI (n=75) and coronary thrombosis (n=61) were more likely to be carriers of the Met allele of the Thr/Met polymorphism of the GpIb-IX-V collagen receptor (OR 2.5 and 4.0, respectively, p<0.005 for both) compared to controls who died of non-cardiac causes (n=340). In men under 55, Met allele carriers were over represented (OR 1.9) among victims of SCD (n=97) compared to controls (n=249). In men under 55, 14/28 (50%) of men with acute MI and 16/23 (69.6%) of men with coronary thrombosis were carriers of the Met allele compared to those 50/249 (20.1%) who had died of non-cardiac causes (ORs 4.9 and 9.0, respectively). Similar associations were observed in the separate analysis of both individual autopsy series.

Our results suggest that prothrombotic mutations in blood platelet collagen and fibrinogen receptor genes occurring normally in 20-25% of the population are found in 60-70% of victims of acute fatal myocardial infarction below 55-60 years. This suggests that they are major risk factors predicting coronary thrombosis and early prehospital coronary death.

Sudden Cardiac Death, Coronary Thrombosis, Myocardial Infarction

G17 Under Reporting of Fatal Child Abuse by State Vital Statistics ICD-9 Codes

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The goals of this research project are to learn how to identify the difference in the incidence of fatal child abuse cases as reported by ICD-9 codes versus state child death review boards, to establish awareness of underreporting of fatal child abuse cases, and to discuss recommendations for improvement.

The purpose of this study is to document the difference in the incidence of fatal child abuse cases as reported by the International Classification of Diseases, Ninth Revision, codes versus that reported by state child fatality review boards. The ICD, designed to promote international comparability in the collection, processing, classification, and presentation of mortality statistics, includes translating reported conditions into medical codes. The coding rules consolidate conditions, and systematically select a single cause of death from a reported sequence of conditions. State child death review teams are comprised of multi-agency, multi-disciplinary members, who meet periodically to examine circumstances surrounding the deaths of children. State child review teams are comprised of members such as law enforcement, coroners, social services, physicians, educators, legal community and members of the Department of Health and Environment, who bring a variety of experience and perspectives on children's health and maltreatment issues. Under the ICD-9, category E967 is Child Battering and Other Maltreatment. For a homicide to be coded E967, the decedent must be younger than eighteen, and the death certificate must list evidence of prior abuse or the certifier must specify abuse, beating or other maltreatment. The general definition of child abuse by medical examiners and child fatality review boards is death of a child under the age of eighteen by the willful act of a person responsible for the child's welfare.

We retrospectively studied child abuse fatality data from New Mexico, Arizona, Kansas, and North Carolina for the year 1997. The incidences of death resulting from child abuse published in the 1997 annual report for state child death review boards and the deaths attributed to state vital statistics code E967 were compared. Preliminary review reveals a high percentage of under reporting by ICD-9 codes. This can be attributed to failure of the coding system to recognize fatalities due to abuse, inexperience of the coder, interpretation of the code (more than one code for similar conditions), and incomplete or inaccurate reporting on

death certificates. For example, a homicide due to an injury sustained from a single isolated incident of a child under the age of eighteen would not be coded as E967 (Child Battering and Other Maltreatment) due to the fact that there was no history of previous child abuse, beating or maltreatment. Problems occur with varying definitions of what constitutes abuse or neglect, and the failure to categorize neglect deaths as homicides.

We will present suggestions to improve upon the current system of recognizing and reporting fatal child abuse. Improvements in the recording of incidences of child abuse fatalities are crucial in the development of prevention strategies. Recommendations to improve data may include revising the format of death certificates, training coders or restructuring the coding system to include new codes specifically for medical examiner cases. An improved approach to reporting child abuse may require training of coroners, medical examiners and physicians to properly and universally complete death certificates. Items that may help to obtain a higher overall level of recognition of child abuse cases would include education and certification of those individuals responsible for investigating deaths. Standardization of scene investigation and autopsy protocols may be helpful, as well as stringent statutes requiring that autopsies be performed on all children under the age of two. Improvement to the current underestimated mortality figures will require cooperation and collaborative efforts between multi-disciplinary agencies including state vital statistics, child fatality review teams, medical examiners, law enforcement, and the legal system.

Mortality figures determined by ICD-9 coding alone was found to significantly underestimate the incidence of fatal child abuse in four states for the year 1997 when compared to medical examiner/coroner statistics and data from state child death review boards. Accurate recording of fatal child abuse is crucial to determine the true incidence of child homicide, to establish trends, and to allocate resources for prevention strategies.

Child Abuse, ICD-9, State Child Death Review Boards

G18 Venous Air Embolism— A Difficult Postmortem Diagnosis

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The goals of this research project are (1) to report a series of cases where circumstantial evidence and autopsy findings helped determine the cause and manner of death; (2) to illustrate through cases that, though an uncommon complication of a common procedure, venous air embolism can cause sudden and unexpected death; and (3) to bring home the point that awareness of this phenomenon is paramount in making the right postmortem diagnosis.

Case 1. A 59-year-old male on Methadone program for chronic drug abuse was found unresponsive in his hospital room. His central line catheter appeared to have been cut or melted. Suspicion of foul play was entertained initially until the County Sheriff's police ruled it out.

Case 2. While sitting on a chair in preparation for discharge, a 71-year-old female with a history of hypertension and scleroderma developed mental status changes soon after removal of central venous catheter. A family member witnessed this incident.

Case 3. While being detained by police for shoplifting, a 29-year-old female with a history of chronic renal failure on dialysis pulls out her central line catheter and collapses to the floor. The store security cameras recorded this incident.

Case 4. A 40-year-old male with chronic renal failure was found unresponsive in his motel room in a pool of blood with a dislodged dialysis catheter. He had a history of depression and suicidal tendencies in the past.

Central Venous Catheterization is performed frequently in the management of a variety of medical and surgical illnesses. The commonly

recognized complications of insertion and removal of a Central Venous Catheter (CVC) include thrombosis, infection both systemic and local, pneumothorax and hemorrhage. Venous Air Embolism (VAE) is another complication that is preventable, and carries with it a high incidence of morbidity and mortality. The risk of VAE associated with removal of CVC is not widely known, as is demonstrated by Case Two. Several factors known to predispose to the formation of VAE such as failure of spontaneous collapse of the catheter tract due to duration of catheter insertion, diameter of the indwelling catheter, upright position of the patients, deep inspiration or coughing while catheter removal or disconnection, played a significant role in these persons' demise.

The cases being described illustrate that postmortem diagnosis of VAE is difficult at best, but not impossible if one takes into account the medical history and circumstances surrounding death, and has a high degree of suspicion and awareness of this phenomenon.

Venous Air Embolism, Central Venous Catheter Removal, Sudden Death

G19 Virtopsy—New Horizons in Forensic Radiology: Documentation and Analysis of Gunshot Victims With Postmortem Multi-Slice Computer Tomography and Magnetic Resonance

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The goal of this research project is to study the full-body documentation of seven gunshot wound victims, with multi-slice spiral computed tomography (MSCT) and magnetic resonance (Mr), and subsequent comparison with the findings of the standard forensic autopsy.

Virtopsy - New Horizons in Forensic Radiology: Documentation and Analysis of Gunshot Victims with Postmortem Multi-Slice Computer tomography and Magnetic Resonance

Goal: The use of the new radiologic modalities in forensic science promises to be a great help for forensic pathologists. This paper will present the full-body documentation of seven gunshot wound victims, with multi-slice spiral computed tomography (MSCT) and magnetic resonance (MR), and subsequent comparison with the findings of the standard forensic autopsy.

Materials and methods: MSCT was performed on a General Electric Light Speed QX/i. The scan time for 350 axial slices of the head (high-quality data and overlapping data acquisition) was 40 seconds, and for the rest of the body we required only 20 seconds (high-speed data acquisition; 70 axial slices). The MR examination was performed on a 1.5 Tesla General Electric machine. Post processing (2-D and 3-D reconstructions of CT data sets) was performed with the GE Advantage Windows workstation. Then a classical forensic autopsy was made.

Results: With the spiral CT and MR examination and the subsequent 2-D multi-planar reformation / (MPR) and 3-D shaded surface display reconstruction (SSD), all the gunshot-created complex skull fractures and brain injuries (such as the wound channels and the deeply-driven bone splinters) could be impressively documented in complete and graphic detail. With the CT / MR examination it was also possible to document and demonstrate some signs of vital reaction to the gunshot: air emboli in the upper thoracic veins and the heart and the classic pattern of blood aspiration in the lungs.

Discussion: We agree with B.G. Brodgon, who says in his book, *Forensic Radiology*: "The sad truth is, that a century after the first x-ray was introduced as evidence in a court law, there is no general appreciation of the extent of the radiology potential in the forensic sciences." To the best of our knowledge this paper is the first study that compares prospectively the results of postmortem MSCT and MRI with the findings of forensic autopsies. Utilizing the modern methods of MSCT and MR it was possible to document the relevant forensic injuries. An advantage in comparison to the classic autopsy is that the data collection of the radiological examination is produced non-destructively. In addition, this radiological data, including the 2-D and 3-D reconstructions, can be archived, in contrast to the real injuries of the corpses. In summary, the radiological documentation has some significant advantages in comparison to the classic forensic autopsy and documentation. In the future this documentation and analysis process with MSCT and MR and magnetic resonance opens the door for a "Digital Autopsy" or a "Virtual Autopsy" in selected forensic cases.

Forensic Radiology, Computed Tomography, Magnetic Resonance

G20 Evaluation of 122 Forensic Autopsies of Unprotected Victims Killed in Traffic Accidents

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The goals of this research project are to present the results of 122 autopsies of unprotected victims killed in traffic accidents. Proposals are made to improve the efficiency of the forensic procedure which is very complex.

Unprotected road users, such as pedestrians, bicyclists and motorcyclists, are not shielded by the body of a vehicle and are therefore at a high risk of being killed in a traffic accident. If it is impossible to undo the tragedy in a fatal accident, one must address the severe consequences it has on the family of the victim and on the drivers and their families as well. It is thus extremely important to establish the precise sequence of events in an accident and to assign clear responsibilities. If the police and the technical experts are primarily responsible for elucidating the circumstances surrounding an accident, a careful post-mortem forensic examination can provide significant and important evidence.

Because a forensic autopsy of a victim of a fatal traffic accident is a complex, laborious and time-intensive task, we wished to analyze the results from such work with the following objectives in mind:

- to evaluate the contribution of forensic investigations to the elucidation of the circumstances of an accident and of the responsibilities of the involved parties;
- to evaluate the efficiency of forensic investigations taking into account the significant time expenditure and efforts necessary to complete this work;
- to identify and propose preventive measures to reduce the frequency and gravity of traffic accidents; and
- to identify and propose improvements in the forensic investigations carried out in fatal traffic accidents.

Our study was conducted on 122 traffic accidents that occurred in Switzerland between 1979 and 1996 and which required the expertise of the University Institute of Forensic Medicine of Lausanne. To evaluate the autopsy findings, standard questionnaires were employed that addressed the following variables:

- age and gender of the victims,
- classification of victims as a function of their mode of transportation, survival,
- vehicles involved in the accident,
- speed of vehicles involved in the accident,
- location and circumstances surrounding the accident,
- visibility: lighting, weather conditions, color of clothing of the victims,
- cause of death,
- observed lesions,
- primary lesions,
- medical history, and
- toxicological analyses.

Our results are in agreement with those reported in the literature with respect to the following findings:

- the largest proportion of accidents involve elderly persons;
- elderly victims are most likely to survive the accident and succumb later from accident-related complications that would not be lethal for younger, healthier individuals;
- private automobiles constitute the largest category of vehicles involved in accidents;
- a high proportion of accidents occur within towns or villages;
- a high proportion of accidents occur in darkness;
- the prevalence of cranio-cerebral lesions, polytraumatism, thoracic lesions and spinal chord lesions as the cause of death;
- the nature of the primary lesions;
- the role of alcohol consumption.

Based on the data published in the literature and on our own results, the forensic examination can provide very important information in establishing the degrees of responsibility of both the drivers and the victims of traffic accidents. The forensic examination is clearly an efficient approach; the information can often be obtained only by this means and its value is very significant. Such examinations must be conducted irrespective of constraints linked to time, cost, and efforts deployed by forensic scientists.

We make a series of proposals to increase the safety of unprotected road users and to improve the efficiency of forensic examinations in fatal traffic accidents.

Traffic Accidents, Unprotected Victims, Usefulness and Efficiency

G21 Undeclared by Surgery: The Utility of Post-Surgical Foot and Ankle Radiographs as a Basis for Identification

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The goals of this research project are to demonstrate to participants how 1) radiographic comparisons for positive identification can reliably be made in some cases, even if there has been an alteration in the anatomy; and 2) what may be done to quantitatively evaluate the "matchability" of a postmortem radiograph to a premortem film.

Foot and ankle radiographs can be utilized as the basis of identification in forensic investigations involving decomposed, mutilated, or

fragmented remains (1-6). The lower extremity may be better preserved in both aquatic and terrestrial environments than other anatomical regions (7). The structural complexity of the foot and ankle facilitates identification by providing potentially unique skeletal features and/or configurations.

The process of radiographic comparisons for identification is intuitively understood, but not easily represented in an algorithmic fashion. While the result of the comparative evaluation may be easily verbalized ("match" or "no match"), the process by which that determination is made may not be as easily described. Qualitative factors addressing the reliability of that match may also be difficult to convey. The authors evaluated the possibility of developing a numerical representation of the reliability of a match evaluation.

Experimentally, 30 sets of pre-surgical (premortem) and post-surgical (simulating postmortem) radiographs of the foot and ankle were obtained from a tertiary care medical center simulating a postmortem identification. Up to three different views were used, including, anteroposterior (AP), medial oblique (MO), and lateral projections. All sets were prepared by one author (JR), and included both real matches and actual mismatches to provide a potential false positive result. Premortem and simulated postmortem radiographs were separated by a surgical event to simulate the effects of an alteration in anatomy. The time lapse between the premortem and simulated postmortem radiographs ranged from 2 to 36 months.

The reliability of the match results was evaluated and graded by a numeric system. As a first approximation and as evaluated in the experiment described herein, we considered 10 characteristic skeletal features in the simulated postmortem radiographs. We then looked for the same radiographic features in the premortem films and scored the results as follows:

- +1: If the feature was present and matched.
- 0: If the feature was either not present or its presence could not be determined.
- 1: If the feature was present, but did not match, or if the trait was present in either the pre- or postmortem radiographs but not in both.

For each set, we added the score. The radiographic sets were independently evaluated according to the medicolegal standard, "with a reasonable degree of medical certainty, these radiographs came from or did not come from the same individual." Additionally, we noted if we could not determine with a reasonable degree of medical certainty whether or not the films came from the same person.

Examiners included a forensic pathologist, forensic anthropologist, physician-coroner, and musculoskeletal radiologist who graded the radiographs according to the 10-feature scheme noted above. As a second exercise, we evaluated the set for a match. A correlation between the score and whether or not there was a match was determined. Simulated postmortem radiographs were evaluated for mean and standard deviation of the "matchability" score. Similarly, the match reliability score was evaluated and finally the correlation coefficient between the two was calculated.

Preliminary results indicate that at least two matching characteristics are necessary for determining that two radiographs have come from the same person. At least two characteristics must be present in the films that do not match each other to determine that two radiographs are from different individuals. The three most useful traits of the ten skeletal features examined were a) the overall shape of the calcaneus and the cortical bone of the metatarsals, b) the trabecular pattern of the calcaneus and the metatarsals, and c) osteophytes.

It is anticipated that the approach described in this study may evolve into a radiograph scoring system allowing a quantitative variable to be considered in addition to a "yes or no" match result with regard to forensic investigations.

Human Identification, Radiographs, Surgical Modifications

G22 Paraphyly in *Lucilia Cuprina* (Diptera: Calliphoridae) Mitochondrial DNA: Implication for Forensic Entomology and Evidence for an Ancient Hybridization Event

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The goal of this research project is to learn about the large number of recent published papers and important conceptual issues concerning DNA and insect evidence.

The closely related species *Lucilia* (=Phaenicia) *cuprina* (Meigen) and *L. sericata* (Meigen) are widespread, common, and extensively sympatric blow flies. Both may be collected as evidence during an investigation of human death. Taxonomic identification of insect evidence is usually an essential first step in a forensic entomological analysis, because different species can have different habits, growth rates, etc. Recently several authors have proposed the use of DNA sequence data for identifying forensically important insects. This is because fly larvae (also called maggots) and eggs are often difficult or impossible to identify using anatomical features. Furthermore such specimens are often dead or dying by the time the entomologist receives them, and they cannot be reared to the more easily identified adult stage. An implied assumption of most authors who advocate this DNA-based approach is that the genetic locus used has an evolutionary history identical to that of the organism as inferred from traditional taxonomic characters. In the language of systematic biology, the morphological and DNA evolutionary trees are assumed to be concordant.

This assumption was tested using a global molecular systematic survey of *L. sericata* and *L. cuprina*. Specimens from Europe, Africa, North America, Australasia and the Hawaiian island of Oahu were each classified as one of these two species based on bristle patterns and male genitalia. For each specimen we obtained DNA sequence data from a nuclear locus, a 2.2 kb region of the large subunit of the 28S ribosomal RNA gene (28S), and a mitochondrial locus, a 2.3 kb region of the first and second subunits of cytochrome c oxidase (CO). The DNA extraction, PCR, and sequencing methods used were described in previous publications (Stevens & Wall. *Forensic Sci Int.* 2001. 120:116-23; Wells & Sperling. *Forensic Sci Int.* 2001. 120:110-5).

Polymorphic base positions within the 28S gene were largely confined to three distinct portions within the D domains, while those within CO were evenly spread across the region.

Phylogenetic analyses of the data using the calliphorids *Lucilia caesar* (L.) and *Calliphora vicina* Robineau-Desvoidy as outgroup species found a significant lack of concordance between the most parsimonious tree (also called a cladogram) based on the nuclear 28S sequence and that based on the mitochondrial CO sequence (Kishino-Hasegawa test, $P < 0.0001$). The 28S tree included monophyletic lineages corresponding to each of the species as defined by morphological criteria. In contrast, the CO tree strongly supported a paraphyletic *L. cuprina*, with specimens from Hawaii as the sister group (i.e., the most closely related lineage) of *L. sericata*. Prior to this study CO sequence analysis of an *L. cuprina* larva or egg from Hawaii may have misidentified the specimen as *L. sericata*. While that particular mistake is no longer possible, our results suggest that widespread geographic sampling and/or a multi-gene approach may be needed before DNA-based identification of carrion insects can be considered a reliable technique in all situations. It is most important to survey genetically isolated populations such as on remote islands.

A possible explanation for this evolutionary pattern is that the Hawaiian *L. cuprina* are descended from a hybridization event between a female *L. sericata* and a male *L. cuprina* with the subsequent loss of *L. sericata* nuclear alleles. Both flies were probably introduced to Hawaii by

human activity, and small initial populations would make the above scenario more likely. However, the observed genetic distances were about 0.9% sequence divergence between the Hawaiian *L. cuprina* lineage and the *L. sericata* lineage compared to about 0.2% sequence divergence within each of these lineages. This suggests that the *L. sericata* and Hawaiian *L. cuprina* CO diverged long before humans first reached the islands. Given the Pacific island route by which humans colonized Hawaii, as well as the fact that samples from other Pacific islands were not included in this study, we suggest that islands occupied earlier in the geographic expansion of Polynesian humans be surveyed for the possible origin of the Hawaiian *L. cuprina* clade.

Forensic Entomology, Non-Human DNA, Molecular Systematics

G23 Investigation of Italy's Deadliest Building Collapsed: Forensic Aspects of a Mass Disaster

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The goal of this research project is to respond to mass fatalities: Investigation and morgue operations.

In the early morning hours (approximately 3:00 a.m.) of November 11, 1999 a six-story apartment building, approximately 30 years old, collapsed before dawn in Foggia (viale Giotto, 120), Italy, killing many of the residents while sleeping and others trying to escape. Minutes before the structure crumbled some tenants were awakened by a loud cracking sound. Consequently, they knocked on doors, trying to wake other tenants and escaped just moments before the building collapsed. It took literally seconds for the building, which was in a working class suburb, to fall on itself floor atop floor. The collapse reduced the apartment building to a pile of rubble no more than one story high and a blaze soon broke out in part of the ruins. Search and recovery operations were immediately set up with the help of the local fire departments and military rescue divisions. Using trained dogs, emergency crews rescued approximately 17 people injured and trapped inside the structure. Most of the people who survived the crash were residents of the top floor.

Immediately after the crash the state attorney engaged two different groups of experts. He assigned to a group of engineers the task of establishing the cause of the event and to a group of forensic pathologists the task of identifying all the victims and determining cause and manner of death. For this purpose a Medical Examiner Team, composed of five forensic pathologists familiar with anthropological procedures for personal identification, was set up. Between 70 and 75 people were in the building when it collapsed but the number of the victims was unknown. The mass fatality morgue was established at the Pathology Division of the local hospital, just a few miles from the incident site. In the morgue, autopsy tables, coolers for body storage and medical facilities with X-ray and dental stations were available. The environment was divided in three sections: the first section was established at the catholic chapel next to the morgue for receiving the human remains and exhibiting them to the families; the second area was for inspection and removal of personal effects, photographing the remains and medico-legal autopsy; the third area was the final holding area for aftercare of the bodies before their release.

From 11 to 14 November, 1999 61 cadavers (31 males and 30 females), ages ranging between 3 to 86 years old, were recovered beneath the ruins of the building. All the victims were well preserved except for two cadavers largely burned by the explosion of gas pipes with missing body parts. Most of the victims wore night-dress clothes or were partly dressed, suggesting that they were overcome in the process of sleeping or getting clothes; only seven cadavers were fully dressed and several of them were found in the stairways as they were unable to get out in time as the building came down around them. Most of the victims (thirty people)

died almost immediately due to the severity of the multiple regional injuries observed during the examination; only four people died a slow death, trapped in the mass of pillars with air oxygen running out (asphyxia by confined space). Fourteen people died due to an asphyxia by mechanical fixation of the chest. For the rest of the victims (eleven people) the cause of death was an association of regional injuries and mechanical asphyxia by fixation or compression of the chest. Most of the victims were identified by visual recognition and/or clothing, personal belongings and body features (i.e., scars); for two bodies the positive identification was achieved respectively by dental comparisons with ante-mortem data and by DNA analysis.

The Engineers Team finally determined that the cause of the mass fatality was a structural collapse as the building's foundation was built with cheap materials. The above disaster was Italy's deadliest building collapse since 1959, when a falling building crushed at least 58 people a few miles from Foggia.

Mass Disaster, Building Collapsed, Personal Identification

G24 Differential Decomposition I: Partial Ground Contact

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The goal of this research project is to give participants the opportunity to achieve a greater understanding of time-since-death variables in this unique crime scene setting.

Purpose: Homicide victims bound to trees are not an atypical crime scene occurrence. In fact, 7% of rural wooded crime scenes involve ligature binding of the victim to a tree, post or other structure. Within the past 18 months, the junior author was requested to provide time-since-death estimations on three such cases long after the remains were autopsied/processed and buried. To date, our shared personal "case-based" events provide the only collective knowledge base about the decomposition rates of these specific victims. Later, i.e., post two weeks, time-since-death estimations come from our generalities of gross morphological change from the more common surface and buried bodies. Not surprisingly, the decomposition rate of above ground victims proceeds differently than surface finds and grave victims. Questions posed by law enforcement agencies regarding time-since-death estimation on bodies found above ground require special consideration when compared to our "collective" knowledge of surface decomposition events.

Materials and Methods: At the outdoor Human Decomposition Facility at The University of Tennessee Forensic Anthropology Center two nude and two partially clothed bodies were harnessed to trees with a variety of bindings to mimic the above mentioned scenario/scene. Of particular value was our ability to mimic the exact season of placement and record decomposition on a longitudinal scale. Five control bodies were placed on the ground surface several hundred yards away so that climatological data would precisely match. The five easily identified visual variables to assess time-since-death include: epidermal slippage, bloating, marbling, discoloration and entomology. No biochemical analyses were performed on any tissues or soil. Accumulated degree days for assessing time-since-death allow us to pinpoint precise time to morphological change.

Finally, the presence of blood from wounds of interpersonal violence was of particular concern as most homicide victims receive some perimortem perforative trauma from sharp-force, blunt-force, ballistic or sexual assault. This factor obviously hastens entomological activity and decomposition in wounds and necessitated our use of human blood during experimentation. Data were collected at 6-hour intervals for five weeks on each body for each variable (defined by Marks et. al., 2000) and correlated/converted to accumulated degree days (after Vass et. al., 1993).

Results: We found the rate of decomposition in above ground bodies to be significantly decreased when compared to our controls placed on the ground. All variables and levels of decomposition were reached at a later time than in those remains placed on the surface. Therefore, the assessment of time-since-death for these special cases cannot be estimated using time-since-death estimations for surface victims.

Time-Since-Death, Rate of Decomposition, Homicide

G25 Are Autopsies Necessary in Centenarians?

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The goals of this research project are to provide the forensic community with the understanding that the elderly are living longer and causes of death are shifting. At the same time, the rate of autopsies is very low, and the interest in geriatric autopsies is even lower. Thus, the prevalent cause of death in this age group remains poorly studied.

Only few necropsies have been performed in patients dying after age 100 years and little attention has been made on the clinical and morphologic features observed in these oldest of the old. For that reason we reviewed 28,312 consecutive autopsies done during a 12-year period (1989 to 2000) at the Institute of Forensic Medicine, Vienna, Austria.

We focused on cases who met our working definition of sudden natural death in very old people: "Unexpected or unexplained deaths of non-hospitalized persons over the age of 100 years, which apparently are due to natural causes that are not explicable with a reasonable degree of medical certainty." In particular, all persons who had not consulted a physician within 10 days before death were included and autopsied.

Of the 20 study corpses, 8 were men and 12 were women; all were Caucasian. The age of these out-of-hospital patients ranged from 100 to 108 years.

Without periodical care from relatives or welfare centers, four persons lived alone in their homes. Another six persons also lived alone, but were regularly cared for by neighbors, relatives or welfare workers. 10 lived with at least one family member.

Sudden natural death occurred in all cases in private homes and in 35% of these cases while sleeping. Resuscitation was attempted in 10% of the cases. Sixty percent of the deceased were described as having been previously healthy. 30% had cardiac antecedents such as stable angina pectoris. Only one person had a history of myocardial infarction. Other pre-existing conditions were hypertension (20%), diabetes mellitus (15%), respiratory (10%) and gastrointestinal disorders (5%).

25% of the men and 40% of the women had a body mass index exceeding normal range.

The most common cause of death was cardiovascular disease (75%). 20% of the elderly died of respiratory illnesses, and 5% of gastrointestinal disorders.

Myocardial scars or focal myocardial fibrosis were detectable in 2/8 men and in 3/12 women, who died due to cardiac disorders. Three men and five women had acute myocardial infarcts. Calcification of the mitral annulus and of the aortic valves were present in 80%; 15% of the calcified valves were anatomically stenotic.

All deceased had extensive aortic sclerosis, mainly focused in the abdominal part. In all 20 corpses the aorta was dilated in its transverse and longitudinal planes, with aneurysm formation in four cases, two resulted in fatal rupture (1 man, 1 woman). Two cases of sudden death were caused by pulmonary embolism (1 man, 1 woman) emerging from the left femoral veins. Two patients died of bacterial pneumonia. A gastric ulcer caused perforation with acute diffuse peritonitis in one 106-year old man.

Although the quality of life cannot be assessed from the study of pathologic lesions alone, the reduced prevalence of chronic debilitating diseases may indicate that longevity is a desirable goal when medical

resources are available for diagnosis and treatment for acute medical problems. Our study underlines the need for more baseline data of the elderly which can be obtained only by more and well-performed autopsies.

Sudden Natural Death, Oldest Old, Autopsy Study

G26 In-Hospital Deaths for Forensic Autopsy

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The goals of research project are to present reasons, findings, gender differences and in-hospital survival time on in-hospital deaths where forensic autopsies were performed.

We have retrospectively analysed nearly 7000 in-hospital deaths in our forensic pathology department, using the chart review method. In-hospital death cases represent 35% of our total caseload, but there is a wide range in different groups (i.e., it is 70% of our all autopsies on 2-5 year-old age group, and only-quarter of those between the age of 21-30 years of age).

Out of all our in-hospital cases, the group of aging people (60 years and over) represents more than half of the cases. We have performed proportionally more autopsies with natural cause of death in every disease category on in-hospital cases, except for cardiovascular diseases (53% of all in-hospital natural cause of death cases and 82 % of all non-hospital natural cause of death cases were cardiovascular origin).

We have also compared the major natural and unnatural causes of death categories between our in-hospital and non-hospital cases. Interestingly, there were more unnatural cause of death cases on in-hospital cases and more natural causes of death cases from our non-hospital cases. We had more than twice as many male than female with natural cause of death in our non-hospital group and only 20% more males with similar natural cause of deaths in our in-hospital series. Suicide victims showed 2:1 m:f ratio in our non-hospital group, but the the same ratio was less than 1 in our in-hospital group. We had more female accident victims from our non-hospital database, but our in-hospital group showed more than twice as many male accident victims coming for forensic autopsy after an accident.

We have also analysed survival time in each cause of death categories, showing age group and gender differences. An ample number of charts will be displayed to explain our findings.

In-Hospital Deaths, Forensic Autopsy, Survival Time

G27 Characteristics of Different Types of Fatal Head Trauma and the Factors That Influence Survival Time and Activity Prior to Death

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The goals of this research project are to teach participants how to recognize and differentiate between different types of head trauma, including those caused by gunfire injuries and sharp and blunt force trauma. Further, participants will appreciate the relationships between the nature of these injuries, amount of blood loss, and role of drugs and alcohol to the amount of activity and time prior to death.

There is a wide spectrum of fatal head injuries, each with unique characteristics. Fatal injuries produced by gunfire, sharp, and blunt force trauma are discussed. The nature of these injuries and the presence of

different types of traumatic cranio-cerebral hemorrhages result in differing survival time (i.e., the amount of time between injury and the time of death) and activity. Importantly, the particular location of each injury, damage to blood vessels, the amount of blood loss, and presence of drugs and alcohol are discussed.

Statistical and descriptive analyses are used. Further, the frequency and type of hemorrhage, the association with the presence of cerebral edema and the demographic profiles of victims within each injury category are described. Variables analyzed include the type of weapon, location of injuries, number, size, and track of the wound(s), amount of blood loss, presence of alcohol or drugs, and amount of activity from time of injury to death. Additional variables specific to gunfire injuries include the distance of the shot and the caliber of the weapon. Finally, the position of the deceased in fatal motor vehicle accidents with resulting blunt force craniocerebral trauma and the use of safety belts are assessed.

Medico-legal cases from 1980-2000 were reviewed from the Lancaster County Coroner's Office in Lincoln, Nebraska, the Cook County Medical Examiner's Office in Chicago, Illinois, and the Knox County Medical Examiner's Office in Knoxville, TN. Information for this study was collected from a variety of documents including autopsy and police reports, medical records, death scene investigator's notes, and death certificates. Further, data is presented on gunfire injuries and blunt and sharp force trauma for over 200 homicide, suicide, and accident cases.

Our test results show that the presence of alcohol and drugs (56.8%) does not directly influence survival time or activity per se, however, they do affect blood loss, which in turn influences survival time and therefore activity. In gunfire and sharp force injuries, internal blood loss measured less than 500 ml, in 60% (6/10) of cases. Further, 55.3% (21/38) of gunfire injuries are single deeply penetrating gunshot injuries to the head, which means that in a small majority of cases, the bullet does not exit the cranium. The most commonly used firearms were .22 and .45 caliber weapons, each occurring in 23.8% (5/21) of cases. The majority of gunfire and sharp force trauma victims are male, at 85% (35/41); whereas, 70% (29/41) of all victims are under the age of thirty years old.

Gunfire Injuries, Blunt Force Trauma, Sharp Force Trauma

G28 Seizure Associated Fatalities: An Analysis of Cases in Milwaukee County

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The goal of this research project is to present the information derived from a review of deaths associated with seizure over a five-year period. Relevant observations are emphasized.

Deaths associated with seizure disorders comprise a relevant proportion of routinely investigated cases by medical examiners and coroners. To better understand the nature and demographics of these cases, we chose to examine these deaths in a major medical examiner system. This work describes the findings of a systematic review of deaths associated with seizures occurring in a five-year period.

The database consists of deaths within Milwaukee County, Wisconsin, certified by the Milwaukee County Medical Examiner's Office (MCMEO) in the years 1995 through 2000. The computerized MCMEO case files were searched for the key word "seizure." All cases in which the investigator's report, the death certificate or the autopsy report contained the term are included in the review. The total number of cases is 164 deaths. Details regarding age, race, sex and other pertinent aspects were recorded.

The majority of cases consist of middle-aged (30-50 yrs.) African-American males. The manner ascribed to most deaths is natural, with accidental being second in frequency. In most cases, the decedents had a

history of a seizure disorder and deaths were attributed to seizure. Cause of the seizure disorders spanned the spectrum of possibilities. Etiological categories included developmental disease, traumatic, vascular lesions, drug-related, infectious, idiopathic, and neoplastic processes.

Several important aspects of seizure related fatalities were identified. Drugs of abuse played a role in a high percentage of deaths. Drugs were isolated in postmortem toxicological specimens and were implicated as causal to the seizure disorder in many cases. Alcohol was the principle drug within both categories. Cocaine was second in prevalence. In patients for whom anti-epileptic medicines were prescribed, a disproportionately high number revealed sub-therapeutic levels in postmortem toxicological analysis. Medical history in many such patients documented prior noncompliant issues. Additional reasons for this observation are a focus of discussion.

Certain determination of seizure as a cause of death is difficult. There are currently no morphological or laboratory tests, which confirm legitimate antemortem seizure activity. The "gold standard" is witnessed convulsion in the setting of a clinically defined seizure disorder. We reviewed the autopsy findings in witnessed cases of seizure related fatalities. Convulsive activity was observed in slightly more than 17% of cases. Several morphologic autopsy findings are noted in these cases. These include tongue bites, minor superficial contusions and abrasions to the face and head, and minor hemorrhage in deep cervical neck musculature. The most consistent finding was tongue bites, noted in over half of the cases. In those without documented tongue bites, many were edentulous or the tongue exam was omitted in the autopsy report. This observation indicates tongue bites are a useful postmortem marker suggesting perimortem convulsive activity.

These findings and additional statistics are presented. Significance of the data will be discussed.

Seizure, Epilepsy, Sudden Death

G29 Homicide by Second Impact Syndrome... or Unfortunate Coincidence?

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The goals of this research project are to understand that the second impact syndrome is a rare and possibly underreported mechanism of death. The present case involves an adult individual who died following two contemporaneous head injuries — one accidental and the other inflicted. The learning objective of this presentation is to understand the various features of the second impact syndrome, and to evaluate the plausibility of the mechanism in fatal successive head injury cases. The importance of this mechanism, as it relates to manner of death, is a focus of this presentation.

The second impact syndrome is a clinicopathologic entity in which an individual sustains a concussive head trauma (with or without loss of consciousness) then, before symptoms of the initial injury have cleared, sustains a second, often relatively mild, head trauma. Closely related temporally with the second trauma, the individual develops uncontrollable cerebral edema, with or without subdural hematoma, and ultimately often succumbs. This form of head trauma has been most often reported in young athletes in collision sports such as football and boxing. The case reported here is a 48-year-old male who was the lone occupant in a single-vehicle car crash, and subsequently, less than 1 hour later, was assaulted and lost consciousness. On admission to the hospital, he had brain edema and bilateral subdural hematomas, which were partially evacuated. He remained comatose for nine days. Neuropathologic examination revealed severe brain edema with cerebellar tonsillar and bilateral transtentorial herniation, and residual bilateral convexity subdural hematoma. The brain had evidence of global hypoxic-ischemic injury, with symmetric necrosis

of deep cerebral nuclei. Microscopically, axonal spheroids were widespread; however, in the setting of global hypoxic-ischemic damage with no gross or microscopic intraparenchymal hemorrhages to indicate significant shear type injuries, the diagnosis of diffuse axonal injury was not warranted. Other autopsy findings were infectious complications of the comatose state, specifically bilateral bronchopneumonia with pulmonary abscesses and empyema. The historic and anatomic findings in this case raise a number of questions. First, "Can the injuries be ascribed to one or the other of the traumatic incidents?" Of themselves, the head injuries have no features to allow specific assignment to one or the other (manner undetermined). Second, "Can the injuries be ascribed to BOTH traumatic incidents?" Second impact syndrome, if established, provides a plausible mechanism by which the answer to the latter question is positive. If the death can be ascribed to both of the injuries (car crash and assault), then the manner of death is homicide. The existence of second impact syndrome has been questioned in the literature. One of the questions that has been raised relates to degree of documentation of both head injuries. In this case, some details of the first head injury are not well established. The vehicle, a pickup truck, had front-end damage, on the driver's side, and had been crashed into a stationary bridge support. An uninvolved party did witness and converse with the subject in the interim between the crash and the assault; the witness stated that the subject had a laceration of the bridge of the nose, indicating a blunt force impact to the face/head. However, the severity of the first "impact," whether the subject was restrained or not, and whether transient loss of consciousness occurred, are not known. Of note, details of the assault, in which the subject received a rapid succession of multiple blows to the head/neck and face, are well documented in congruous witness statements. A review of the literature does not reveal any previous reports of homicide by second impact syndrome.

Adult Head Injury, Second Impact Syndrome, Homicide

G30 A New Technique to Estimate a Postmortem Submersion Interval (PMSI) Using Algal Growth Rates

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The goals of this research project are to present to the forensic community a new technique to establish a post-mortem submersion interval in aquatic habitats using algae on corpses. Attendees will learn that algal growth on corpses changes over time and how this change can be used to estimate a PMSI for a corpse in an aquatic habitat.

This presentation will include a portion of graduate thesis work which focuses on the role of aquatic organisms in pig decomposition in streams. The purpose of this presentation is to evaluate a new technique utilizing algal or periphyton growth on corpses as a method to estimate the postmortem submersion interval. The objectives of this study include 1) the identification and determination of the duration of each stage of decomposition, 2) the comparison of algal growth on pigs to a natural substrate such as ceramic tiles and, 3) the determination if algal growth differs between riffle and pool habitats.

This study was conducted on two 2nd order streams in Lancaster County, Pennsylvania. Stillborn pigs (six pigs per stream) and ceramic tiles were used as substrates for periphyton growth. The duration of each stage of decomposition was estimated in degree days. To examine spatial differences in periphyton growth, pigs and tiles were placed in riffle (high velocity) and pool (low velocity) habitats. Periphyton samples were collected from pigs and tiles every four days for approximately 40 days. Samples were transported to the lab for filtration and preservation. Chlorophyll-*a* concentrations in periphyton samples were determined through fluorimetric analysis. Chlorophyll *a* comparisons between pigs

vs. tiles and riffle vs. pool habitats were analyzed with a 1-Way ANOVA and Fisher's pairwise comparison test. Regression analysis was used to compare chlorophyll *a* concentration as a function of time.

The literature identifies several stages of decomposition in aquatic habitats: Submerged Fresh, Early Floating, Early Floating Decay, Advanced Floating Decay, and Sunken. As we describe them in this study, they included: Submerged Fresh, Early Floating, Early Floating Decay, Advanced Floating Decay, and; Decay. Total degree days for pigs submerged in riffle habitats were 363.8, while pigs in pool habitats accumulated 773.8 degree days during the decomposition process. The duration of the Submerged Fresh and Floating Decay stages was significantly longer in the pool habitat compared to the riffle habitat. Chlorophyll *a* concentration increased as a function of time regardless of habitat. Chlorophyll *a* concentration was significantly greater on pig carcasses vs. ceramic tiles; whereas, it did not differ between riffle and pool habitats. Although periphyton growth on pigs in riffle and pool habitats was significantly impacted by a spate or rain event during this study, we found that chlorophyll *a* concentrations were still significantly correlated over time.

To date, an accurate measurement of a PMSI has been difficult in aquatic habitats. In terrestrial systems, insects have evolved to feed on carrion, this is not the case with aquatic insects. Aquatic insects essentially utilized the corpse as an extension of their natural substrate. Some species may feed on the corpse or on attached algae. Recent more qualitative evidence suggests that aquatic flora in the form of algae may provide a more reliable approach to estimate the PMSI in aquatic systems such as rivers or lakes. These studies have examined algae and other aquatic flora from a taxonomic perspective in an attempt to correlate species diversity with each stage of decomposition. Our study provides a more quantitative method to estimate a PMSI based on algal or periphyton growth over time. Since pig carcasses were found to have significantly more periphyton growth than ceramic tiles, we suggest that the nutrients leaching from a corpse may provide a more optimum habitat upon which algae may grow. An inherent problem with the use of algae from a qualitative or quantitative perspective is that rain events can change the composition and amount of algae on a corpse. Our study illustrates how a rain event impacts chlorophyll *a* concentration on pigs in riffles and pools in streams.

Postmortem Submersion Interval, Degree Days, Periphyton

G31 Assisting the Living

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The goal of this research project is to present to the forensic community a model of positive communication with grieving family members.

The death of a loved one may be the most difficult and traumatizing situation that a family has to endure. The coroner or medical examiner is thrust into the lives of the decedent's family and is therefore in a very unique position. The medical examiner/coroner need only invest a small amount of time to produce an immense and everlasting effect on the family's ability to accept their loved one's death and promote the healing process.

The relationship between the medical examiner/coroner and the decedent's family begins with the death scene investigation and the notification. But this should only be the beginning. The role of the coroner can extend well beyond determination of the cause and manner of death. There are many opportunities in which the coroner can interact with the family to instill compassion and assist with the grieving process.

A good opportunity for the medical examiner/coroner to interact with the family arises following the autopsy. In our office, the next-of-kin is called immediately after all postmortem examinations, except in cases of homicide investigations where communication is usually through law enforcement. An explanation of the preliminary findings is given and the family is informed if additional studies are pending. Calling the next-of-

kin after the autopsy gives them an opportunity to ask questions, to discuss property disposition and medical history, or just to tell you about their loved one.

Following the completion of the autopsy report, a condolence letter is generated expressing sympathy for the loss of their family member. This letter also gives the medical examiner/coroner the opportunity to review the autopsy findings and include any additional studies or tests that were completed after the initial phone conversation immediately following the autopsy. A short explanation of the cause of death is often helpful to the family. Any types of diseases that may have a genetic component should also be mentioned with directions to consult their family physician. Having this information on paper is also helpful to the family physician, particularly if a genetic or environmental cause of death was diagnosed. The family physician is then able to conduct genetic testing on remaining family members or suggest lifestyle changes. These explanations often reduce future phone calls by anticipating what questions may be asked. In cases of homicides, the letter can be brief and reiterate the information stated on the death certificate, especially if a criminal trial is pending.

Following the initial death investigation and postmortem examination of a possible sudden infant death (SIDs), our office generates a letter to the parents. The letter should include some general information about SIDs and inform the family that additional studies such as microbiologic cultures, metabolic screen, histology, toxicology and other tests may be pending. A final letter will then be sent to the family following completion of the autopsy report.

In difficult and emotional cases such as an infant overlay, possible medical malpractice or an unsuspected suicide, a meeting in the medical examiner/coroner's office may be suggested to the family prior to signing the death certificate. This will give the pathologist an opportunity to explain the final investigative and autopsy findings in a controlled environment. Open communication assures that there are no surprises when the family receives the death certificate.

These actions lend support during a very difficult period and may result in a positive attitude toward the medical examiner/coroner's office from the general public.

Condolence, Communication, Grieving

G32 Some Empirical Data on the Past and Future of the Autopsy

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The goals of this research project are to help participants: 1) become familiar with the history and purposes of the autopsy; 2) examine the causes and significance of declining autopsy rates and uses; and 3) consider suggestions to revitalize the autopsy based on a survey of physicians at a major university hospital.

Background: The autopsy has been an important method of exploration, education, and discovery for hundreds (perhaps thousands) of years. Medicine as a scientific field has progressed in tandem with the acceptance of the autopsy, the precision of its performance, and the accuracy of its results. Recently, however, autopsy frequency has declined from approximately 50% of patients dying in hospitals in the 1950s to a range of 5 to 13% of similar patients today. Reasons given in the literature for this decline include physician belief that modern diagnosis is so accurate that autopsy is not needed, cost (and lack of profit) of the procedure, fear of litigation prompted by autopsy findings, and the difficulty of communicating with families regarding autopsy. Given that individual physician opinions about autopsy are important determining factors in autopsy requests and use of results, it is helpful to understand the nature of these opinions and what influences them.

Methods: This study makes use of a survey on autopsy practices and opinions which was distributed to all attending physicians in a large,

urban, university affiliated medical center. The 10 question survey was distributed to 215 full time attending faculty based at the hospital or the adjacent Ambulatory Care Center. The survey was an anonymous, one page, multiple choice format questionnaire that could be completed in under five minutes. Clinicians first identified their department, years of practice, and approximate departmental autopsy rate. The inquiries then examined, among other topics, physician beliefs about the value of the autopsy for confirming diagnostic results, its possible use in clinical practice, the desirability of medical quality assurance using autopsy data, and the effects of litigation concerns on autopsy requests. Surveys were distributed to 24 individual clinical departments, including Pathology, based in the Medical School.

Results: A total of 53 physicians responded to the survey (24.7%). Departmental response rates varied from a high of 60% to a low of 0. Faculty varied in years of practice from 5 to over 20 years with the largest proportion having practiced for 5 to 10 years. Most (26/48 or 54.2%) respondents reported an estimated departmental autopsy rate of under 10% with the next largest group (17/48 or 35.4%) selecting "don't know." Overall, respondents were split almost equally on the question of whether their departmental autopsy rates were sufficient. Respondents were strongly in favor of the autopsy on questions that pertained to its potential usefulness. Most (36/50 or 72%) disagreed with the statement that current diagnostic procedures were sufficiently accurate to make autopsies unnecessary. Though respondents were more cautious on the question of whether the autopsy should be used for quality assurance, 28/50 (56%) strongly agreed or agreed that they would like to see this application in their departments. Interestingly, responding physicians disagreed (79.1% total) that concerns over litigation affected their decision to request autopsies, rejecting one of the primary causes for the autopsy decline cited in current literature. Responses did not differ significantly among physicians of various levels of experience, but did tend to separate along departmental lines.

Conclusions: The survey data suggest that the responding physicians continue to value the autopsy as a tool for diagnosis and education, even in the face of radically declining autopsy rates. Suggestions for improving the frequency and efficacy of the autopsy range from better standardization of requests and communication of results and reporting to centralization of hospital and forensic autopsies into regional centers. Clearly, a revitalized autopsy can help identify new diseases and environmental problems and improve the contribution of the procedure to the forensic sciences.

Autopsy, Diagnosis, Autopsy Rates

G33 The Postmortem Diagnosis of Skull and Brain Injuries by Imaging Methods (MRI, Multi-Slice CT)

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The goal of this research project is to present to the forensic community a new application of a clinically well-established method in forensic medicine, i.e., the postmortem collection of data by utilizing imaging processes such as MRI and multi-slice CT.

Content: In 20 cases in which the deceased succumbed to skull/brain injuries, a forensic investigation had been ordered and whole body MS-CT and MR examinations were performed. In seven cases the cause of head trauma was secondary to a road accident; and three persons sustained blunt force trauma; in three cases, there had been a fall from a height; and seven persons died following shotgun injuries. MRI studies were performed on a 1.5 T GE Signa system; CT data were acquired with a GE LightSpeed multi-slice scanner. Post processing (2-D and 3-D reconstructions of CT data sets) was performed with the GE Advantage Windows workstation. Subsequently, a standard forensic autopsy was carried out. The radiological data were used to answer the forensically important questions such as the cause of death, the traumatological findings, the differentiation of antemortem inflicted injuries from post-mortem trauma, and the reconstruction of the traumatic sequence. Finally, the radiographically obtained results were compared to those obtained from autopsy findings.

Conclusions: In all examined cases, a forensic reconstruction (impact axis reconstruction, the priority of skull fractures, the direction of impact in traffic accidents, etc.) was possible based upon the radiological data obtained. Forensically important findings, such as scalp hematomas, fracture systems, direct and indirect brain injuries and various forms of intracranial hemorrhaging could be clearly detected and diagnosed. Secondary trauma consequences, such as brain edema, increased brain pressure, and secondary brain stem hemorrhaging, were correctly recognized.

A complete collection and documentation of forensic relevant data can be obtained by utilizing imaging processes. MRI and MS-CT are suitable methods for the post-mortem diagnosis and reconstruction of skull and brain injuries. The data obtained objectively in a non-destructive way showed to complement standard autopsy methods in many respects.

Forensic Radiology, Multi-Slice CT, MRI

G34 Use of Magnetic Resonance Microscopy for Evaluation of Retinal Hemorrhage

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The goal of this research project is to present to the forensic community a novel technology which allows nondestructive three-dimensional assessment of retinal vasculature.

In recent years, magnetic resonance technology has advanced to provide the ability to achieve extremely high-resolution spatial information associated with magnetic resonance spectra. The ability to achieve spatial resolution in the tens of microns through MRI allows the capture of truly 3D anatomic information at near histologic resolution with minimal deformation or registration error. The ability to capture nuclear magnetic spectra at high spatial resolution provides the opportunity to chemically and physiologically characterize those tissues. This has been used to great effect, for instance, in the elucidation of the 3D anatomy in embryos as well as characterization of 3D morphology and relationships in such things as new bone formation and cartilage growth.

The importance of retinal hemorrhage has been of some debate in the evaluation and diagnosis of child abuse. The ability to map perfusion in three dimensions as well as the ability to localize hemorrhage in three-space at high resolution provides the opportunity to map and volumetrically characterize these lesions in known child abuse and non-child abuse cases.

We have created three-dimensional visualizations of whole eyes at between 70 and 100-micron resolution, and are currently bringing on line a coil which will provide approximately 10-micron resolution using

Bruker magnetic resonance microscopes. Non-invasive three-dimensional maps of blood distribution can be achieved on formalin-fixed eyes without serial sectioning. While our current visualizations are striking, there remain nontrivial technical challenges ahead. These include appropriate mounting media. It is extremely important that no water remain on the surface of the globe; we have achieved good results both with embedding the entire eye in paraffin and by placing the eye in fluorocarbon. In both cases, the eye can later be evaluated by conventional means. Another limiting factor is the time necessary to achieve a sufficient signal to noise ratio at high resolution. Current scans require approximately 30 hours per eye. We are currently exploring methods of data reduction using combinations of thicker sections to provide super-resolution at higher speeds. We are beginning work on spectral analysis at high resolution and expect to provide a more certain extraction of hemoglobin distribution.

Visualization challenges include appropriate segmentation and voxel-counting to provide volumetric measurements of hemorrhage. Our current methods are watershed-based, but we expect to transition to the Imagine Toolkit (ITK), a freely-available software toolkit for segmentation and registration currently being developed by the National Institutes of Medicine and the National Library of Medicine Visible Human Project for segmentation of Visible Human tissues. This toolkit is in alpha distribution, but should be in general distribution within a year. We are also exploring the question of validation of volumetric measurements. Standard histologic sectioning can provide a standard whereby localization can be tested, but the choice of a "gold standard" for volumetric measurement of hemorrhage is not obvious.

While we are in the early stage of exploring this technology for this application, the three-dimensional retinal vascular imagery we have gathered provides a measurable visualization not achievable elsewhere. We are currently exploring validation issues, since any volumetric statements about hemorrhage must be matched with more conventional visualization of hemorrhage. This paper will provide a short review of the technology, visualization issues, validation issues, and early results in the three-dimensional characterization of these retinal lesions.

Magnetic Resonance Microscopy, Shaken Baby Syndrome, Retinal Hemorrhage

G35 Phenylpropanolamine and Acute Intracerebral Hemorrhage

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The goal of this research project is to assess the status of current scientific research and literature regarding Phenylpropanolamine and the risk of acute intracerebral hemorrhage.

This presentation reviews the case of a young woman who died from complications of two near-simultaneous, acute, bilateral basal ganglia hemorrhages. Complete autopsy examination, including the examination of the brain by a neuropathologist, and full toxicological examination, failed to uncover an etiologically specific risk factor for the intracerebral hemorrhage. The decedent ingested an over-the-counter cold preparation containing Phenylpropanolamine (PPA) minutes prior to the first intracerebral hemorrhage.

The literature on the toxic and fatal effects of PPA is extensive, spanning many decades. It is mostly represented by single case reports, or presentations of a small number of cases. Scientific study on the effects of PPA consists of a small number of animal studies and a few human studies, which have produced provocative but also highly controversial and contradictory results. There is significant variability in the clinical presentation of these patients. The proposed mechanisms by which PPA is said to produce these clinical results cannot consistently be applied to all of the reported cases. Despite this controversy, this presentation proposes that PPA as the cause of unexplained acute intracerebral hemorrhage in the proposed "at risk" population is a valid consideration.

A publication in the *New England Journal of Medicine* in December of last year and a recent FDA voluntary recall of over-the-counter preparations containing PPA have resulted in much media attention via the lay press and the Internet. As a result, the legal community has responded with media-based efforts to assimilate groups of cases of PPA toxicity, including fatalities, for the purposes of civil litigation. As public awareness increases, and because of the near total omnipresence of these over-the-counter preparations in American households, the forensic pathologist will be asked to consider PPA either as a possible cause of death in cases of otherwise unexplained acute intracerebral hemorrhage in the defined "at risk" population, or as a possible contributing factor in persons who are at risk of acute intracerebral hemorrhage from other diseases or conditions.

A familiarity with the current literature and an understanding of the proposed pharmacological actions of Phenylpropanolamine will better prepare the forensic pathologist in the evaluation of individual cases, and also in the preparation of responsible testimony in relevant litigation.

Phenylpropanolamine, Acute Intracerebral Hemorrhage, Spontaneous Intracerebral Hemorrhage

G36 The Use of Lidocaine to Commit Homicide

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The goals of this research project are to report the first case of Lidocaine being used to commit homicide outside a hospital setting; to pull known cases of iatrogenic homicidal Lidocaine poisoning into the forensic sciences literature; to review and compare the two groups highlighting similarities and differences; and, to distinguish those situations where an elevated Lidocaine level should trigger a more extensive investigation.

Lidocaine is a drug that is commonly used during the course of resuscitating critically ill patients. It is most effective at treating ventricular tachycardia associated with a myocardial infarct. It is therefore a drug commonly found on the toxicology reports of medical examiner cases. It is so common that one could even say that it has become part of the "normal flora" of drugs found in people who die suddenly and unexpectedly along with Cotinine and Caffeine. It is not uncommon for Lidocaine levels to be elevated, even above the "potentially toxic" level because of the grave situations in which the drug is administered. As a result, medical examiners/forensic pathologists can become desensitized to the dangers of this drug. Above therapeutic levels, it can cause severe cardiovascular and neurologic effects, including immediate asystole, apnea, and convulsions. It lowers seizure thresholds and may increase the risk of bradycardia and asystole. Yet the common assumption about Lidocaine is that if it is found in a patient's blood, it was administered by the careful hand of a physician or paramedic with the goal of saving the patient's life. The cases presented here illustrate that this is not always so. One case illustrates how Lidocaine was used as a tool to commit homicide by a non-professional, while the other three show that when used in the medical setting, it is not always with a therapeutic intent. The former case is the first reported of its kind, while the latter cases have been chronicled in the popular press.

In this paper, the cases of iatrogenic homicide are reviewed, characterizing the perpetrators, the victims, the motives, and the keys to recognizing the deaths as homicides. The majority of the focus however, is on the case involving the homicidal Lidocaine poisoning outside the hospital. Similarities and differences between that case and the hospital-based homicides are highlighted with the goal of raising awareness as to when an elevated Lidocaine level should trigger a more extensive investigation.

The majority of known Lidocaine homicides have been committed by so called "Medical Murderers." These are health care professionals of one form or another who made Lidocaine their weapon of choice. Robert Diaz was a 46 year old nurse who killed 12 patients (and possibly 50 more) by Lidocaine injection while he worked as a nurse at two California Hospitals. His motive stemmed from his desire to appear to have a "doctor's" knowledge of how sick patients were and to "predict" when they would die. Joseph Dewey Akin was convicted of killing a quadriplegic patient by injecting him with Lidocaine for the "fun of watching him die." He committed this crime in Birmingham, Alabama but was suspected to have killed 17 others while working at a hospital in Atlanta, Georgia. And finally, Randy Powers was a 26-year-old respiratory therapist who was never convicted of murder but was convicted of "assault with a deadly weapon" and "practicing medicine without a license." He gave an eleven-month-old child an intramuscular injection of Lidocaine inducing a high fever and seizure activity. He participated in the resuscitation and was originally thought to be a hero. Physicians, however, identified a needle puncture wound on the child's thigh and toxicology revealed elevated Lidocaine levels. Powers was suspected to have been involved in many other unexplained deaths. The bodies that were exhumed, however, failed to show needle puncture wounds or elevated Lidocaine levels.

The case of homicidal Lidocaine poisoning outside a hospital was perpetrated by the husband of a 69 year old female with a past medical history most significant for Alzheimer's Disease, schizophrenia, and macular degeneration. He was her sole caretaker but was also an active volunteer at the Red Cross and at a local Michigan hospital. On the day of her death, he found her lying on her bed around 8:00 a.m. She was unresponsive and this prompted him to notify emergency medical personnel. On arrival, paramedics determined that she had been dead for some time and pronounced her dead at the scene. Police and the medical examiner investigator found the scene secured with no evidence of a struggle. The decedent was found lying supine on her bed and on top of her bedding. Her husband reported that she was in her usual state of health and had no complaints when he put her to bed the prior evening (around 11:00 p.m.). The autopsy confirmed the diagnosis of Alzheimer's Disease and revealed moderate atherosclerotic cardiovascular disease. There was no evidence of injury or needle marks. EKG leads were the only evidence of therapy. Postmortem urine toxicology revealed Lidocaine, Tocainide, Meperidine, Salicylate, and Caffeine. A postmortem blood drug screen (subclavian blood) revealed Lidocaine 12.4 mcg/ml (potentially toxic >8 mcg/ml) and Salicylate (non-toxic levels). Paramedics confirmed that EKG monitoring was the only resuscitative procedure performed on the decedent. The medical examiner investigator confirmed that there was no evidence at the scene of accidental ingestion of topical anesthetics. Subsequent police investigation revealed that her husband had the opportunity, motive, and ability to administer the IV Lidocaine and may have been involved in previous attempts to kill her. Follow up testing (including DNA analysis) confirmed the presence of Lidocaine and ruled out the possibility of specimen mix-up at the laboratory. Based on this information the cause of death was determined to be Lidocaine poisoning and the manner of death was homicide.

This paper is valuable for multiple reasons. It first pulls cases of homicidal Lidocaine poisoning into the forensic literature. Secondly, it highlights how the deaths of elderly people and the severely ill are often treated casually despite the fact that they are precisely the people most likely to be the victims of homicidal poisoning. It highlights how elevated Lidocaine levels are treated with similar benign neglect. This is clearly illustrated in the comment by one forensic pathologist who was asked to evaluate the toxicology report knowing only that it was a case of an elderly person who died at home. He quickly stated "there is nothing here," automatically attributing the elevated lidocaine level to "an artifact of resuscitation." This paper illustrates how the hobby or profession of the assailant/caregiver can give important clues as to the cause of death and to the poison used. And finally, it illustrates how doing a thorough scene

investigation including a detailed medical and social history of the decedent and the family can alert investigators to a situation perfect for homicidal poisoning.

Lidocaine, Homicide, Poisoning

G37 Where Do People Die Suddenly and Unexpectedly?

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The goal of this research project is to discuss statistical data and major trends on different places of death of unnatural and unexpected natural death categories along with gender differences.

There is no place like home even when it comes to dying. Home would be an ideal setting, but never possible for all of us. The vast majority of unnatural and unexpected natural deaths occur outside of the deceased's residence. None can predict the place of death in a sudden lethal event. In the last seven years we have performed nearly 20,000 forensic autopsies in our institution. Using retrospective chart review of this group we analyzed the place of death from many aspects.

We used eight categories to further sub classify the place of death: a person's own home, someone else's home, public place, roads, buildings, workplace, ambulance and hospitals. We investigated for age related trends (i.e., only 3.4% of the 16-20 year-old category died in their own home, but almost one third of those over the age of 70 years died at home). We also reviewed our data by investigating manner of death, including natural, homicide, suicide, and accident victims. Our statistical analysis gives data on place of death in major natural and unnatural cause of death categories. We also depict the monthly and the weekday distribution of deaths occurring in different places. Higher work place deaths occur on Monday; higher sudden deaths in buildings on Thursday; high numbers of cases from ambulances on Friday; and, high workplace related deaths in January and October, etc. Further discussion regarding types of cases accepted for forensic autopsy from hospital versus ambulance/home environments will also be highlighted. Very important features of the presentation will be the analysis of gender differences in each of the categories discussed. The high number of cases (nearly 20,000) allowed us to make interesting conclusions on where our forensic cases are coming from.

Place of Death, Home Deaths, Ambulance

G38 The "Holy Crown United" Southern Italian Mafia Organization Homicides

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The goal of this research project is to present to the forensic community the aspects of the homicides perpetrated by "Holy Crown United" (Mafia Organization) in the South of Italy.

The Authors reported all cases of homicides committed from 1986 to the present by the "Holy Crown United" The "Holy Crown United" was a complex and territory infiltrated Mafia Organization operating in the southern part of the Apulia (southern Italian region), well connected with the Albanian Mafia, quite completely routed in 1995-1995. The "Holy Crown United" specialized in burglary, extortions, bank robberies, illicit traffic of drugs and arms, and illegal immigration of boat people. The deep religious significance of the chosen name "Holy Crown United," the historical origin, the internal organization in eight levels, and the meaning behind the crime rituality are briefly described.

Seventy-five homicides are reported to be victims involved in the illegal activities of the organization, members of the gang who needed to be punished, their family or relatives, and other innocent people.

Cause and manner of death are described. In all cases large calibre firearms were used. Post-mortem treatment of the bodies described the homicides as terrifying. The bodies were usually charred to demonstrate the Organization's strong power and to frighten the remaining population.

All the members of the Organization to be punished were executed; if this proved to be impossible, homicides on their relatives, close friends, family members were performed. Bodies were then hidden by burial on free land, somewhere in Apulia, so no one could cry or have mercy on their graves. All this violence was directed at close relatives or friends of the deviated members to further threaten them so that they would not retaliate on the Organization. All the criminal acts perpetrated by the "Holy Crown United" were performed using a high volume of fire, sometimes including bombs. Those who were killed or who vanished were called "victims of white lupara" (lupara is a shotgun with cut barrels typically used for Mafia crime) The cadaver research modality, the approach and the rescue of these bodies, the personal identification techniques, and autopsy and ballistic results are reported.

In these cases, a body was usually found through information obtained by "pentiti," a "Holy Crown United" member that decided to collaborate with the State Attorney, in order to obtain protection even for his/her relatives and/or a lighter sentence of guilt. In these particular cases, personal identification of the body was extremely important to have proof that all the information given by the informer was correct.

The methods used by the "Holy Crown United" allowing no possibility of finding any cadaver remains are reported. Peculiar cases are described, such as the personal identification obtained by an isolated patella, or the hierarchical position of a victim in the organization resolved by the analysis of a tattoo.

Holy Crown United, Southern Italian Mafia Organization Homicides, Case Report

G39 Homicide Attempt With a Japanese Samurai Sword

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The goal of this research project is to explain to participants the importance of examining all the material evidence to show the mechanism of injuries caused by a Japanese sword.

A 30-year-old man was admitted in the emergency unit of the Hospital of Strasbourg with a right 2.5-cm long low thoracic wound caused by a sharp object. After an emergency thoracic and abdominal CT-Scan, consequent bleeding led to rapid laparoscopic surgery showing a penetrating wound located at the right side of the liver. The wound had crossed the right inferior pleural cavity and the diaphragm. A right hemo-pneumothorax was treated with a drainage tube, whereas the wound of the liver was clotted and thus needed no complementary treatment.

The victim explained that he had been attacked while sitting in his car in the parking area of a shopping center by another man armed with a Japanese sword with whom he had a quarrel a few months earlier. According to this statement, the perpetrator gave a first blow on the windscreen of the car, a second blow on the front right passenger's car window, and finally a third direct blow which hit him on his right side. The assailant was quickly identified and arrested by the police. He gave another version arguing that he had only given two circular blows and that the second blow had unfortunately hit the victim.

The public prosecutor gave us the opportunity to examine the sword and the victim's clothes. The sword was a sharp, 76-cm long, 2 to 3-cm wide Japanese sword as used by samurais, bought by the assailant during a journey in the French Caribbean and sharpened by himself. A sample of

blood was taken for DNA typing. The clothes worn by the victim were an anorak, a sweater and a polo shirt. On each of these pieces of clothing, a 2 to 3-cm long slit could be seen. This gave evidence of penetration by of the sword.

The CT-Scan showed a deep 4-cm long wound of the liver giving another argument for a penetrating wound. Close examination of the sword, the clothes of the victim, the size of the skin injury, and the aspect of the thoracic and abdominal CT-Scan provided sufficient evidence to confirm the victim's statement.

The use of Japanese swords in homicides is rare. A Japanese samurai sword is a sharp, cutting object which may inflict two different kinds of injuries: penetrating or cutting. This paper focuses on the importance of the examination of all the evidence, showing to the Court only one possible mechanism of injury: a penetrating sharp force wound.

Japanese Sword, Homicide, Evidence

G40 Sharp Force Injury Fatalities in New York City

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The goal of this research project is to present participants with an overview of sharp force injury deaths in one year in New York City.

Several studies in the United Kingdom and Sweden have examined large numbers of sharp force injury deaths. Most of these studies involved long time periods for data collection that ranged from 9-45 years in order to examine from 28 to 279 sharp force injury deaths. There have been a few large cohort studies of sharp force injury fatalities in the United States. We reviewed the case records of 120 people who died from sharp force injuries in New York City in a single year, 1999. The epidemiological profile, circumstances, toxicology findings, location, and injuries were examined.

There were 120 deaths: 101 homicides, 17 suicides, and 2 accidents. The causes of death included: 112 due to stab(s) with or without incised wounds and 8 pure incised wound fatalities of which 5 were suicides. No sharp force injury fatality had an undetermined manner of death. In sharp force fatalities, the patterns of injuries and the circumstances often demonstrate the intent of suicide or the hand of another in a homicide, thus allowing the investigator to discern the manner of death.

The locations of injuries may help determine the manner of death. It is extremely rare for a person committing suicide to cut his/her face. Hesitation and defense injuries also are useful in determining manner, as may the clustering of wounds which were seen in twice as many suicides (41%) as homicides (17%). Tight groups of wounds may assist in the investigation and reconstruction of homicides and suicides. In a homicide, grouping of sharp force injuries usually indicates that the decedent was repeatedly stabbed following incapacitation. In a suicide, injuries may be concentrated over accessible vital region(s) and typically are superficial (i.e., hesitation marks). In addition, suicidal incised wounds tend to be parallel or colinear. In a homicide, with continued infliction of injury after incapacitation of the victim, the grouped wounds, typically deep, may not be in an accessible area to the decedent (e.g., the posterior thorax) and are typically deep.

"Defense wounds" were reported in 49% of the homicides and "hesitation" wounds were found in 65% of the suicides. There were no self-inflicted sharp force injuries of the face and no sharp force injury suicides by Hispanics, Asians, or anyone under the age of 18 years. Over half of the suicides at home occurred in the bathroom and 78% of these occurred in the bathtub. A study of suicide by stabbing in the United Kingdom of suicide by stabbing found that the majority of decedents were discovered in the bedroom or kitchen. Suicide notes were found in 24% of the cases, and an additional 24% verbally expressed a plan to commit suicide.

Deaths due to a single stab wound occurred in 34% (34/101) of the homicides and 24% (4/17) of the suicides. Of these 38 deaths, 58% were of the anterior thorax (chest) and 71% injured the heart and/or great vessels. The remaining deaths with single stab wounds involved the femoral artery, abdominal organs, or head. A common question with fatalities from a single stab wound to the anterior trunk is, "Was the decedent intentionally stabbed or did he/she run into the knife?" When considering this issue, it is helpful to consider the overall directions of the stab wound track. It is extremely unlikely for a person to be stabbed by "running into" a knife that is positioned other than perpendicular to the decedent's body.

The age range was 5 to 84 years for homicides (mean of 34) and 18 to 76 for suicides (mean of 49). There were more men than women for both homicides (3.2 to 1) and suicides (2.4 to 1). Hispanic (40%) and Black (44%) decedents made up 84% of the homicides. Among the suicides, 65% were White and 35% were Black. Alcohol and/or illicit drugs were found in both homicides and suicides as in other studies on sharp force injury fatalities. Detection of ethanol and/or illicit drugs constituted 61% in the homicide and 12% in the suicide groups. Among male and female homicide victims, ethanol and/or illicit drugs were detected in 72% and 38%, respectively. More homicides occurred in the warmer months from April to September. The percent of sharp force-related homicides that occurred indoors was similar in the colder (51%) to the warmer months (49%). The percent of homicides that occurred outdoors (typically on the street) was greater in the warmer months (78%) than the colder months (22%).

Forensic Pathology, Sharp, Forensic Science

G41 No Homicide on Christmas Eve !? — Case Report of an Unusual Stab Wound of the Brain

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The goals of this research project are to learn about the clinical and autopsy findings of stab wounds of the brain with particular emphasis on an unusual case, which was initially misdiagnosed as cerebral contusion and led to false conclusions concerning the manner of death

A Russian immigrant was celebrating Christmas in his apartment with his wife and a friend. One or two bottles of vodka were also present. After a while the men began to argue and the tenant wanted his mate to leave. The argument turned into a fight on the stairs. Eventually the mate was laying unconscious on the stairs, a knife in his hand and bleeding from several chest and skull wounds. The wife of the tenant who had only some minor cuts called the emergency doctor. The victim was admitted to nearby Wuerzburg University Hospital by helicopter and immediately underwent diagnostic CT and surgery. At this point he was first seen by the 24-hour forensic service provided by the Wuerzburg Institute of Legal Medicine. According to the clinical findings, diagnoses were stab wounds of the chest and abdomen, with penetration of several ribs, and cerebral contusion, with beginning cerebral swelling.

The victim was said to be eccentric and alcohol-dependent in contrast to the presumed assailant who was a well-integrated employee with intact family and personally known by one of the police investigators. Obviously, nobody wanted to have a "case" on Christmas Eve. This may explain why the police initially believed that the victim's injuries were self-inflicted. During examination of the knife found in the victim's hand by the forensic pathologist, however, it became clear that the blade was not thick and pointed enough to penetrate bone or cartilage which meant that the weapon involved was unknown.

After the emergency treatment of the victim, his condition deteriorated due to further elevation of intracranial pressure and his death came

within the next days. Since the brain injury had to be considered as future cause of death, the police insisted on the possibility that a fall on the sharp-edged stair could have caused the brain injury. The case then would have been qualified as bodily harm or as accident and not as homicide, and there would have been no need to intensify the search for a murder weapon during Christmas. The forensic pathologist in charge agreed eventually to this interpretation although the wound margins seemed to be rather sharp and regular. But, due to the therapeutic intervention no closer examination of the wound could be performed. The assailant remained under arrest, the intensive care unit personnel worked at their best and everybody had a nice Christmas.

As expected the victim died two days after Christmas. The autopsy revealed that the brain injury was clearly caused by a stab wound of the left temporal region. In the following days, the police presented every knife they found in and around the apartment of the assailant, where his wife and children still lived. Due to the lapse of time since the day of the fight there would have been enough occasions for the tenant before his arrest, or for his wife, who must have witnessed the fight but who refused any statement, to walk off with the knife. However, about ten days later one knife found in the apartment met all the requirements to be considered as the murder weapon. Moreover, despite several dishwasher cleanings, DNA from the deceased could be found on the blade by STR analysis. The retrospective examination of the CT scans revealed findings consistent with an intracranial stab wound and not typical for contusions due to blunt injury or fall.

This case is presented for several reasons:

1. Cranial stab wounds are rare events and present problems in clinical and forensic differential diagnosis as long as the patient is alive. They allow for exact requirements for the presumed weapon involved. This will be illustrated by our case and by a short literature review.

2. Forensic investigation under the influence of external factors like holidays or personal relationships may exert subtle pressure on the forensic pathologist which may be difficult to resist. Although this case could be worked up completely despite the delay in considering the case as homicide, the forensic scientist never should rely on clinical information and should never agree to any statement he is not totally convinced of. All clinically available information including CT scans should be personally reviewed by a forensic specialist who is familiar with radiography of brain injuries or by a radiologist who has forensic casework experience.

Stab Wounds of the Brain, Homicide, Clinical Diagnosis

G42 Accidental Hanging Death of a 10-Year-Old Boy From a Lanyard Key Chain

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The goal of this research project is to recognize the dangers of lanyard key chains around the neck and the importance of a thorough death scene investigation, especially when hanging deaths of children are at issue.

Any item around the neck can be dangerous, especially if the item hangs loosely and can become entangled in moving machinery or caught on a fixed object. The popularity of lanyard key chains has exploded in recent years. They are used to hold keys or identification badges at home, school, and work. The lanyards are made of strong woven cloth or nylon material, made to hang around the neck to the mid-chest with a plastic or metal clasp at one end to hold keys or badges securely. The lanyard chains are also commonly imprinted with advertising or promotional slogans or logos. The danger is that these lanyard chains are extremely strong and do not break or separate if they become entangled.

Case Report: A 10-year-old Black male child was found in his mother's bedroom hanging and suspended by a lanyard key chain around his neck from an elevated metal bedpost of a four-poster bed. He was

found by his mother when she returned home from work early in the evening. He had been home alone during the day while she worked, and was not at school due to a one-day suspension for a note-writing incident. His mother lowered him from the bed post, laid him on the bed, and called police. Resuscitation was unsuccessful and his body was brought to the Medical Examiner's Office as a presumed self-inflicted event.

Examination showed a well-developed and well-nourished 10-year-old child with a sharply backwards- and upwards-slanting abraded ligature impression mark consistent with the lanyard found around his neck and accompanying the body. His neck additionally showed marked hypermobility, and internally showed dislocation of the first and second cervical vertebral bodies with posterior neck muscle hemorrhage, consistent with an abrupt drop-type hanging.

Scene investigation, reconstruction and interviews were conducted to determine the nature and circumstances of the hanging. The boy commonly wore the lanyard chain outside his clothing to hold his house key so that he could let himself into the home after school. His mother stated that he was often reprimanded for jumping up and down on her bed and swinging from the crossbars that connected the four raised bedposts. This swinging had caused the crossbars to bend downward, which was noted by investigators. The metal bedposts were of sufficient strength and configuration to support his weight and to catch the lanyard while he was jumping up and down. The lanyard itself, which had no safety release clasp, could easily support his weight without breaking. It was concluded that there was no evidence of an intentional hanging. With the autopsy and scene investigation findings, the death was ruled an accidental hanging. Medline review reveals no similar incidents involving lanyard key chains.

Methods are available to prevent accidental hangings by lanyards. A simple do-it-yourself method involves cutting the lanyard chain in the back to form two ends, and affixing commercially available adhesive Velcro to refasten the ends. This prevents the lanyard from supporting body weight or withstanding enough force to cause injury, but still allows it to hold keys and badges securely. Another method requires that the manufacturer use a "break-away" fastener where the two lanyard cloth ends meet at the clip in the front. The use of lanyard key chains has markedly increased, and as with any item around the neck, there is a danger in its use. Fortunately, means are available to prevent this type of injury from recurring while still preserving the lanyard's useful function, especially for children.

Lanyard Key Chain, Hanging, Children

G43 Sudden Death in Baseball: A Case Report and Review of Literature

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The goals of this research project are: (1) to document a cause of sudden death on the baseball arena; and (2) to review the currently available literature about the causes, patterns, and consequences of baseball fatalities.

Sports, as they say, is big business. Death in such a setting, in and around the sporting arena, attracts much public attention and media coverage. We have, after all, come a long way from the era of the gladiators and the days of blood, gore and death as spectacular spectator sports. Thus, it is not surprising that deaths occurring due to stampedes secondary to stadium collapses or mayhem perpetuated by soccer hooligans make banner headlines around the world. Deaths of participants in sporting events also generate widespread media coverage, public outcry, and political pontification. Such deaths are no surprise when they occur as a consequence of illicit or prescription drug abuse. Moreover, we are psychologically prone to think of sudden deaths due to fatal impact injuries as more likely to occur in contact sports like boxing, football or

hockey than in non-contact sports like baseball. Most catastrophes leading to sudden and unexpected death of young athletes in non-contact sports are often the consequence of unsuspected congenital or acquired cardiovascular disease. A less well-recognized cause of sports related sudden death on the baseball, cricket, hockey or lacrosse fields is "Comotio Cordis." We present here a case report of a sudden death due to fatal impact occurring on a baseball field.

The case report is that of an 18-year-old male who was playing baseball. He was chasing a ball hit to the outfield, when he collided with a fellow player. As no video or photographic records of the fatal event were available, it could not be verified whether the shoulder, arm, elbow or the knee of the fellow player made contact with the neck of the victim. The victim was observed to collapse and become cyanotic soon afterwards. The emergency medical services responding to the scene were unable to intubate him and so transported him to the nearest available hospital. An emergency tracheotomy was performed which revealed significant hemorrhage within the trachea. An emergency thoracotomy was subsequently performed. Despite the several therapeutic maneuvers, the victim succumbed to his injuries. At autopsy, fractures of the cricoid and thyroid cartilages were present. Aspirated blood was present within all major bronchi and extending into the bronchioles.

It is estimated that more than 19 million children are involved in youth baseball in the United States. A Consumer Product Safety Commission Report stated that in the 5 to 14 year-old age group, more fatalities and injuries necessitating emergency room visits occurred in baseball and softball compared to any other sport. There were 88 deaths related to baseball in the 5-14 year age group between 1973 and 1995, of these deaths, 68 were caused by impacts with the ball, 13 were caused by impacts with the bat, and 7 were from another cause or were of unknown cause. These data translate into one death in youth baseball for every 4.75 million participants. The case report that we present is thus a documentation of a very unusual and really freakish accident. In our search of the literature, we failed to find a similar case of sudden death during a baseball game.

Blunt Neck Trauma, Sudden Death, Baseball

G44 Post Collision Vehicular Fires—Determination of Probability of Occupant Survival Post Impact

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The goals of this research project are to present the forensic community with an explanation of the analysis necessary to determine the survivability of a post collision vehicular fire. This analysis can also be used in the determination of death in other cases in which fire may mask the injuries and death.

This paper will discuss the problems of determining the survival of an occupant involved in an automotive crash that subsequently involves a post collision fire. This will provide some insight into the primary questions involved in this type of incident. Did the occupant survive the collision? Did the occupant sustain injuries that, even though the fire and/or its consequences may have played a role in the death, prove he/she would have died from the collision injuries regardless?

To make this determination, one of the first steps in the analysis is to consider the collision dynamics of the incident. The first parameter, and probably the most important, is the Delta V or crash severity of the incident. As important as the Delta V are the direction of the impact to the vehicle, and a rollover, if one has occurred, how many rolls and at what speed the rollover began. The next parameter is the pulse or duration of the crash and also whether or not there are airbags in the vehicle and if these devices deployed during the incident.

After the investigator has an understanding of the collision dynamics, he must analyze the next piece of the puzzle, the injury pattern. This includes determination of all the injuries sustained in both the collision and due to the post collision fire. Within this portion of the analysis, consideration has to be given to the method of removal of the bodies from the vehicle as well as the mode of transport to the forensic science laboratory. During this examination a determination of true traumatic injuries versus fire related injuries should be separated out. Of additional importance, an attempt to determine whether or not restraints were in use may be possible based on types of injuries present, absence of injuries, and information from vehicle inspection.

A toxicological analysis should be performed to determine the carboxyhemoglobin levels of the victims. Due care has to be taken in the use of the values in the overall determination of the cause of death. This requires further investigation into what types of materials were contained within the fire environment, what type of air exposure, and whether the decedent(s) were smokers.

To complete the piecing together of this complex puzzle, consideration of witness accounts to the incident have to be evaluated. These persons can provide testimony as to the intensity of the fire, movements of any of the bodies within the fire, sounds and other noises heard from the fire during its progression.

The determination of post collision survival and whether death has occurred as the consequence of a vehicle fire is a complex issue. In some cases post mortem examination and autopsy may stand alone in answering this question. In many cases, however, even with a post mortem and autopsy, the additional information accumulated in the investigation is extremely important and necessary in making such a determination.

There may be cases in which without an autopsy there is enough accumulated information from other sources to determine that there is a reasonable probability that the person survived the crash, and that fire, within a reasonable degree of forensic, medical and scientific probability caused the death of the individual.

Fire can mask many types of death including homicides, suicides and natural deaths. It is only the work of a skilled and trained investigator that the answers from the dead in such a case can be heard.

Fire Death, Carboxyhemoglobin, Vehicle Fire

G45 Decapitation by Motorized Shoulder Harness: A Case Report

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The goal of this research project is to present an unusual traffic fatality associated with a motorized shoulder harness, and to inform the audience how a shoulder harness without a lap belt can cause serious and fatal injury.

Deaths associated with motorized shoulder harnesses have been the subject of recent litigation. Automobiles with motorized shoulder harnesses automatically draw the harness against the occupant when the ignition is turned on. This "passive" restraint may give the occupant of the vehicle a sense of security, allowing him or her to think he or she would be safe in a frontal collision. In truth, the occupant is at serious risk for injury unless the lap belt is fastened. Failure to use a lap belt results in injuries from "submarining" — the harness restrains the movement of the lower body forward during a frontal collision while the upper body. Serious and fatal thoracic and neck injuries can occur from submarining. Also, the shoulder harness without the lap belt does not prevent occupant ejection. The following case illustrates an unusual and fatal injury pattern resulting from the use of a motorized shoulder harness alone: decapitation.

While driving a two-door sedan and traveling at about 80 miles per hour on an interstate highway, a 58-year-old female collided with two

slower cars prior to leaving the road at a high rate of speed. As her vehicle rotated counter clockwise, it became airborne after leaving the shoulder of the road. The left rear of the car forcefully struck the ground, and the driver was ejected to the left and rearward through the opened driver side door. Her headless body and decapitated head were found 100 feet from each other.

Autopsy disclosed the level of decapitation to be at the base of her neck, level with her shoulders. About 2 inches of cervical spine and attached hemorrhagic soft tissue protruded from the margin of decapitation. Brush abrasions lay in the skin of the upper chest and over the right clavicle, and contusions involved the tissues inferior to the right clavicle and in the right upper anterior chest. The cervical spine disclosed a ragged fracture-transection between cervical vertebrae three and four. Additional injuries included a frontal deep scalp contusion, light subarachnoid hemorrhage throughout the cerebrum and cerebellum, and fractures of the anterolateral aspects of right ribs one, three, four, five, six and seven. Other head, trunk or extremity injuries were slight to absent. Toxicologic evaluation of blood from femoral vessels and urine disclosed no evidence of ethanol or drugs.

Examination of the vehicle disclosed damage mostly to the front and left rear portions of the vehicle. The driver side door was deformed in an open position. In spite of the frontal damage, there was minimal to no intrusion into the front occupant compartment. There was no evidence of damage to the steering wheel or dash and no evidence of body impact against the front windshield. The shoulder harness was in the fully engaged position, and the receptacle was bent to the left toward the opened driver-side door. Blood and tissue stained the shoulder harness from 4 to 9 inches from the receptacle. There was no evidence of lap belt use at the scene of the accident.

During her ejection through the driver-side door at a high rate of speed, the fabric of the shoulder harness decapitated the victim. Failure to use a lap belt with the shoulder harness allowed her neck to be severed by the harness as her body ejected from the vehicle.

Traffic Fatality, Motorized Shoulder Harness, Decapitation

G46 The Memorials at the Lockerbie and Ermenonville Forest Air Disaster Sites

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The goals of this research project are to 1) earn that mass disasters involving aircraft evoke swells of both communal anger and grief. These evolve into the need to keep alive the memory of both the event and the victims by erecting memorials; and 2) recognize that the forensic scientist may benefit personally and professionally by seeking out and viewing these memorials.

Visiting and viewing memorials brings forcibly and poignantly to the forensic scientist both the reality and the finality of the disasters which they commemorate. This may be true in particular when the scientist has previously read extensively about the disasters and has seen images of them in the media.

A memorial, for instance, a monument or a holiday, serves to keep alive the memory of a person or an event. It serves as an historical record, and may recognize and give permanence to valiant lives or deeds. A memorial may also keep alive the memory of a tragedy, serving as a site for gathering, mourning, and remembering.

Thus, memorials have been erected to commemorate sites of forensic interest, primarily mass disasters, both natural and man-made. Of these, and particularly in the second half of the 20th century, a number commemorate aircraft crashes in which there was great loss of life; i.e., aircraft disasters.

A recent visit to Europe enabled the author to visit two such memorials: the first, that to the destruction by sabotage, and the subsequent crash of Pan Am Flight 103 in Lockerbie, Scotland on December 21, 1988; the

second was that to the crash of Turkish Airlines Flight 981, in the Ermenonville Forest northeast of Paris, France on March 3, 1974, following the loss of a rear cargo door which irretrievably damaged the plane's controls.

Motives for the visits included adding to knowledge of these disasters gained through reading and the media, coming to terms with emotions brought about by this research, and recording images to be used in teaching.

Lockerbie: The small town of Lockerbie is in southwest Scotland, just north of the border of the English county of Cumbria. Portions of the aircraft and the passengers fell both into the town and onto surrounding countryside.

The Garden of Remembrance is located at the edge of the town. Rolling fields and hills are all about. High-flying airliners, some flying transatlantic routes similar to that set out on by Pan Am 103, are seen and heard directly overhead. A large, central memorial of tablets bearing the names of all of the victims is flanked by individual tablets to passengers and crew. There are attractive flowers and plantings. Several miles in the opposite direction, in hills and fields above the town, is the small Tundergarth parish church. Nearby, the cockpit and anterior cabin of the 747 "Maid of the Seas" fell into a field; images of this wreckage have been published throughout the world. In the churchyard was erected a small cabin, the Tundergarth Memorial Room, which contains a large book in which there are text and images of the passengers and crew, and floral arrangements.

Ermenonville Forest: This dense virgin forest contains a number of structures of historic interest, and is a popular recreational site for both Parisians and other visitors. The crash occurred deep in the forest, and the memorial is accessible only by graveled footpaths through the forest. This is a soaring memorial of dark grey Cornish stone, adjacent to which is a tablet bearing a commemorative poem. Most unexpected, and most riveting, is the finding of numerous small, usually charred fragments of the crashed DC-10 previously retrieved from the surrounding forest and laid upon the edges of the monument. Other such artifacts still lie in surrounding vegetation. Opposite the memorial are low stone tablets bearing the names of passengers and crew. Aircraft taking off from Paris Charles de Gaulle Airport are seen and heard just south of the Forest.

Conclusions: Visiting and viewing public memorials to aircraft disasters give visible evidence of the strong communal feelings of both grief and the celebration of individuals' lives engendered in the survivors following such disasters. It also makes much more immediate and memorable to the forensic scientist, who has previously heard and read of a disaster, the locale and immediate surroundings of the same, the magnitude of loss of life, and the conflicting emotions which were, and always will be, so strong within the survivors. Even more poignant are the continual commercial air traffic above and near the memorial sites and the finding of artifacts at one.

Aircraft Accident, Forensic Sciences, Memorial

G47 Experiences Following the Crash of Singapore Airlines SQ006 Boeing 747-400 in Taipei

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The goals of this presentation are to address the events following the aviation disaster of Singapore Airlines SQ-006 and to detail the standard operation procedures used during this experience.

On October 31, 2000, at approximately 23:17 Taiwan time (15:17 UTC), Singapore Airline Flight SQ-006, with Singapore registration 9V-SPK, Boeing 747-400 aircraft, entered the runway under construction

at Chiang-Kai-Shek (CKS) Airport, Taiwan. Heavy thunderstorm and strong wind from typhoon "Xiang Sane" arrived at the time of this aviation accident. Before taking off, the airplane cracked when it collided with the runway construction equipment and the impact produced a fire. There were a total of 179 people on board: 159 passengers, 3 flight crew members, and 17 cabin attendants. Official reports show that 83 people died (including 4 cabin crewmembers) and 44 people were injured. The accident of Singapore Airline SQ-006 at CKS International Airport resulted in the instant deaths of 79 persons from 19 different countries. 77 bodies were rescued from the scene immediately after the fire was extinguished; two of 79 bodies were found under the cracked aircraft about 43 hours after incident.

Although many of the bodies were identifiable, the prosecutor's office of Tau-Yuan District Court (40 km to the south of metropolitan Taipei) decided to request the DNA typing method to confirm identity of each body; in addition, odontological and anthropological identification that included one X-ray mobile van was also requested. Immediately after this accident, the Criminal Investigation Bureau, Ministry of Interior and medical examiners of IFM were asked 1) to collect the samples, mostly consisting of muscle tissue from deceaseds' bodies; 2) to label carefully the evidence; and 3) to follow independently the chain-of-the-custody. STR profiling system was applied and MJIB and IFM were assigned to collect the family members' blood samples. STR profiling types were processed for further paternity matching. In order to increase the efficiency of DNA typing, the forensic scientists of molecular biology were organized into a blood collector group, a DNA extraction group, a STR typing group, and STR matching work stations as a DNA typing and identifying mass production chain. The CODIS 13 STRs were applied to fulfill the DNA data interchange. The first group of families arrived on the next day at 8:30 a.m., about 9 hours after the crash; their blood samples were drawn for DNA typing to establish genetic relationship to the decedents. 20 hours after the crash, the first group of 12 bodies was identified including anthropological and odontological examination and DNA confirmation.

After five days of mass production operation in the DNA laboratory, 80 bodies matching their relatives from 19 different countries were identified including one rescued survivor who died about 24 hours after incident. Another two decedents died in the hospital; these two were identified by next-of-kin. One of the 80 decedents was identified by STR direct matching (STR typing result and blood sample sent from Singapore) from a previous blood sample left in the blood bank of Singapore. An exceptional case involved one decedent who was identified after the CODIS 13 data of decedent's family member sent from India. 15 of 65 decedents were identified by sibship profiles with collateral consanguinity and paternity test with linear consanguinity, respectively.

Forensic DNA matching correlated with odontological and anthropological examination is a very accurate and efficient tool used to identify badly injured bodies. Established professional guidelines as standard operation procedures of DNA typing and body identification played a crucial role in coping effectively with mass disaster of Singapore Airlines SQ-006 Air crashed Accident.

Forensic Science, CODIS 13, Air Crash

G48 Mortality Estimate for the 1994 Northridge Earthquake

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The goals of this research project are to present sources of error in the Medical Examiner's report of mortality from a widespread disaster.

On January 17, 1994, a large earthquake occurred in a suburb of Los Angeles, causing widespread damage. The Los Angeles County Department of Coroner received a large number of requests from the

media for the number of earthquake-related deaths. There were also several requests for identity of the victims, both from the media and for purposes of compensating the families.

The official death toll of 57 was based on the following case definition: "A death is considered earthquake-related if it occurred on the day of the earthquake, and it was a direct result of trauma (such as structural collapse) or if it resulted from a stress-related illness." The official death toll underestimates the actual death toll because it does not include the following:

1. Deaths from atherosclerotic disease that were not reported to the Coroner. Deaths from atherosclerotic cardiovascular disease increased on the day of the earthquake, but then decreased for several days afterwards.
2. Deaths occurring in other counties.
3. Delayed deaths, including deaths from aftershocks and suicide.
4. Deaths from an earthquake-related epidemic of *Coccidioidomycosis*.

Based on analysis of excess mortality on the date of the earthquake, the actual death toll was approximately twice the official death toll.

Mortality statistics from a widespread disaster have sources of variation not present in a confined disaster. These include the region surveyed, the time interval examined, and the causes of death considered. In this situation, it may be impossible to give an accurate death toll, or to determine the identity of many of the victims.

Earthquake, Mortality Statistics, Northridge

G49 Death in the Desert: Multiple Fatalities as a Consequence of Environmental Exposure

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The goal of this research project is to further illustrate the multidisciplinary nature of death investigation, especially as this pertains to multiple deaths and resource management within a medical examiner's office.

In May of 2001, the Office of the Medical Examiner, Pima County, Arizona, was requested by the Yuma County Medical Examiner to provide assistance in the investigation of the deaths of fourteen people who had been found in a remote area of the Sonoran Desert near Yuma, Arizona. Explicit in this request was the need for the determination of cause of death for each of the fourteen individuals—all of whom were presumed to be Mexican Nationals—as multiple charges of homicide were to be filed against the person or persons responsible for leaving these unfortunate people in such a desolate landscape. Both the Yuma County Sheriff's Department and the Pima County Sheriff's Department, as well as the FBI, assumed a role in the investigation because at the time of the postmortem examinations it was uncertain whether these cases would be prosecuted by state or federal officials. Serving as a much-needed liaison between the medical examiner's office and relatives of the victims was the Mexican Consulate in Tucson. This assistance was invaluable because the majority of the decedents were not identified when they were received into our office. The receiving of fourteen individuals en masse—in addition to the regular daily caseload—into a medical examiner's office can create problems, as well as additional stress, but these problems and stresses can be managed by mobilizing the appropriate resources.

The immediate resources tapped were the employees of the office of the medical examiner. To the credit of these dedicated personnel, workdays were lengthened, days off were postponed, and vacations were delayed without complaint. Teams were organized so that the examinations of the usual daily caseload could be conducted while the examination of the fourteen related deaths could be performed with continuity. The

office was a beehive of activity for a few days, with all of the medical examiner employees working along side representatives of the sheriff's office, the FBI, and the Mexican Consulate. Because this multiple-death event offered the unique opportunity to gain experience in managing a future mass-disaster, our office implemented another resource: mobile refrigerated storage space. To this end, a local beverage distributor donated—and delivered to our door—a refrigerated trailer. Although it was not necessary to utilize this storage space in this instance, logistical experience was gained that will be beneficial if the need ever arises.

After the post mortem examinations were completed, it was revealed that each of the fourteen individuals died as a result of exposure to an arid, desert environment. To date, thirteen have been identified by a variety of techniques and repatriated (with the assistance of the Mexican Consulate) to Mexico. Efforts to identify the final individual continue. Through the utilization of the various resources available to the medical examiner, successful resolution of a multiple death event was accomplished.

Multiple Deaths, Multidisciplinary Investigation, Resource Management

G50 The Role of the Forensic Anthropologist in Determining the Manner of Death in Suicidal Shotgun Wound to the Back of the Head

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The goals of this research project are: (1) to present a case of suicidal shotgun wound to the back of the head, (2) to outline the methods employed in the reconstruction of the fragmented skull to understand the bullet trajectory, and (3) to discuss how this reconstruction was crucial in supporting the alleged manner of death.

The value of the forensic anthropologist in assessing trauma to and identification of skeletonized remains is clearly understood and is widely accepted in both the forensic anthropology and forensic pathology communities. Assessing such trauma in completely fleshed remains, however, is not as clearly defined or as well recognized. What is clear is that there are cases of significant skeletal trauma in fleshed remains where cause and/or manner of death are in question. In these cases the services of forensic anthropologists can also be invaluable because of their ability to reconstruct fragmented bones, to recognize injury patterns, and to determine possible weapons used to inflict the trauma. This paper discusses a case of complex cranial trauma in a fully fleshed body and illustrates how forensic anthropology can assist in determining the cause and manner of death.

The case involved a 33-year-old male who reportedly shot himself with a 12-gauge shotgun loaded with deer slug ammunition in a successful suicide attempt. The decedent had a history of depression and multiple ongoing social stressors including an impending divorce, the recent loss of a job, and impending foreclosure on his house. He had been arguing off and on with his live-in girlfriend on the day of his death. During their final altercation he verbally threatened to commit suicide and retrieved a gun from another room in the house. His girlfriend reported that he placed it near his right ear at an upward angle and pulled the trigger. The gun did not fire and she turned to leave the room. As she walked away, she heard the gunfire and turned to find him on the floor, surrounded by blood. Paramedics were called and pronounced him dead at the scene. Police

responded and “determined” that it was a suicidal gunshot of the head but could not determine the entrance site. The county medical examiner did not order an autopsy and the body was released to the funeral home. During the embalming process, the funeral director noticed that the entrance wound was at the rear of the skull and questioned the likelihood of the presumed scenario (i.e., a self-inflicted shotgun wound to the rear of the head). Upon receiving this information, the medical examiner ordered an autopsy on the embalmed body. Autopsy revealed a massively distorted head with shattering of the cranial vault and virtually complete evacuation of the endocranial space. An entrance site was identified on the right side of the occipital squamous, approximately two inches posterior to the right ear and soot was identified on the inner and outer tables of the adjacent bone. Because numerous skull fragments were missing or dislodged, it was impossible to identify the exit site(s) or to determine the trajectory of the projectile. The question posed at autopsy was this: could this really be a suicidal shotgun wound to the back of the head or is this a homicide being disguised as a suicide? There was evidence to support the hypothesis that it is physically possible to commit suicide in this fashion if the slug took a tangential course through the skull. Therefore, the determination of the path of the bullet was considered critical.

The complexity of the cranial injuries and the gravity of the questions raised warranted the involvement of the forensic anthropologists from Michigan State University. At the time of the autopsy, it was the anthropologists’ opinion that a proper determination of the exit wound and therefore the bullet trajectory required the removal of the head and ultimately the examination of the relevant skeletal material devoid of flesh. The head was defleshed and reconstructed at the Michigan State University Forensic Anthropology Laboratory. This process resulted in the identification of a minimum of three exit sites (i.e., the slug had fragmented) in the right parietal area, posterior to and to the right of bregma, and allowed for the reconstruction of the most likely trajectory. From the reconstructed cranium, it was apparent that the bullet entered the skull from the right side of the occiput, fragmented and that the fragments took a steeply vertical path along the right side of the head. The determination of the wound path made it possible to conclude that the death was consistent with a self-inflicted gunshot wound to the back of the head and these findings were consistent with the girlfriend’s account.

Examination of Fleshed Human Remains, Suicide, Anthropology

G51 Sudden Death Due to Myocardial Infarct Associated With Systemic Lupus Erythematosus: Two Case Reports and a Review of the Literature

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The goal of this research project is to understand the etiology of myocardial infarcts associated with systemic lupus erythematosus.

The authors present two cases of sudden death due to myocardial infarcts (MIs) associated with systemic lupus erythematosus (SLE) and discuss the etiologies for MIs associated with SLE.

The two patients, one a 29-year-old white female and the other a 25-years-old white female, had known diagnoses of SLE. Both collapsed at home, one with no acute complaints and the other, who was 22-weeks pregnant, had complained of bilateral arm pain for two days prior to her death. At autopsy of the 29-year-old woman we found multiple aneurysms of the right coronary artery caused by arteritis. One of the coronary artery aneurysms was thrombosed and the inferior wall of the left ventricle had an AMI. The second case showed occlusion of the left anterior descending coronary artery by atherosclerosis and thrombus with an associated anterior and lateral wall AMI.

AMI is a recognized fatal complication of SLE. Reported mechanisms include atherosclerosis, arteritis, coronary artery aneurysms, intracoronary thrombi without significant coronary artery disease, coronary embolus from verrucous endocarditis, and coronary ectasia. In general, older age at diagnosis, longer time since diagnosis, longer duration of corticosteroid use, hypercholesterolemia, and postmenopausal status are more common in women with lupus who suffer cardiovascular events.

Patients with SLE often have accelerated atherosclerosis. An autopsy study of 21 women between the ages of 16 and 37 with SLE showed >75% narrowing by atherosclerosis of one or more coronary arteries in 10 of the women.

The accelerated atherosclerosis seen in lupus may be due to hypertension, chronic corticosteroid use, and hyperlipidemia.

Although uncommon, coronary arteritis associated with SLE and resulting in MI, is well documented. In addition to the case presented here, several other cases of coronary artery aneurysms and MI in patients with SLE have been reported. The uncommon vasculitis of major coronary arteries and the vasculitis of small coronary artery branches are not usually seen in drug-induced lupus-like syndromes.

Patients as young as 8-years old are reported to have suffered MIs due to intracoronary thrombi without significant coronary artery disease in SLE. The presence of antiphospholipid antibodies (such as the lupus anticoagulant) has been associated with such thrombotic events in SLE. In one reported case, thromboses of small intramural arteries of the heart were associated with a thrombus in a coronary artery.

Conclusion: AMI is a well-described complication of SLE. Accelerated atherosclerosis is the most common risk factor for an AMI in patients with SLE, but a number of other mechanisms may result in the vascular stenosis responsible for the infarct.

Systemic Lupus Erythematosus, Myocardial Infarct, Sudden Death

G52 Unexpected Multicystic Encephalopathy After Accidental Intoxication by a Corrosive Agent: Case Report

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The goal of this research project is to illustrate an unusual neuropathological autopsy finding and to discuss the probable etiology, using text and photographs.

Multicystic encephalomalacia is an extremely dramatic disease usually presenting in the immature fetus. The lesions typically occur in the white matter, because of this region’s putative higher metabolic activity and, therefore, high vulnerability to anoxia related to active myelination. The cysts may vary greatly in size and be distributed throughout the cerebral cortex bilaterally. A few, rare studies have reported cerebral encephalomalacia in adult life in patients following toxic intoxication or after gastrointestinal surgery. We report an unusual case of multicystic encephalomalacia observed in a 55-year-old man with a history of alcohol intake, who had undergone partial gastrectomy after caustic ingestion. In March 1998, the patient accidentally ingested caustic liquid (Sumazon – containing sodium hydroxide, sodium hypochlorite and phosphates) used for dish washing. On his arrival in hospital, a stomach pump was administered and appropriate pharmacological treatment was started. Esophago-gastro-duodenoscopy (EGDS) performed two days later showed acute esophagitis and gastritis due to caustic ingestion, with multiple irregular ulcers especially in the antro-pyloric region. On discharge, the control EGDS demonstrated diffuse gastric scarring. In April, the patient was hospitalized for persistent post-prandial vomiting

associated with epigastric pain, and EGDS showed tight stenosis of the scarring in the pylorus. Partial gastroduodenal resection was performed according to Billroth II. In May, due to persistence of the vomiting and progressive deterioration of the patient's nutritional status, he was examined once more and the presence of a mechanical obstacle to the passage of food was excluded. Irritation of the residual gastric mucosa induced by bile and pancreatic secretion was postulated to be the cause, and a new operation was proposed (biliary and pancreatic derivation). On 24 May 1998, the patient was admitted to a surgical ward and refractory vomiting, malnutrition, anemia, electrolytic alterations (Na^+ , K^+ ; H^+) and calcemia were recorded, together with a state of mental confusion, visual disturbances, vertigo and paresis of the right arm. The patient was administered parenteral nutrition and a cranio-encephalic CT scan was performed, which showed asymmetry of the lateral ventricles ($\text{sin} > \text{dx}$) and cerebral atrophy; no areas of pathological density were revealed in the parenchyma. On 4 June the patient died of irreversible cardiac arrest. As there was some suspicion of malpractice, the judge ordered an autopsy. External examination of the cadaver evinced greenish areas of putrefaction over the inferior abdominal quadrants, various tattoos of varying sizes, no teeth in the superior maxillary arch, and the scars due to the partial gastrectomy. On sectioning the body, acute polyvisceral congestion was observed (right lung gr. 650, left lung gr. 680; heart gr. 300; liver gr. 1400; spleen gr. 130; right kidney gr.220, left kidney gr 240); scars were due to partial gastrectomy, absence of pleural, pericardiac and peritoneal leakage. The brain, weighing 1,250 grams, was asymmetrical in the two hemispheres, and flattened grooves and wide circumvolutions were apparent. The circle of Willis showed scattered atheromatous plaques along the walls of the vessels. Examination and section of the encephalon were performed after fixation of the organ (30 days in 20% formalin); before cutting into the parenchyma, post-mortem brain magnetic resonance imaging (MRI) coronal proton density and T2 scans showed multiple cyst-like lesions involving the subcortical white matter and basal ganglia. The genu of the corpus callosum presented an area of gliosis on the left side. All these aspects were absent on the CT scan performed only a few day before exitus. Section of the encephalon confirmed the presence of cystic lesions in the white matter, containing cerebrospinal fluid and ranging in diameter from 3 mm to 1.3 cm, symmetrically distributed along the cerebral hemispheres, in the brain stem, the ganglia of the base and the cerebellum, especially the periventricular areas. The left ventricle was dilated and there was no tissue herniation. Sections 4-5 microns in size, stained with hematoxylin-eosin, Pas, Luxol Fast Blue, Azan-Mallory, Grocott and Zihel-Nielsen, were observed under the optical microscope and it was seen that the cystic cavities mainly involved the white matter and rarely the grey matter, and that they had no epithelial sheath and were delimited by zones of astrocytosis. Demyelinated foci were present, and there were areas of gliosis in the corpus callosum. Tests for bacteria (mycobacterium tuberculosis and atypical mycobacteria), fungi (candida and cryptococcus), viruses (cytomegalovirus, herpes) and protozoa (toxoplasmosis) were negative. Histology of the other organs confirmed the overall state of congestion but provided no other noteworthy findings apart from areas of fibro-adipose tissue in the ventricular myocardium (left and right) and hepatic steatosis. Death was thus attributed to the synergic effect of the cerebral lesions provoked by the metabolic acidosis together with the persistent electrolytic imbalance. The case we describe confirms the reports in literature indicating ungovernable vomiting as a rare, severe complication of gastrectomy and suggests that a metabolic imbalance may be etiopathogenic for cerebral cyst formation in the adult. To ensure correct diagnosis at autopsy, therefore, examination and MRI of the brain, previously fixed in formalin, is advisable to investigate the features of tissue damage in cases of death induced by metabolic imbalance.

Corrosive Agent Intoxication, Electrolytic Imbalance, Mulcistytic Encephalopathy

G53 Notochord Regression Failure Initially Suspected as an Abusive Fracture in an Infant

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The goal of this research project is to have participant become familiar with an atypical case of notochord regression failure initially suspected as an abusive fracture in an infant

Background: The evaluation of any infant death must include a full skeletal survey in order to detect any possible trauma. The finding of suspicious trauma would eliminate the diagnosis of sudden infant death syndrome as a cause of death and may suggest abusive treatment by the caregivers.

Case History: The decedent was a four-month-old male infant. According to reports, the decedent was found by his father in a crib under a blanket unresponsive in the early morning hours. He was brought to the emergency room with a poor respiratory effort. He was intubated but continued to decline and never regained consciousness. He was pronounced dead approximately four days after admission to the hospital. Evaluation in the hospital included an antemortem skeletal survey and ophthalmologic examination. These were both unremarkable except for a defect of the 3rd lumbar vertebra which was interpreted as a possible fracture. However, follow-up radiological studies of the lumbar vertebrae failed to reveal a definite fracture. There was no history of trauma or abuse.

Pathological/Anthropological Assessment: Initial examination of the antemortem radiographs taken of the infant revealed a clear defect of the vertebral body of L3, with a slight defect in L5. Autopsy examination failed to reveal any fractures or hemorrhages in the lumbar area. In order to accurately determine if the defects were due to developmental abnormalities or trauma, the lower lumbar vertebrae were removed, dissected and macerated for evaluation. The defects were also noted in the postmortem radiological examination.

Visual examination of the vertebrae revealed a complete coronal cleft of the centrum of L3, while the centrum of L5 possessed only slight indentations of the lateral aspects. No residual defects were noted on L4. Linearly transecting the two portions of the centrum of L3 were residual cartilaginous tissue and the remnants of the notochord. The coronal cleft and the cartilaginous tissues are consistent with the failure of the notochord to regress appropriately during the development of the vertebral body (Barnes, 1994). This would interfere with the normal unification of the anterior and posterior portions of the centrum, and give the false appearance of being fractured. Microscopic examination confirmed the diagnosis of notochord regression failure. This type of vertebral body cleft defect is more commonly seen in the lumbar region.

Conclusions: The pathologic correlation to the radiological findings of this defect in the spine was failure of the notochord to regress, a developmental defect and not the result of trauma. No other developmental or congenital anomalies were identified. No other significant trauma or anatomic cause of death was identified and the cause of death was classified as sudden infant death syndrome. Although a rare occurrence, failure of the notochord to regress is an important entity, primarily because it may be confused with an abusive traumatic fracture.

Notochord Regression Failure, Fracture, Child Abuse

G54 The Clinical and Pathological Features of Fatal Concussion

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The goals of this research project are to present the clinical and pathologic features of fatal concussion, with emphasis on potential contributing factors.

Diffuse brain injuries (DBIs) are the most common type of head injury and form a continuum of progressively severe brain dysfunction. The majority of cases fall under the clinical heading of Cerebral Concussion, in which minimal or no sequelae follow a brief period of unconsciousness, and rarely come to the attention of the forensic pathologist. More frequently encountered are the severe DBIs associated with motor vehicle or pedestrian accidents, assaults, or falls from a height. The hallmark of DBI is damage to the axon resulting from the shearing forces of rotational acceleration. The severity of the injury and length of survival determine the degree to which axonal injury can be appreciated microscopically. The characteristic finding of axonal bodies becomes apparent 18 to 24 hours after injury. With the use of immunohistochemical stains for beta-amyloid precursor protein (?APP), the window between injury and detection is reduced to three hours. Small hemorrhages in the parasagittal subcortical white matter, corpus callosum, and dorsal brainstem, as well as mild subarachnoid (SAH) and/or intraventricular hemorrhage can be macroscopic markers of axonal injury due to the susceptibility of small blood vessels to the same shearing forces.

Rare are the cases in a sudden death following blunt head trauma where autopsy fails to demonstrate any injury to the brain, either macroscopically or microscopically. This entity has been referred to as *commotio cerebri*, fatal concussion, and reflex death. While this subject is well known anecdotally, it is obscure in the literature. A couple of articles have been published in recent years that discuss possible pathophysiologic mechanisms for death in these instances. The general consensus is that a "concussion" of the reticular formation in the brainstem is paramount to the lethal outcome. Whether this event triggers death via a cardiac dysrhythmia or apnea remains a topic of debate. Ethanol intoxication has long been recognized as a cofactor in the mechanism of death in certain individuals; however, this finding is not absolute.

The purpose of this study is to determine the incidence of fatal concussion in New York City and to further delineate its clinical and pathological features, as well as possible contributing factors, in order to gain a better understanding of possible mechanisms for sudden death in these instances.

The electronic database for the Office of Chief Medical Examiner in the city of New York was retrospectively searched from January 1997 through July 2001 for potential cases that met criteria for fatal concussion, that is immediate death following blunt impact to the head; no skull fractures, epidural or subdural hemorrhages, or focal brain injuries; and no other explanation for death. Identified cases were reviewed to determine the circumstances surrounding death, resuscitative efforts, acute intoxications, and underlying natural disease. A complete autopsy including toxicologic studies and neuropathology consultation had been performed in each instance. Microscopic evaluation of the brain was not included due to the short survival period. Findings were recorded in a new database for analysis.

Seven cases were identified during this 4 ½ year period. All victims were male and the ages ranged from 14 to 56 years (mean 34.4 years). Two of the decedents fell from standing and struck their head on the ground, two fell down a flight of stairs, and two were struck by an object. The seventh individual was an unrestrained passenger in a motor vehicle accident. Toxicology was negative in one instance. Of the remaining six decedents, five were acutely intoxicated with ethanol (0.12-0.36 g%). In

one of these five, cocaine was additionally detected in the blood and ethylbenzoylecgonine in the urine. Furthermore, chronic alcoholism was a recognized factor in four of these five decedents. Cannabinoids were detected in the blood of the seventh individual. Six of the decedents had cardiac hypertrophy defined as a heart weight exceeding 0.5% of body weight in kilograms or a left ventricle wall thickness ≥ 1.5 cm. The heart in the seventh individual fell well below the expected weight. Traumatic injuries were limited to scalp lacerations in two victims. Additional findings of thin SAH were present in three decedents. One instance involved a blow to the posterior neck with hemorrhage in the muscles overlying the second to the fourth cervical vertebrae, but no detectable injury to the spinal cord or vertebral artery. The remaining individual had no external manifestations of trauma to the brain, but a few small hemorrhages in the frontal white matter and pontine tectum were detected upon sectioning.

Fatal concussion is an infrequently encountered entity that has received little attention in the literature. It is generally accepted that the sudden nature of death in these instances results from a "concussion" to the vital centers in the brainstem. But what is a concussion? Recent studies have shown that patients who suffer a cerebral concussion and survive but die shortly afterwards from another cause have evidence of axonal damage demonstrable using immunohistochemical stains for ?APP. With this information, one can consider axonal injury the structural defect common to all DBIs and it is the distribution and extent of damaged axons that determine the severity of brain dysfunction. It is the belief of these authors that fatal concussion falls within the continuum of DBIs and the reason autopsy often fails to demonstrate any injuries is because of the extremely brief survival period between impact and death. The presence of subtle hemorrhagic markers supports the theory that axonal damage plays a mechanistic role in the death of these individuals. The reticular formation in the brainstem controls the autonomic functions of the body, most importantly breathing and heart rhythm. Therefore, axonal damage within this vital center could theoretically trigger episodes of apnea and/or cardiac dysrhythmias. Of the two, cardiac arrhythmia is by far a more common cause of sudden death.

The second question we must ask is why do some people die from a concussion while others survive with minimal residual effects? This study identifies two cofactors that can help explain why some people may be predisposed to sudden death following what otherwise appears to be minor head trauma: ethanol intoxication and cardiomyopathy. Conduction disturbances and arrhythmias are frequently seen in those with cardiomyopathy whether it is due to hypertension, ethanol or stimulant abuse, or of an idiopathic nature. Acute ethanol intoxication alters sympathetic activity resulting in tachycardia or bradycardia depending on the level of intoxication. Ethylbenzoylecgonine, a byproduct of the concomitant use of cocaine and ethanol, is another recognized cardiac toxin, which can induce ventricular arrhythmias. Even cannabinoids have been associated with electrical disturbances in the heart. Five of the six decedents in this study with an underlying cardiomyopathy were also under the influence of an arrhythmogenic substance. Each of the individuals had at least one cofactor present. It seems reasonable to conclude then that a blunt impact to the head or upper cervical spinal cord producing a concussion in the brainstem can easily trigger a fatal arrhythmia in an individual with an underlying predisposition to sudden cardiac death.

Fatal Concussion, Cardiomyopathy, Ethanol Intoxication

G55 “Doctors as Detectives” (1987 - 2001): Fifteen Years of Introducing Forensic Medical Science to High School Students in Northwest Ohio and Southeast Michigan

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The goals of this research project are to describe a low cost and minimal effort approach for sharing forensic medical science with local high school students and their teachers.

In the May/June 2001 issue of *Academy News*, President Mary Fran Ernst indicates that “middle and high school teachers are now clamoring for information and pleading for resources and assistance to help them incorporate forensic sciences into their science and math curriculums.” She also states “the Academy is now providing you an opportunity to help our children and the forensic sciences” and asks “Are you going to step up to the plate?” (President’s Message). In actual fact, Toledo Ohio, members of the AAFS associated with the Lucas County Coroner’s Office and the Medical College of Ohio “stepped up to the plate” in October 1987 and have since shared forensic science with at least 4,400 students and their teachers from at least 40 high schools in Northwest Ohio and Southeast Michigan.

In 1989, we presented a poster on this subject at the AAFS Annual Meeting. At that time we wrote in our abstract:

“A desire to replicate the AAFS’ Student Academy locally led forensic scientists from the Medical College of Ohio and the Lucas County Coroner’s Office to organize a day long series of lectures, posters and demonstrations for area high school students. Although lead time was short, the response to our announcement was overwhelming and we were forced to limit participation to about 200 students and teachers from 33 schools (requests indicated that at least twice as many wished to attend). Presentations by forensic pathologists (Patrick, Desley and Scala-Barnett) introduced the general field, followed by specialists from anthropology (Saul and Saul), odontology (Burns and Strickland) and toxicology (Forney and Darling). Questionnaires filled out by participants (analyzed by DeBruin) indicated that these potentially disconcerting presentations were well received and it was unanimously requested that the event be repeated annually.”

We have now (as of 3 October, 2001) successfully conducted fifteen of these annual programs for about 300 students and teachers per year since we began the series on 20 October, 1987. The format remains essentially the same with morning presentations on the basic forensic medical sciences by members of the Lucas County Coroner’s Office (forensic pathology, anthropology, odontology and toxicology). Separating each topic are 15 minute breaks during which time students can view exhibits and demonstrations and speak one-on-one with forensic scientists. A one-hour break for lunch (supplied on campus) is followed by a one-hour afternoon session on some special aspect of forensic science, usually given by guest faculty. These afternoon sessions vary from year to year.

The afternoon programs provided an opportunity to focus on DNA as early as 1990 (“Molecular Biology in the Courtroom”) and have also included airplane crashes and other mass fatality incidents, forensic entomology, crime scene analysis, facial reconstruction, blood spatter analysis, burial customs (and grave robbing), the role of dogs in death investigation, etc. Guest speakers have come from a variety of agencies including the Armed Forces Institute of Pathology, the FBI Evidence Response Teams and other law enforcement agencies.

Teachers have often indicated that these programs provide an applied and meaningful context for some of their basic science teaching. Several schools have developed courses that relate to our program. In addition, a number of students have obtained access to internships at the Coroner’s Office through this program.

Program expenses are minimal and include administrative costs (donated), lunch and room rental. The buffet lunch at the Hilton Hotel on the Medical College campus has risen from \$5 in 1987 to about \$13 and auditorium rental at the Dana Center, also on campus, has risen from \$125 in 1987 to about \$600. Occasional donations from the Ohio Embalmers Association (for providing them with a similar program) and a few other outside donations have helped us hold down the registration fee which has risen from \$5 in 1987 to \$15. Some schools pay the fee but most registrants pay their own way. Financial aid has always been offered but never accepted.

Forensic Medical Sciences, High School, Teachers and Students

G56 Exsanguination From a Dialysis Catheter: Trace Evidence Examination in Determining Manner of Death

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The goal of this research project is to recognize an unusual cause of death in patients undergoing chronic renal dialysis, and the usefulness of trace evidence examination in resolving the issue of manner.

A blind, 70-year old man receiving thrice-weekly renal dialysis for chronic renal failure was found dead in his wheelchair in blood-covered clothing. He had exsanguinated and sustained venous air embolism from an exposed, indwelling central venous dialysis catheter coiled on his upper chest, inspection of which showed a number of transverse slits, most of them superficial, but at least one of which penetrated to the catheter lumen. Deliberate cutting of an indwelling venous catheter is occasionally encountered as a means of suicide, and the multiplicity of the defects, somewhat resembling hesitation marks, suggested that possibility. The alternate possibility of structural failure of the plastic catheter was also entertained.

The catheter was submitted to the trace evidence section of the Hamilton County Crime Laboratory for examination, specifically to determine if the defects in the tubing were cuts or breaks and, if cuts, what implement might have been used to cause them.

Microscopic examination of the catheter revealed a series of 18 slits within the space of approximately one inch. Two of the slits reached the lumen. They were sequentially shallower with increasing distance from the deepest slit. Though uniformly transverse, the slits were not perfectly parallel. Many, indeed, were not straight and could not have been made by a sharp-edged tool.

In cross sectional view, the inside edges of the slits appeared fractured and displayed no markings or striations indicative of being made by a tool. A known cut was made with a scalpel blade in the tubing away from the area of interest. Comparison photographs were made of the questioned splits and the known cut, revealing obvious differences between the known and questioned defects. Additionally, near the questioned defects, a series of fine cracks in the plastic was observed, analogous to fractured glass.

Several tools collected at the scene of death and submitted to the laboratory were also examined and eliminated; however, on the basis of examination of the tubing, it was concluded that the decedent’s exsanguinating hemorrhage was due to structural failure of the plastic tubing rather than to its deliberate incision.

Exsanguination, Dialysis Catherer, Trace Evidence Examination

G57 Sudden Death Due to Idiopathic Giant Cell Myocarditis: Case Report and Literature Review

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The goal of this research project is to increase forensic awareness of idiopathic giant cell myocarditis as a cause of sudden cardiac death and discuss the pathogenesis, histologic findings and differential diagnosis.

We present a case of a 15-year-old female with a one-week history of chest pain who had been diagnosed with costochondritis and treated with prednisone and hydrocodone + acetaminophen. She was found unresponsive in the bathroom. An EKG in the Emergency Department showed an elevated ST segment with a slightly widened QTc interval of 449 ms. Because of her continued instability she was transferred to a tertiary medical center. During transport, she had narrow complex tachycardia and was given two doses of adenosine without result. She had persistent pulselessness and CPR was discontinued and she was pronounced dead 3½ hours after being found unresponsive.

Major findings at autopsy included diffuse tan-gray areas of poorly delineated necrosis and infiltrates with focal areas of serpiginous hemorrhage mainly involving the left cardiac ventricle. These extended from the apex to the base, mainly involving the inferior left ventricle but also involving the posterior septum and free wall. About 40% of the ventricular myocardium appeared replaced by the tan-gray hyperemic infiltrate. The right ventricle was less involved. Microscopically, the myocardium exhibited extensive myocytic necrosis with a polymorphous, nongranulomatous mixed inflammatory infiltrate containing multinucleated giant cells. Special stains for acid-fast bacilli and fungi were negative. Other findings included epicardial fibrinous adhesions, a pericardial effusion, bilateral pleural effusions, pulmonary edema, cardiomegaly (420 gm) and Hashimoto thyroiditis.

Idiopathic giant cell myocarditis is a rare form of myocarditis of unknown cause characterized by the presence of multinucleated giant cells. It often causes rapid congestive heart failure and dysrhythmias in young- to middle-aged adults. At autopsy, the distinctive features often include cardiac enlargement, ventricular thrombi, grossly visible serpiginous areas of ventricular myocardial necrosis and microscopic evidence of multinucleated giant cells within an extensive inflammatory infiltrate. The cause of myocardial giant cell myocarditis remains obscure although it has occurred in association with autoimmune disorders.

The differential diagnosis of idiopathic giant cell myocarditis includes cardiac involvement by sarcoidosis, tuberculosis, syphilis, rheumatic fever, fungal infections, rheumatoid arteritis, inflammatory pseudotumor, metastatic osteosarcoma and lymphoma.

Idiopathic Giant Cell Myocarditis, Sudden Death, Cardiac Death

G58 Immunopathological Study of Methamphetamine (MAP)-Induced Fatalities

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The goal of this research project is to understand the mechanism of MAP-induced neuro-toxicities and the correlation of the MAP-induced behavioral sensitization and its dopaminergic system of MAP abusers.

The abuse of illicit drug is a worldwide phenomenon that causes serious social problems. Hence, such abuse prompts much attention regarding the issue of illicit drug abuse and additionally related public hazard and criminal activities. It is essential to understand the pathogenesis of MAP-induced lesion in order to propose a prospective anti-drug program and to inform the public on the government's strategy. Long-term MAP abusers may become addicts and may generate psychotic, self-destructive behavior and emotional disturbances. A close relationship exists between MAP-induced fatalities and high homicide rate (25-30% in the manner of death) in comparison to opiate-related fatalities and low homicide rate (0-5%). MAP induces long-lasting deficits in the innervations involving the striatum from DA (dopamine) neurons of *substantia nigra*. This study is primarily based on MAP-induced fatalities collected from the IFM. We used Hematoxylin & Eosin stain (HE) and immunohistochemical treatments, including tyrosine hydroxylase (TH), vesicular monoamine transporter (VMAT), neuronal membrane DA transporter (DAT) and glial fibrillary acidic protein (GFAP), to understand the morphological characteristics. We evaluated alterations of catecholamine metabolites within *substantia nigra pars compacta* and *reticula* of the ventral midbrain of MAP-induced fatalities with the history of long-term MAP abuse. Furthermore, this study aims to identify the relationship of the nigrostriatal dopamine system with its deficits and the alternations of dopamine neuron in the *substantia nigra*. In this study, the assessed cases of MAP abuse were divided into control group and MAP group (four male and four female fatalities in each group). The sections of *substantia nigra* in midbrain were isolated, stained with HE stain, and then with Immunohistochemical stains (TH, VMAT, DAT and GFAP). It has been demonstrated that the morphology of dopamine neurons of MAP-related fatalities under HE stain exhibit a metaphase-like nucleus and nucleoli in the *substantia nigra* correlative with a metamorphosis of cytoplasm characterized by a granular aggregation that segregated into lucid and granular zones. It develops into four "circularities" in the marginal region of DA neuron under HE stain in MAP-induced fatalities. Decreasing numbers of the enzyme-positive neurons after immunological treatment of TH, VMAT, DAT were noted. However, increasing numbers of spines with enlarged round-shape vesicles of terminal synapses become aggregated after the treatment of GFAP, showing neo-growth of glial cells with innervations. This implied that MAP-related DA neuronal lesions were associated with regeneration of glial processes. Under the observation of Laser Scanning by using a confocal microscope after the fluorescent treatments of TH, VMAT and DAT, the fluorescent activity of the MAP group appeared attenuated compared with control. These data demonstrate that long-term dopaminergic deficits with retardation of dopaminergic-metabolite enzyme could reduce the neuronal fluorescent activity. Chronic abuse of MAP may cause morphologic alternations in *substantia nigra* and a decrease in the number of enzyme-positive neurons after immunological treatments of TH, VMAT, and DAT. On the other hand, increasing numbers of GFAP-positive glial cells aggregate after treatment with GFAP implying the healing process with gliosis. These studies demonstrate that long-term dopaminergic deficits may decrease neuronal activity by destruction of the DA neuronal terminal and cause degeneration as well as neo-growth of glial cells as part of the healing process. This study demonstrates well the relationship of dopaminergic deficits and the behavioral model of MAP abusers. In conclusion, these results will assist in the recognition of the mechanism of MAP-induced neurotoxicities, in explanations of MAP-induced behavioral sensitization, and will also provide strategic schema for the government's anti-drug program.

Forensic Science, Dopamine, Methamphetamine

G59 Experiences of Human Bodies Identified by DNA Typing in Singapore Airlines SQ006 Crash in Taipei

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The goal of this research project is to establish the standard operation procedure to manage the mass disaster during the experience of Singapore Airline SQ-006 Air crashed Accident by using CODIS 13 STRs profilers to identify badly wounded bodies.

On October 31, 2000, approximately 2317 Taiwan time (1517 UTC), a Singapore Airlines Flight SQ-006, with Singapore registration 9V-SPK, Boeing 747-400 airplane entered the incorrect runway at Chiang-Kai-Shek (CKS) Airport, Taiwan. Heavy rain and strong wind from typhoon "Xiang Sane" prevailed at the time of the accident. The airplane was destroyed by its collision with the runway construction equipment and by post impact fire. There were a total of 179 people on board with 159 passengers, 3 flight crewmembers and 17 cabin attendants. Official report, 83 people died (including 4 cabin crews), and 44 people injured. After the airplane SQ-006 of Singapore Airline got an accident at CKS international airport before taking off, 79 persons from 19 different countries died instantly. Although some of the bodies were identifiable, the prosecutor's office of Tau-Yuan district court (40 km away located southern Taipei metropolitan) decide to request the DNA typing method to confirm each body identity in addition to odontological and anthropologic identification.

Immediately after this accident, the Criminal Investigation Bureau, Ministry of Interior and medical examiners' of IFM were asked to type the sample from deceased's bodies and STR typing were applied, and MJIB and IFM were assigned to collect the family members' STR for further paternity matching. For the purpose to increase the efficiency of DNA typing, the forensic scientists of molecular biologist were organized into blood collector group, DNA extraction group, STR typing group and STR matching work stations as a DNA typing and identifying mass production chain. The CODIS 13 STRs were applied to fulfill the DNA data interchanging.

The first group of families arrived on the next day 8:30am about 9 hours after the crash accident and their blood samples were drawn for DNA typing to establish genetic relationship to the deceased, with the access of the 24 hour running-basis working team, 20 hours after the crash, the first group of 12 bodies were identified. After five days' mass production operation in the DNA laboratory, 80 bodies matching their relatives from 19 different countries were identified including one once rescued decedent died about 24 hours after incidence. Another two decedents died in the hospital without identification problem. Due to lack of lineal or collateral consanguinity information of one decedent to claim the body until the odontological and anthropological characteristics were confirmed. One of the 80 decedents was identified by STR direct matching (STR typing sent from Singapore) with previous blood sample left in the blood bank of Singapore. An unique case of a decedent was identified after the CODIS 13 data of decedent's family member who were unable to be Taiwan in time. 15 of the decedents were identified by sibship profiles due to collateral consanguinity. 65 of the decedents were recognized by paternity test with linear consanguinity. Forensic DNA matching is an accurate and efficient tool for badly crashed bodies identifying in addition to the odontological and anthropological method. To establish the professional guideline as the standard operation procedure of DNA typing and body identification is a crucial role to cope the mass disaster effectively during the urgent operation period. The Singapore

Airlines SQ-006 Air crashed accident by using STR CODIS 13 profilers to identify badly wounded bodies during five days' experience is worth for strategic schema.

Forensic Science, CODIS 13, Air Crash

G60 A Case Report of Sudden Death in a Patient With Kartagener Syndrome

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The goals of this research project are to (1) Review the pathophysiology of Kartagener Syndrome with emphasis on the cardiac manifestations, and (2) to demonstrate how cor pulmonale can complicate Kartagener Syndrome as a result of chronic lung disease (bronchiectasis) and obesity resulting from the side effects of the medication used to treat lung disease.

A 23-year-old obese white female was diagnosed to have immotile cilia syndrome and hypertension since eight years of age. She had been trying to lose weight and was a cigarette smoker. The night before her death she and her friends were dancing at a dance hall during which she drank six wine coolers. She went to bed without any complaints and awoke the next day to help a friend clean house. She sat down on a couch laughing and drank a soft drink (Mountain Dew). Suddenly, without complaint she fell forward and stopped breathing.

Upon their arrival, EMS found the decedent supine on the floor, apneic, cyanotic, and pulseless. Quick look monitors revealed pulseless ventricular tachycardia. Despite ACLS protocol, the cardiac rhythm deteriorated to an agonal rhythm. She was pronounced dead upon arrival to the hospital. Follow-up coroner interview with the decedent's mother revealed that the decedent and a sister had immotile cilia syndrome. Throughout childhood she underwent surgical procedures for duodenal obstruction and complications from situs inversus. Her sister, still living with immotile cilia syndrome, had a "hole in the heart" that healed without surgery. She and her sister were prescribed steroids to control both nasal congestion and chronic bronchiectasis of immotile syndrome. The decedent and her sister battled obesity throughout their lives and had tried many diets. The decedent was not on any diet medications at the time of death. The only other sudden death in the family was that of a grandmother at the age of 36.

On external examination, she was an atraumatic, extremely obese female with a body mass index of 44 kg/m². Internal examination revealed situs inversus with polysplenia and bilateral "left sidedness" (bilobed right lung). Bronchiectasis was prominent in both lungs with increased fibrovascular tissue around the affected airways on microscopic examination. The heart weighed 580 grams and exhibited biventricular hypertrophy. Other findings in the heart included a ventricular septal aneurysm with an associated tethered septal leaflet of the tricuspid valve. There was evidence of aortic insufficiency. No isomerism was seen between the atrial appendages. Other findings included a foreshortened thoracic cavity and early nephrosclerosis of the kidneys.

In view of the sudden collapse and anatomic findings on autopsy, the cause of death was ascribed to cardiac dysrhythmia due to biventricular hypertrophy resulting from Kartagener Syndrome. Cor pulmonale was characterized by right ventricular hypertrophy. Other conditions contributing to the development of pulmonary hypertension included obesity with a foreshortened thoracic cavity, sleep apnea, and chronic pulmonary disease. Kartagener Syndrome or Immotile Cilia Syndrome consists of the triad of sinusitis, bronchiectasis and situs inversus. Ciliary motility of cells of the body is abnormal due to defects of structures in the microtubular doublets within the cilia. The most common defect is absence or abnormal dynein arms. Impaired ciliary motility predisposes the body to infection resulting from poor bacterial clearance from the

sinuses and bronchi. Males affected with the condition are infertile due to the immobility of the sperm tails. Cell motility during embryogenesis is affected and results in situs inversus in about half of the patients. The mode of inheritance is autosomal recessive and the phenotype is variable. This is a case of sudden death in a patient with Kartagener Syndrome manifesting cor pulmonale as a complication.

Kartagener's Syndrome, Cor Pulmonale, Situs Inversus

G61 Micro-Computed Tomography: An Advantageous Tool for the Analysis of Patterned Tool Marks in Bones

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Micro-Computed Tomography (Micro-CT) may offer a worthwhile opportunity to analyze patterned injuries in bone. In the field of forensic science, it has not been possible until now to non-destructively document such damages to bone. However, based upon high resolution imaging of these patterned injuries, it is now possible to draw conclusions on the injury-causing instrument. In fact, those conclusions may lead to the identification of the perpetrator.

Materials and methods:

Based on a real murder case, porcine pelvic bones were experimentally stabbed with multiple knives. Afterwards these bone samples were examined with a micro-CT system developed at the IMP Erlangen. This cone beam scanner can achieve an isotropic resolution from 10 to 100 μm for sample diameters from 1 to 40 mm. We used a scan protocol of 720 projections for a 360° rotation with a 512 detector matrix. The 512³ data volume is reconstructed using a modified Feldkamp algorithm. Resolution in the specific bone samples is 30 to 75 μm depending on the sample size. Until the present, analysis has been performed by visual inspection of double oblique slices of the reconstructed volume to optimally display the plane cut by the knife using Impact View (VAMP GmbH, Erlangen, Germany). Additionally, stabbing wounds were quantitatively evaluated by measuring distances and angles. We also tried out different stabbing techniques in and out with and without additional rotation of the knife.

Results:

The micro-CT datasets of the injured bone samples were used to obtain those 2D slices that optimally showed the stabbing wounds inside. Based on the measured distances and angles, it was easily possible to uniquely identify the size and shape of the injury-causing knife in straight stabs. Additional rotating and twisting cause broader wounds, thus an expert visually selects the injuring instrument from a choice of known knives by fitting the shape to the stab in the micro-CT image. In this way, not only the knife can be identified, but also information about the action of injury is received.

Conclusions:

In the field of forensic pathology, Micro-CT provides a new and advantageous tool for the non-destructive examination and analysis of patterned tool marks in bones. By using the micro-CT technology, new horizons are open for matching a possible injury-causing instrument against the patterned lesion in the bone.

Forensic Radiology, Micro Computed Tomography, Patterned Injuries

G62 Immunohistochemical Study for Determining the Time of Injury to Rats Following Stab Wounds and Blunt Trauma to the Brain

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The aim of this research project is to investigate the possibility of utilizing changes in the proliferating astrocytes expressing glial fibrillary acidic protein (GFAP) and proliferating cell nuclear antigen (PCNA) in determining the time of brain stem injury following stab wounds and mechanically induced injury.

Astrogliosis is a predictable response of astrocytes to various types of injury caused by physical, chemical, mechanical, and pathological trauma. It is characterized by hyperplasia, hypertrophy, and an increase in glial fibrillary acidic protein (GFAP), which is an intermediate filament protein. GFAP is the principal marker for brain astrocytes; whereas, proliferating cell nuclear antigen (PCNA) is an intrinsic marker of DNA replication. In forensic pathology, there are few reports concerning the differentiation of early antemortem brainstem injuries from postmortem injuries following stab wounds and blunt trauma. In the present study, investigation was carried out to determine the possibility of utilizing changes in the astrocytes expressing glial fibrillary acidic protein (GFAP) and proliferating cell nuclear antigen (PCNA) following stab wounds and mechanically induced injury in determining the time of brainstem injury. Forty-eight rats (150-200 g) were divided into two groups (24 rats in each group) and received stab wounds and blunt trauma respectively. After the rats were anaesthetized, sagittal median incisions of the scalp were made right above the foramen magnum. For antemortem injury, a 3-mm deep stab wound was made with a sterilized stainless steel needle through the upper median point of the foramen magnum. For brain stem contusions, a 10g impact rod was allowed to drop from a height of 5 cm at the same site. The rats were killed 1, 5, 24, and 48 hours after trauma. For post-mortem injuries, the brainstem was either stabbed or mechanically traumatized 15 minutes after the rats were killed, and the brain was removed one hour after injury. For the normal control, no wounds were made and the brain was removed 15 minutes after death. The brain was then placed in 10% formalin solution, embedded in paraffin, and serial 5 μm sections were prepared. In each of the studied group, one section was stained with hematoxylin-eosin according to routine procedures and two sections were stained by immunohistochemical method for GFAP and PCNA. In the antemortem group, GFAP-positive astrocytes showed a gradual increase in number after injury and their immunoreactivity became intense especially at the vicinity of the wound. On the other hand, there was no significant difference between the postmortem injury group and the normal control group. Proliferating cells were identified by immunostaining for PCNA, which showed a high labeling index around the wound at 48 hours. The results indicate that early brainstem injury could be diagnosed by GFAP immunohistochemistry. Also, the chronological changes in the number of GFAP-positive cells could be utilized in determining the time of brainstem injury. PCNA could be used as a marker for survival after fatal head injuries.

Brain-Stem, Glial Fibrillary Acidic Protein, Proliferating Cell Nuclear Antigen

G63 Postmortem Interval Decomposition Chemistry of Human Remains: A New Methodology for Determining the Postmortem Interval

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The goal of this research project is to present to the forensic community a novel and accurate methodology for determining the postmortem interval.

This study was conducted to characterize the chemistry associated with the decomposition of human remains with the objective of identifying time-dependent biomarkers of decomposition. The purpose of this work was to develop an accurate and precise method for measuring the postmortem interval (PMI) of human remains. Eighteen subjects were placed within a decay research facility throughout the year and allowed to decompose naturally. Field autopsies were performed and tissue samples were regularly collected until the tissues decomposed to the point where they were no longer recognizable (encompassing a cumulative degree hour (CDH) range of approximately 1,000 (3 weeks). Analysis of the biomarkers (amino acids, neurotransmitters and decompositional by-products) in various organs (liver, kidney, heart, brain, muscle) revealed distinct patterns useful for determining the PMI when based on CDHs. The initial results of this study demonstrated that one particular compound, oxalic acid, is an important determinant which affects PMI decisions. This compound was not initially targeted as important in PMI determinations, but was discovered incidentally. Oxalic acid derivatizes easily and is readily detectable in even the earliest tissue samples with a characteristic molecular ion of $m/z=261$. This compound, given time, then goes through a reduction reaction, apparently converting a C=O group to a methylene group producing an oxalic acid derivative with a molecular ion at $m/z=247$ and is subsequently identified as hydroxyacetic acid (glycolic acid). This reduction reaction occurs at different times (CDHs) depending on the tissue type and is an informative PMI indicator by itself.

Other important compounds, which have been found to be reproducible between corpses, include a variety of amino acids and gamma amino butyric acid (GABA). In order for a compound to be relevant for PMI determinations in this study, its ratio compared to other biomarkers must be reproducible over time. Initial tissue surveys indicated that the common, odoriferous amine indicators of decomposition, cadaverine and putrescine, would be useful biomarkers. Unfortunately, this was not the case in this study. While the concentrations of these compounds were quite abundant ($>3,000$ ng/mg tissue) in some instances, the values (between corpses) were quite inconsistent as were the precursors of these compounds (lysine and ornithine). GHB was also a disappointment as a useful biomarker.

Since every death involves its own unique set of circumstances, the model was designed to take into account the many ways in which individuals perish. To accomplish this, the model was developed to encompass more than one indicator organ. For instance, if the individual's heart was damaged by trauma, there are four other organs from which to obtain useful data. The more organs used, the narrower the PMI becomes. Crossmatching PMIs from several organs can result in intervals as narrow as five CDHs, a time frame below the ability of the investigator to obtain reliable temperature data. This model also has the distinct advantage that additional information about the victim, such as weight, is not required since the model was developed based on ratios between the biomarkers and not absolute values. One of the interesting results to emerge from this study was the observation that every organ studied produced such a varied assortment of complex biomarker information. Intuitively all the organs should possess a relatively similar

composition. While the water content and assortment of cellular enzymes varies from organ to organ, the basic building blocks should be quite similar. During putrefaction, the abdominal organs (kidney, liver) are exposed to different bacterial populations than the thoracic organs (heart, lungs) and while this may produce varying results initially, it appears as if the tissue still exerts its "personality" long after decomposition has progressed to the point where the organs are no longer recognizable.

It has been demonstrated that proper use of these methods allows for PMIs so accurate that the estimate is limited by the ability to obtain correct temperature data at a crime scene rather than sample variability.

Postmortem Interval, Time-Since-Death Determination, Tissue Composition

G64 Effect of Ant Activity on Decompositional Rates and Estimation of Postmortem Interval: A Case Study

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The goal of this research project is to demonstrate the problems encountered when estimating the postmortem interval in cases involving blowfly and ant invasion of human remains. This presentation will provide insight into foraging behavior of ants on blowfly larvae which can significantly retard the decompositional process and lead to false assumptions of a short postmortem interval.

The use of forensically significant insects to estimate the postmortem interval is well established. Analysis of insects for the estimation of the postmortem interval is primarily based on the development of the fly. The fly families commonly utilized in these analyses are the Calliphoridae (Bottle Flies), Sarcophagidae (Flesh Flies), and Muscidae (House Flies). Postmortem estimates provided by these insects are most accurate within the first thirty days, and involve the determination of the larval developmental age under reported environmental conditions. Adult flies are attracted to a body within minutes to hours after death. Each female is capable of ovipositing hundreds of eggs on the deceased which hatch within approximately twelve to twenty-four hours. The newly emerged larvae migrate about the body feeding with a ravenous appetite.

Not only are flies attracted to a decomposing body, but a large array of insects, including beetles, wasp, and ants are, too. The successional pattern of these carrion frequenting insects is quite unique as some come to feed on the decomposing tissues, while others prey upon other insect species attracted to the body. Ants, for example, are commonly associated with a decomposing body, and are typically observed shortly after death or during the early postmortem phase. Many small punctate or scratch type lesions may be observed on a body which are the result of postmortem ant attack. Soft tissue injury resulting from postmortem ant attack is many times misinterpreted by inexperienced examiners as the result of antemortem trauma.

Ants are not only attracted to a decomposing body corpse as a food source, but also as an opportunistic event by which the adult ants feed on fly eggs and larvae. Entomological studies have demonstrated that scavenging ant colonies are capable of removing fly eggs and larvae which have been deposited on a corpse in such numbers as to actually slow the rate of decomposition. Early removal of fly eggs and larvae many times leads to the misconception of a short postmortem interval. In cases involving postmortem interval estimates based on entomological evidence, the presence or absence of ants should be taken into account.

One such case in which postmortem ant activity was initially overlooked involved the shooting death of a young male in Washington State. In early May 2000, the body of a twenty-two year old Caucasoid male

was discovered in a partially wooded area of the US Army post, Ft. Lewis, Washington. During the examination of the death scene, investigators noted the presence of a large number of red and black ants crawling over the corpse. The only other carrion frequenting insects noted in context with the remains were a few fly eggs which were located in the hair of the scalp.

Examination of the body found the decompositional state to be moderate, with exposed epidermal tissues exhibiting a leathery consistency with an orange-brown discoloration. A white-colored mold was also noted growing on exposed body surfaces. Rigor was pronounced, but easily broken with pressure, and livor was fixed. The internal organs were in a relatively good state of preservation. Cause of death was attributed to multiple gunshot wounds to the head, one to the right parietal area which exited the left parietal area, and a second which was located along the occiput, which exited at the nose.

Based on the minimal state of decomposition and the absence of blowfly larvae and unhatched fly eggs, the postmortem interval was thought to be relatively short, approximately twenty-four to forty-two hours. A secondary review of the decompositional findings and reported environmental conditions suggested a longer postmortem interval, approximately four to six days. The wooded terrain and loose soil conditions along with the considerably cool temperatures and precipitation were found to be conducive to retarding the decompositional changes. Cool temperatures and intermediate precipitation also acted to slow degradation of the body by limiting carrion insect activity, specifically that by blowflies. The limited number of blowfly eggs and absence of larvae were attributed not only to the inclimate weather conditions, but in large part to the foraging activity of ants inhabiting the corpse in large numbers. As a result of the ant activity and environmental conditions, the degradation of the corpse was significantly retarded.

Investigation into the death revealed that the deceased had been murdered by another soldier approximately five and a half days prior to the discovery of the corpse. A suspect later confessed to authorities that the shooting was accidental; however, evidence revealed the shooting to be intentional and robbery to be the motive. The accused was found guilty and sentenced to life in prison. When faced with estimating the postmortem interval, investigators should take into account not only environmental conditions which are conducive for delaying decomposition, but the presence of foraging ants which can delay the degradation of the corpse by eradication of blowfly larvae.

Decomposition, Entomology, Postmortem Interval

G65 Forensic Entomology: Decomposition in Cars

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The goals of this research project are to determine the entomological succession on a decomposing pig inside a vehicle following its sacrifice by CO poisoning (suicide pig), to calculate the time of decomposition of a suicide pig and determine temperature fluctuations inside vehicles.

Decomposing animal tissues provide an opportunity for flies to utilize the fauna and flora of microorganisms. Cadavers undergo a series of predictable changes during decomposition, and are "visited" by a succession of flies and other insects. This ordered process has handed us an invaluable tool for estimating the age of cadavers (post mortem interval), and the biology of this process has resulted in the science of Forensic Entomology. One current program at UWA is determining the post mortem intervals of pigs decomposing in vehicles (simulated suicides).

The significance of this research is: the requirement by police, coronial and justice systems for accurate information on cadavers, particularly in regard to homicide and suicide, and the accuracy of the

Post Mortem Interval (PMI) which depends on the available knowledge base, and which in most cases is dependent on a number of facts and assumptions concerning insect biology, behavior and ecology. It is the assumptions that require investigation especially in cases of suicide and suicide/homicide. The police service and the justice systems are constantly expressing concern about the accuracy of the PMI.

Most suicides conducted in vehicles happen in isolated areas where the vehicle is parked in wooded areas for the purposes of concealment. Generally, this is a shaded area or an area with minimal exposure to the sun. The methodology includes sacrificing 45kg pigs using CO gas. Following death, the pigs are quickly dressed and placed inside a vehicle. CO gas is pumped into the vehicle for another 5 hours. Decomposition is recorded using infrared video cameras as well as daily observations of insect activity. Decomposition rates are compared with two other pigs (one pig sacrificed by CO poisoning and the other by head bolt) decomposing under normal conditions. Each pig has a datalogger placed inside its throat, abdomen and colon. The temperature inside the car is also measured and compared with the recorded ambient temperature.

One particular aspect of this work is the modeling of temperatures inside vehicles. To determine how a body decomposes inside a vehicle, it is important to understand the temperature changes inside a vehicle. The temperatures inside the trunks and passenger compartments of 30 vehicles (sedans) have now been measured under a variety of conditions. These include full sun and shade and partial shade. Vehicles are placed in a north/south and east/west position and the temperature in each vehicle is monitored every 30 minutes over a three week period. This work has now been extended into community service especially in cases where young children or animals are confined to cars on hot days. This study demonstrates how vehicle temperatures increase in a parked situation in direct sunlight with windows completely closed and with windows slightly open.

Forensic Entomology, Postmortem Decomposition Inside Vehicles, Entomological Succession

G66 Deceased, Dismembered, and Disarranged: Central Nervous System Consequences of an Unusual Body Disposal Strategy

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The goal of this research project is to present an unusual thermal artifact of intracranial contents in a dismemberment case, and suggest mechanisms by which it develops.

Postmortem criminal dismemberment of the human body may be performed in the context of one or more of several possible motives, including but not necessarily limited to, ease of disposal of a body to prevent discovery of the death; to confound body identification; aggressive body mutilation in homicides reflecting intense emotion on the part of the assailant; as a symbol intended to intimidate or otherwise convey some message to others; during the course of ritualistic behaviors associated with either a natural death or with a homicide; or in the context of behavior related to necrophilia or other forms of psychopathology. Based on information available at the time of this report, the victim presented herein was dismembered for the purpose of covert disposal.

The dismembered body of a 73-year-old male was found in refrigerator and freezer compartments of his private residence. He was last seen alive three weeks prior to discovery of the remains. Recovered body parts included torso, head, neck, hands, feet and several smaller tissue fragments but did not include the remainder of the extremities.

Body parts were found in a variety of containers and wrappings, and the methodology suggested an above-average level of dissection skill and anatomic knowledge. For example, the neck was disarticulated between C7 and T1, and the torso between L2 and L3 with minimal damage to adjacent bone.

Tool mark analysis was consistent with use of at least two instrument classes: a saw and a sharp instrument such as a knife. The partially dissected head and neck was found in the refrigerator, incompletely submerged in brownish liquid in a large metal pot with lid. The color, texture and histologic appearance of the head and neck tissues were consistent with having been subjected to prolonged boiling. No other body parts demonstrated evidence of thermal injury; most were frozen.

The general autopsy findings included generalized atherosclerosis, (with an estimated 75% obstruction of the right coronary artery and 50% obstruction of the left anterior descending coronary artery), myocardial interstitial fibrosis, pulmonary emphysema, and post mortem autolysis/putrefaction. The scalp had been removed. Gross, microscopic, and radiologic examination of body parts revealed no definite evidence of antemortem trauma. Since the evidence that dismemberment was postmortem and a negative toxicology examination did not exclude foul play leading to death (particularly given other information discovered during the investigation) the cause and manner of death was listed as undetermined.

The primary focus of this presentation is on the appearance of the intracranial contents. There was no skull fracture. Removal of the cranial vault revealed numerous curd-like tissue fragments varying in color from gray to tan to dark brown, filling a very enlarged epidural space. Removal of this material from the epidural space exposed a dark brown structure with the shape of a miniaturized brain, firmly adherent to the base of the skull. The dura demonstrated two localized defects bridged by meningeal and cerebral vessels. Subsequent study revealed the epidural space to be filled with brain tissue admixed with a small amount of blood. A widely distributed, very thin layer of subdural blood was also present. Internal brain architecture was largely obliterated, having been replaced by intradural fragmented brain tissue and blood similar to that present in the epidural space but much more tightly packed.

This very unusual type of disarrangement of intracerebral contents has rarely been reported in the forensic literature, and, to our knowledge, has been described only in burned bodies. This case shares some features resulting from prolonged exposure of tissues to high temperature with the reported burn cases, but is devoid of burn artifacts such as skin splitting, scalp charring or heat-induced skull fractures which are typically seen in the latter. The open cervical canal in our case excludes global increased intracranial pressure as a contributing factor. Our observations, combined with information derived from a confession by the suspect, are more consistent with this unusual artifact being the consequence of a combination of factors that must be (but apparently rarely are) simultaneously present. These factors may include: a sufficient amount of moist heat (e.g., by immersion or by continued presence of cerebrospinal fluid) delivered over a sufficiently long period; disproportionate shrinking of dura mater relative to brain parenchyma; increased friability of dura mater and brain tissue secondary to thermal effects; relatively weak adhesion (focally or diffusely) between dura mater and inner table of skull; development of a dural defect which allows escape of brain tissue into the newly created epidural space resulting from tissue shrinkage; and variable appearance of the resultant epidural brain tissue depending not only on the degree of brain tissue thermal damage but also the nature of the dural defect (e.g., size, and whether or not it is bridged by vessels and/or meningeal tissue creating a sieve-like orifice through which the brain tissue must pass before entering the epidural space). This hypothesis, if correct, may explain both the low incidence and atypical appearance of this type of heat-induced postmortem artifact.

Dismemberment, CNS, Thermal Artifact

G67 Detection of Chemical Signals by the Parasitic Wasp *Microplitis Croceipes*

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The goals of this research project are to teach participants on the ability of insects to learn various chemicals of legal importance will be presented. We determined that the parasitoid wasp, *Microplitis Croceipes*, is an excellent candidate for the development of a biosensor for the detection of ultra-low levels of forensically important compounds.

Proposition: The wasp, *Microplitis croceipes*, can detect and learn various compounds of forensic importance at thresholds lower than that detectable by modern automated equipment.

Over the course of the past two years protocols for training the parasitoid wasp *M. croceipes* to learn and detect trace amounts of non-native chemicals have been developed. Behaviors associated with the detection of these odors, such as head bobbing, antennating, and complete rotation of their bodies over the source of the odor, have been identified.

Appetite can be used to teach wasps to learn and identify specific odors. Female wasps starved for 48 hours were provided 33% sugar-water solution on an approximately 2 mm² piece of filter paper immediately surrounded by 7-9 holes (each approximately 1 mm diameter) placed in an aluminum foil cover of a 3 cm plastic tube connected to a volatile collection chamber (containing the compound), a flow meter (18 ml per min flow rate), and a motor generating positive air flow. The wasps were allowed to feed on the sugar water for 10 seconds during three sessions, during which time they were also exposed to the chemical odor. Following these training sessions, it was determined that the wasps associate these odors with food and will enter a series of predictable behaviors attempting to locate a food resource when exposed to these compounds.

In order to determine level of learning and sensitivity, individual wasps were placed near a hole (1 mm diameter) in the center of a Teflon cap on a small glass cylinder. The compound was delivered to individuals using the system previously described, but at a much lower rate of 6-8 ml per minute. Percent response was recorded for various concentrations of each chemical examined. For a check, the trained wasps were exposed to air passed through a volatile collection chamber not containing the chemical. A positive response was defined as the wasp entering the hole or bobbing its head into the hole.

Results recorded for wasps trained to chemicals commonly used to train canines to locate human remains (i.e., putrescine and cadaverine) were investigated. To date, results recorded indicate that *M. croceipes* can detect concentrations of certain chemicals < 4 ppb, which are much lower than thresholds determined for a mechanical nose.

Current research is focusing on the development of a mass-training system for these wasps, as well as a system for housing the trained wasps, processing samples, and that signals investigators of a positive detection of a particular compound of interest. Additionally, the ability of *M. croceipes* to detect compounds released by explosives (i.e., 2,4 DNT, a major by-product released from landmines and other explosives), as well as narcotic metabolites, is being investigated.

Information gathered from this research may be used to develop biosensors utilizing the parasitic wasp *M. croceipes* to detect ultra-low concentrations of volatiles released from narcotics and explosives in airports or other locations deemed important. Additionally, such biosensors may be useful in locating human remains that have been buried for an extended period of time.

Associative Learning, Parasitoid, Biosensor

G68 Suicidal Air Rifle Wound of the Head

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The purpose of this paper is to report an unusual means of suicide and to increase awareness of the lethality of air-powered weapons.

Firearm deaths are extremely common in a busy medical examiner office. In 1999, the Dallas County Medical Examiner's Office (DCME) investigated 533 firearm deaths including 233 (44%) homicides, 283 (53%) suicides, 6 (1%) accidents and 9 (2%) undetermined causes of death. The majority of the firearms were handguns (75%), followed by shotguns (15%) and rifles (10%). Firearm injuries accounted for 283 (67%) of the 431 suicides investigated by the DCME in 1999. Though technically not firearms since they are powered by compressed air rather than gases produced by burning propellants, air guns and air rifles are capable of producing serious and, rarely, lethal gunshot wounds. A review of the computerized database of all cases investigated by the DCME from 1992 to the present revealed no previous deaths due to air weapons. The following is a case of a suicidal air rifle wound of the head.

A 33-year-old white male was discovered deceased by his mother on the living room floor of his locked apartment. Beside the body was a .177 caliber air rifle with an empty chamber. A mostly full, 250 count box of .177 caliber pellets was found in the same room. The mother had last spoken to her son by telephone the previous evening. The son had a medical history of hypertension and depression including two prior suicide attempts by drug overdose. He had recently been convicted of driving while intoxicated. Propranolol and Prilosec medications with recent prescription dates were found in the apartment. No suicide note was found.

Autopsy revealed a tiny round entrance wound in the left temple measuring approximately 1/16 inch in diameter surrounded by a thin rim of marginal abrasion. No muzzle abrasion was identified. No exit wound was present. Radiographs of the head revealed a single radiodense object in the right superolateral cranial cavity. Internal examination revealed perforation of the left temporalis muscle, the left squamous temporal bone, the left inferolateral parietal lobe, the body of the corpus callosum and penetration of the right parietal lobe. A tiny flattened lead pellet was recovered from the cerebral cortex of the right superior parietal lobe of the brain. The remainder of the autopsy examination was negative. Toxicology testing revealed 0.17% ethanol in postmortem femoral blood and 0.23% ethanol in vitreous fluid. The drug screen was negative.

The weapon was identified as a Benjamin and Sheridan Model 397PA Bolt Action Pump Air Rifle, a multi-stroke swinging-arm type of pneumatic airgun, manufactured by Crosman in August 2000. The ammunition was identified as Copperhead Model P177 (7.9 grain) Pointed Pellets. The advertised muzzle velocity for this air rifle is up to 800 fps (244 mps) which is comparable to the muzzle velocity of a .38 special handgun. Muzzle velocities of 150 fps and 200 fps are reportedly required to perforate skin and bone, respectively.

Review of the English literature since 1966 reveals several reports of air rifle and air gun injuries and fatalities. In fact, air weapons reportedly cause 30,000 injuries per year in the United States and are the main cause of ocular trauma and subsequent enucleation in children and young adults in Canada. Moreover, dozens of fatalities have been reported to the United States Consumer Product Safety Commission. Most of the reported injuries and deaths involve children with accidental penetrating wounds of the chest and head. Intracranial injuries are relatively rare and typically enter via the orbit, neck, the thin frontal bone of children or the squamous temporal bone of children and adults. Only two homicides and four suicides by air weapons have been previously reported. Three of the suicides and both homicides were the result of

intracranial injuries. This case report of a suicidal air rifle wound of the head again illustrates the commonly unrecognized lethal potential of air weapons.

Air Rifle, Suicide, Atypical Gunshot Wound

G69 Pediatric Injuries: Can CPR Related Injuries Mimic Inflicted Injuries?

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The goals of this presentation are to help attendees understand what types of injuries CPR can cause and be able to differentiate them from inflicted injuries.

Medical experts are often asked whether CPR rendered either by the caretaker or medical personnel could have caused the injuries present in a case of child abuse. This prompted us to undertake a retrospective review of the autopsy findings of all pediatric deaths involving children 2 1/2 years of age and under done in our forensic unit over a 13-year period (1989 to June, 2001). Both clinical and autopsy reports were utilized in order to examine patient demographics, clinical findings, duration of CPR, person/persons administering CPR, cause and manner of death. 234 children were included in this study out of which 173 of them received CPR. The average duration of CPR was 40 minutes with the range being 6 minutes to 259 minutes. 15 out of 173 children sustained minor injuries attributed solely to CPR. Despite the lengthy resuscitative attempts by those with varying skills and levels of performance, there was not a single rib fracture.

No significant injuries were found in our series apart from minor chest contusions. There was one case of retinal hemorrhage and another case of small hemorrhage in the orbital fat without any other evidence of injury that were attributed to CPR.

Our study emphasized that child abuse should be considered in the presence of multiple and major injuries even after a history of prolonged CPR.

CPR, Inflicted Injuries, Pediatric

G70 When "Non-Terminal" Is Fatal—Medical Examiner Cases of Fibromyalgia Fatalities

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The goal of this research project is to present medical examiner cases in which the decedents were young, female and had non-terminal illness as a primary diagnosis. The speaker will discuss the incidence and aspects of forensic pathology, investigation, psychology to assist in the future handling of similar cases nationwide.

The authors reviewed medical examiner cases with a history of Fibromyalgia (FM) for the 42 month period January 1998 through July 1, 2001. 17 cases were identified as containing enough historical and death scene detail for study. The mean age was 48, and all were female, though one decedent was undergoing gender change to male. Forty-seven percent were determined to be accidental deaths, nearly exclusively secondary to overdose with prescription medications dispensed to treat the symptoms of FM. Thirty-five per cent were classified as suicide. We found these cases to be complex, and required the utmost diligence in investigation by the medical examiner staff, toxicologists, and forensic pathologists. The high incidence of accidental and suicidal deaths, particularly by overdose of prescription medications, indicates that further study and education designed for the forensic community about chronic pain patients is necessary in obtaining the most

accurate cause and manner of death in future cases. Treating physicians may also benefit from additional education on the risks of polypharmacy and benefits of multidisciplinary pain management in this patient population.

Accidental Death, Fibromyalgia, Death Investigation

G71 Rapid Death From Phlegmonous Gastritis Associated With Lymphoma

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The goal of this research project is to make attendees aware of this rare pyogenic infection of the stomach and predisposing factors causing rapid death.

Acute phlegmonous gastritis is a serious illness, which fortunately is rare, with an estimated world incidence of 2.5 cases per year. It is a pyogenic infection of the stomach beginning as localized cellulitis which may either become a circumscribed abscess or a diffuse phlegmon. In 70% of cases hemolytic streptococci have been isolated. Other organisms including *E. coli*, staphylococcus, anthrax bacillus have been cultured in some cases. Alcoholism, chronic gastritis, debility, peptic ulcer, previous gastric surgery and hypoacidity of gastric secretions are considered as predisposing factors to the disease. Prompt diagnosis is essential in view of high mortality without therapy. The case is hereby reported to renew awareness of the condition as a cause of death and its possible occurrence in compromised hosts with malignancy or steroid therapy.

Case Report: A 61-year-old female reported to the emergency room of a local hospital one December evening with complaints of continuous vomiting since that morning accompanied by a fever of 105. Denied hematemesis or diarrhea. Had a history of rheumatoid arthritis and prednisone therapy. In the emergency room she had a temperature of 102.6, pulse 100 R 32 BP 120/70 mmHg. Abdomen examination was benign. Chest examination revealed tubular type breath sounds in the bases. Arthritic deformities were seen in hands. Otherwise, physical examination was unremarkable. Chest x-ray showed right base infiltrate. White blood count was 11,600 with 76% polymorphs and 20% bands. Initial impression was gastritis and basilar pneumonia and she was discharged on Tylenol, ampicillin and Compazine. No cultures were done. At home, she apparently spent a restless night and was found unresponsive the following morning. She could not be resuscitated and was pronounced dead by the paramedics.

Medical Examiner autopsy findings revealed (1) rheumatoid arthritic deformities, hands, (2) enlarged mesenteric lymph nodes with firm white cut surface confirmed microscopically to be lymphoma, (3) fatty changes in the liver, (4) diverticulosis, sigmoid colon, (5) cholelithiasis, (6) edematous stomach wall with gray-brown purulent material extruding from pyloric cut surface from between the muscularis and mucosa. Microscopically neutrophilic infiltration of muscle and mucosa was present with microabscess formation. Since the body was embalmed, no culture could be done but gram stain revealed gram positive cocci in chains consistent with streptococci.

Conclusion: One should have a high index of suspicion for this condition especially in a patient with high fever, epigastric pain, vomiting, normal amylase in the absence of radiologic findings of perforated viscus and presence of nondistensible stomach on Barium studies with low incidence of mucosal abnormality. Therapy would be vigorous broad spectrum antibiotic therapy to include a penicillin type drug and prompt laparotomy.

If only antrum is involved, resection can be done; otherwise, a total gastrectomy may be necessary. Mortality rate is high with medical therapy alone.

Phlegmon, Gastritis, Immunocompromised State

G72 Victim-Offender Relationship in Florida Medical Examiner District 8

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The goals of this research project are to establish the correlation between victim-offender relationship and motive, weapon choice, and number of injuries inflicted for 57 homicide cases from Florida Medical Examiner District 8, 1992-1996. Relationship categories are clearly differentiated and new motive categories are introduced. All variables are established independently.

The study of victim-offender relationship is a young field and has received limited assessment. Nevertheless, research in this area has been integral in broadening our understanding of the interplay between victim and perpetrator during the crime event. Previous research of homicide victim-offender relationship has focused mainly on demographic variables of the victim and the offender. In addition, studies of victim-offender relationship with regard to homicide motive have sought mostly to differentiate homicides occurring in conjunction with other felonies, usually between strangers, from all other homicides. Thus, default associations have been created between relationship and motive. Motives have traditionally been denoted as either expressive in nature (as an expression of emotion) or instrumental in nature (occurring for gain, usually financial gain). However, such severely delineated motive categories fail to acknowledge impetuses for homicide that contain both emotional and instrumental aspects such as revenge. This paper seeks to expand upon and clarify previous research in the area of homicide victim-offender relationship by clearly differentiating relationship categories, introducing new motive categories that alleviate deficiencies introduced by motives that are both expressive and instrumental, and defining relationship and motive independently from each other. In addition, this paper will address areas that have received little attention, i.e., the association between victim-offender relationship, weapon choice, and number of injuries inflicted.

Methods: Relationships are divided into primary and secondary categories. Primary relationships include intimates, relatives, and friends. Secondary relationships include acquaintances and strangers. Primary and secondary relationship categories are differentiated based on the level of emotional attachment and positive interaction established between victim and offender. Motives are denoted as dispute/conflict, revenge, and felony type (representing all homicides committed in conjunction with other felonies). Disputes/conflicts are further differentiated between those of a romantic nature and those not of a romantic nature. Weapons are differentiated between firearms and all other weapons, or a combination of the two. Number of injuries inflicted is either singular or multiple.

The sample of 57 homicide victims stems from 177 total homicide cases processed in Florida Medical Examiner District 8 between 1992 and 1996. All state-mandated executions, victims of motor vehicular homicides, child victims of homicide, victims killed during law enforcement activity, homicides ruled accidental in nature, homicides involving suspected mental illness on the part of the offender, and homicides for which some or all information is unknown are excluded from the study. Offender data were collected from the files of the Office of the State Attorney, Florida Judicial Circuit 8.

Results: Significant correlation exists between victim-offender relationship and homicide motive ($p < .0001$). Sixty-three percent of disputes and conflicts occurred between people in primary relationships, and felony type homicides occurred with ten times more frequency between individuals in secondary relationships than in primary relationships. Revenge killings occurred in much higher frequency in secondary relationships. Despite a default association between romantic disputes and primary relationships, no bias is introduced. When subsuming all romantic disputes into a general dispute/conflict category, correlations remain significant ($p = .0012$). In addition, when all romantic disputes are removed ($n = 47$), correlation occurs at the $p = .0375$ level. No correlation

is found between victim-offender relationship and either weapon choice or number of injuries inflicted ($p > .05$).

The new motive categories provide a clearer assessment of the variety of causes behind homicide while not introducing bias. In addition, all variables are determined independently, thus allowing for evaluation of the correlation between each of the variables without default associations. Further analysis of additional factors influencing weapon choice and number of injuries inflicted is needed to fully understand the interaction of these characteristics with victim-offender relationship.

Victim-Offender Relationship, Homicide, Victimology

G73 Medical Malpractice: A Case History Study by the Forensic Medicine Section From Bari

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The goal of this research project is to study the real entity of the medical malpractice phenomenon, the medical actions at risk and their incidence on the mortal event.

Legal actions arising from deaths derived from presumed malpractice and the autopsies arranged by the Judicial Authority, in cases of alleged of medical professional responsibility, are progressively increasing. This phenomenon reflects above all the distrust by the public for the medical community and towards public and private health care institutions. This feeling is amplified by the mass media which, seeking a larger audience, points out and emphatically chronicles single cases of real or presumed iatrogenic injury. In any event, the media are not disposed to reporting the ascertained cause of the danger. Moreover, the possibility of obtaining enormous compensation, increased above all by insurance, either by the single doctor or by the health offices, has decreased more and more the number of judicial proceedings often started on the basis of simple suspicion. On this basis, an important instrument to clarify the situation is surely represented by the autopsy. For this reason, highly qualified and experienced professionals who are able to point out the cause of death and to identify the possible wrong conduct and its exact consequences must carry out the autopsy. Only in this way is it possible to eliminate definitively any doubt about the doctor's action.

For the reasons reported above, it is easy to understand the utility of a study that verifies, with scientific precision, the real dimensions, characteristics and typology of the putative malpractice. To achieve this aim, we examined all data based on the single cases of autopsy occurring in the last decade in the Forensic Medicine Section of the Internal and Public Medicine Department of the University of Bari. We selected the malpractice cases and, among them, we identified the ones in which a death was attributed to a medical error. We differentiated them from the cases in which a death was not related to the medical conduct.

This work also permitted us to document the incidence of the malpractice and to identify the medical and surgical branches more frequently involved. We took into consideration the decade 1991–2000. In this period 2,123 autopsies were performed in our section and 364 of them involved cases in which the medical responsibility was implicated and for which a judicial proceeding was started. In this group we distinguished three different situations: 1) a medical error caused the death of the patient; 2) a medical error, by all accounts, was not directly attributed to the patient's disease or death; and 3) the medical conduct was correct.

In the sample concerning the 364 cases of presumed malpractice, females represented 48% and males, 52%.

A correlation between malpractice and patient death was demonstrated in 30% of the cases; conversely, the medical conduct was correct in 55% of the cases; the medical error could not be directly attributed to

the death of the patient in 15% of the cases. The cases of verified professional responsibility involved 84% of the public institutions, and for the remaining 16% private health care institutions. The highly specialized institutions involved were 31%. The remaining 69% were cases involving lesser-specialized institutions. The service occurred in a public hospital in 87% of the cases. Only 10% of the cases occurred during emergency situations and the 3% in public clinics. The surgical disciplines were involved in 52% of the cases; the medical ones in 41%; and, the anaesthesiology in the remaining 7%. Among these disciplines, obstetrics and gynaecology were involved in 16% of the cases; general surgery, in 14%; internal medicine, in 9%; orthopaedics, in 8%; first aid, 8%; anaesthesiology, in 7%; neurosurgery, in 5%; cardiology, in 4%; pediatrics, in 3%; ear, nose and throat medicine, in 2%; and, 24% in all other disciplines.

Another interesting aspect pointed out by our work is that the malpractice claim is not always linked to substandard conduct of a single doctor; in some cases, it was possible to notice and to distinguish other fundamental causes. These could be summarized as follows: 1) responsibility of the leading doctor in regard to the internal organization of the hospital stay department; 2) responsibility of the general director or of the medical director because one or both did not address in a timely and adequate manner the inefficiency, the insufficiency, the deficiency, of the defects of the institutions and/or the medical equipment; 3) responsibility of the local politicians and administrators connected to the institutions at the medical site and/or of medical equipment suitable and adequate for the population and the site.

The case history research must be considered to be partial, and, at the moment, in progress. In fact, we are aiming at a further, more intense investigation. It is a preliminary methodological approach to understand the malpractice phenomenon in Apulia where the current study has been limited to the autopsy case study of our Forensic Medicine Section.

Malpractice, Medical Error, Autopsies

G74 Nuclear and Mitochondrial DNA Analyses Following X- and Gamma-irradiation

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The goals of this research project are to determine if gamma- and/or x-irradiation adversely affect nuclear and/or mitochondrial DNA for identification purposes.

Identification of human remains is often accomplished by analysis of nuclear or mitochondrial DNA. Nuclear DNA (nDNA) allows a statistically more significant result while mitochondrial DNA (mtDNA) allows results in cases of advanced decomposition where nDNA identification is not possible. Because both methods, nDNA and mtDNA, are often used in cases of advanced decomposition, including skeletonization, the materials under study typically have been or require radiographic analysis for documentation, foreign body recognition/localization, skeletal assessment, and possible identification. Limited data are available regarding the effects of such ionizing radiation exposure on nDNA and mtDNA analysis.

In order to assess the effects of investigator applied ionizing radiation on DNA for identification purposes, 0.5 to 2.0 gram portions of vertebral body (from five co-mingled skeletal remains at 375 day post mortem interval), scalp hair (single living donor), and blood (single living donor),

were exposed to iridium 192 at 3 inches distance for 1 hour (7552r total) and 200 Kv at 4.5 ma x-irradiation at 7.5 inches distance for 2 minutes (7000r total). The exposed samples and matching non-exposed controls were subsequently analyzed by polymerase chain reaction (PCR) – short tandem repeat (STR) at 8 STR loci and amelogenin for nDNA and sex typing.

The fresh blood and hair samples gave consistent results at all eight loci by PCR-STR. The bone samples yielded positive results at up to two loci and positive amelogenin results. One vertebral body was analyzed for mtDNA at hypervariable regions I and II. Nine polymorphisms consistent between samples were identified in the control and x-irradiated specimens. The gamma-irradiated sample yielded no mtDNA results due to insufficient or excessively degraded mtDNA.

These results show that neither x- nor gamma-irradiation, in amounts typically employed in processing of skeletal remains, adversely affects nuclear or mitochondrial DNA for identification purposes.

Identification, DNA, Irradiation

G75 Recovery and Processing of Co-Mingled Remains Following Extended Submersion Period Facilitated by Computer Animation

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The goals of this research project are to utilize multi-disciplinary approach to successfully process co-mingled remains of multiple individuals while utilizing computer animation techniques and accident reconstructionists to allow for better lay understanding of the event.

The extrication of five sets of partially skeletonized human remains from the confines of the rear seat of a passenger vehicle is described. The case was highly emotionally charged and involved extensive press coverage and charges of racial bias.

Six young adults disappeared after last being seen at a nightclub in a rural area. Their whereabouts remained a mystery for five months until the vehicle was located in a local river. Due to the intense public interest and circumstances of the case, the unprocessed vehicle was placed on a flatbed truck and transported several hours away for examination.

On inspection, it was obvious that multiple sets of human remains were co-mingled in the back seat of the vehicle. These were accessed by removing the roof and block lifting proximate materials for evaluation.

The multi-disciplinary approach to this case included motor vehicle accident reconstructionists whose evaluation showed the car entered the water at a low rate of speed (<15 mph). In order to facilitate understanding of the dynamics of this crash, a computer animation of the event was created. The latter allowed interested laity to easily grasp the complexities of the crash and injuries related thereto.

The team approach allowed a rapid resolution to the case without incident, despite one lingering question – only five sets of remains were recovered.

Motor Vehicle Crash, Submersion, Recovery

G76 Comparison of Drug Concentration in Blowflies (Diptera: Calliphoridae) and Human Tissues

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The goal of this research project is to help participants understand the uses of forensic entomotoxicology.

The renewed interest in forensic entomology, as reflected by the great number of recent publications and increasing incorporation of entomological evidence into the routine forensic investigation, has caused us to reconsider one of the more interesting applications: entomotoxicology.

Insects feeding on a decomposing body will introduce various xenobiotics present in that body in their own tissues. For this reason, Diptera and Coleoptera can be proven to be a valuable source of toxicological information for a body in an advanced stage of decomposition, when fluids and tissues normally used for analyses are not longer present.

The significance of this approach was recently underlined by a case in which the insect larvae showed positive for secobarbital while muscle tissues tested negative. Although the use of insects as alternate specimens for toxicological analyses has been well documented, there are still areas for further research, in particular, in the relationship between concentrations of xenobiotics in insects and the human tissues and fluids.

The results presented here deal with three cases from the Institute of Legal Medicine, University of Milan, where there was an insect infestation of the body with suspected drug involvement and 16 rearings of insects from cadaver tissues where there was a known drug intoxication. After a preliminary toxicological screening of blood and urine with EMIT® and GC/MS, samples of all available organs and biological fluids were collected. Samples of liver were removed from each case and exposed to insect activity. Colonizing species were *Lucilia sericata* (Fabricius) (Diptera: Calliphoridae) and *Sarcophaga haemorrhoidalis* (Fallen) (Diptera: Sarcophagidae). Collections were made of 3rd instar and post-feeding 3rd instar larvae, and, in one instance, puparia was rearing of Diptera was also conducted on tissues from traumatic or natural death as controls.

Entomological samples from both cases having postmortem insect infestations and rearings from tissues control and known drug-related death were washed with deionized water and stored at -20°C. Additional samples were fixed in boiling water and preserved in 70% ETOH for species determinations.

Prior to toxicological analyses, larvae were again washed, dried, and homogenized with deionized water. Samples of humans organs were also homogenized. Drugs detections and quantifications were accomplished using GC/MS and ONLINE techniques (Roche©). In addition to opiates, cocaine, and/or benzoilecgonine and barbiturates, we were able to detect clomipramine, amitryptiline, nortryptiline, levomepromazine, tioridazine and methadone from both human tissues and the insects analyzed. All xenobiotics were detected in both feeding and postfeeding 3rd instar larvae. In two of the questioned cases, analyses of Diptera puparia and Coleoptera larvae were positive. Controls were all negative for all drugs involved. From the quantitative point of view, differences were noted between real cases and experimental rearings. All xenobiotics were more concentrated in the entomological specimens from experimental rearings than in those from the real cases.

In most instances, the concentrations of the drugs were lower in the postfeeding 3rd instar larvae than for the feeding 3rd instar larvae. Exceptions for this pattern were encountered in clomipramine and levomepromazine. Both these drugs were more concentrated in the postfeeding 3rd instar larvae. Additionally, while in most instances, drug concentrations were higher in liver tissues than in larvae, in four cases we encountered cocaine concentrations higher in the larvae than in liver tissues.

Our results confirm the reliability of entomotoxicological materials for the qualitative analyses of xenobiotics. Although additional case studies are indicated to further clarify quantitative aspects of entomotoxicology, it must be kept in mind that entomological materials are easy collectible, can be analyzed by unmodified routine techniques, and are free from contaminants due to putrefaction encountered in advanced stages of decomposition.

Forensic Entomology, Entomotoxicology, Blowflies

G77 Removing External Contamination of Maggots With a Bleach Solution Without Inhibiting Genetic Analysis of Maggot Crop Contents

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The goals of this research project are to understand (1) the procedure for dissecting a maggot and removing its crop for DNA analysis; (2) the effect washing maggots has on reducing the risk of external contamination; and (3) the effect washing maggots has on recovering vertebrate DNA from the maggot crop.

The type of corpse a maggot has been feeding on can be identified through mitochondrial DNA (mtDNA) analysis of the maggot crop contents. The crop is a diverticulum of the anterior end of the alimentary canal. Recently, Wells *et al.* identified several situations when this type of analysis would be useful in a forensic investigation (*J Forensic Sci* 46(3):685-687). DNA analysis could help investigators identify a missing victim if maggots are discovered at a suspected crime scene in the absence of a corpse. Maggot crop analysis could also provide a forensic entomologist with another way to associate a maggot with a victim when making a postmortem interval (PMI) estimation. If insect evidence is to be used for PMI estimation, it is assumed that the insect specimen's entire development took place on the victim. Maggot crop analysis could reveal that the maggot had moved onto the victim from a different nearby food source.

When amplifying mtDNA from a new source such as a maggot's crop, the forensic analyst must consider the risk of contamination. For maggot crop analysis, the analyst must be certain the recovered DNA is from the crop and not contaminant DNA from the maggot's exterior. In the case of identifying a missing victim, exterior contamination of human origin could lead to incorrect assumptions about the identity of the missing person. Exterior contamination would also interfere with making correct inferences about whether a maggot had been feeding on multiple food sources.

Removing external contamination could be accomplished through a simple washing of the maggot's exterior. The chosen wash method should reduce the amount of contaminant DNA located on the maggot's exterior, but should not interfere with the recovery of vertebrate DNA from the maggot's crop. In this study, we investigated the suitability of using a bleach solution to sterilize the external surface of a maggot prior to crop content analysis.

Soaking them in beef blood of a different genotype intentionally contaminated maggots raised on beef liver. A portion of these maggots was soaked overnight in a bleach solution. Before crop dissection, all maggots were briefly rinsed in water in order to recover a portion of any remaining outside contaminant. All maggots were dissected to remove the crop, which was then extracted. The water used to rinse each maggot was also extracted in order to detect whether the bleach wash had removed the external contaminant. A portion of cytochrome b was amplified from all extractions using newly developed primers designed to amplify most vertebrate DNA without amplifying insect DNA. Successful amplifications were sequenced using a PE-Biosystems (Foster City, CA) 310 genetic analyzer and BigDye Terminator® sequencing kit.

In all maggots, careful dissection of the crop led to the recovery of the food source DNA without any recovery of the external contaminant. Even maggots that were soaked in contaminant blood and not washed did not show any trace of the external DNA in the analyzed sequences from the crop. However, the maggots used in this study were well preserved and had large crops (6-8 mm in length). Further research is needed to assess the risk of contamination in maggots with near empty crops that have not been well preserved.

Soaking a maggot overnight in a bleach solution does not prevent the successful recovery of vertebrate DNA from the maggot crop. As previously mentioned, DNA from the food source was recovered from all of the analyzed maggot crops. The bleach wash appeared to have no effect on DNA recovery as all crop amplifications resulted in approximately the same quantity of amplified product.

Soaking a maggot overnight in a bleach solution does reduce the quantity of external contaminant. We were unable to recover contaminant DNA from the exterior of intentionally contaminated maggots that had been soaked in a bleach solution. This contaminant DNA was easily recovered from the exterior of intentionally contaminated maggots that had not been washed or washed only in water.

Our results demonstrate that a careful dissection process prevents contamination in maggot crop analysis even when dissecting heavily contaminated maggots. Also, soaking a maggot overnight in a bleach solution greatly reduces the quantity of external contaminant without compromising the ability to recover DNA from the maggot crop.

Forensic Entomology, Maggot Crop, Mitochondrial DNA

G78 The Child Abuse Works of Ambroise Tardieu...Had We Only Taken French

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The goals of this research project are to help participants realize the value of two enduring quotes: 1) "In fine, nothing is said now that has not been said before." (Terence, ancient Rome); and 2) "Those who ignore history are condemned to repeat it." (anon.). All of this will pertain to our so-called recent advances in the diagnosis of child abuse.

In the middle of an eleven-year review of child deaths investigated by the University of Tennessee, Memphis, Division of Forensic Pathology, an advanced literature search regarding the recorded history of forensic involvement in child abuse uncovered the humbling works of Ambroise Tardieu. This general practice physician was born 1818 in France, and rose in stature to become the Dean of the prestigious Faculté de Médecine de Paris. His name is familiar to forensic pathologists world wide by his anatomical tombstone "Tardieu spots." With the recent heightened interest in the phenomenon of child abuse evidenced by Caffey(1946) and Kempe (1962), and more recently, by the Shaken Baby Syndrome, it was a humbling discovery to review Tardieu's seminal work entitled "A Forensic Study on Abuses and Maltreatment Exercised on Children" published in the *Annales d' Hygiène Publique et de Médecine Légale* (1860, 13: 361-398). Often referenced by only one or two sentences in forensic texts, radiologists like Silverman and now Brogdon come closest to appreciating what most English-speaking pathologists will come to regret: that Tardieu's works have not become required reading during their fellowships.

This treatise reflected his involvement with 32 cases of child maltreatment over a 14 year time-span, 18 fatal (with 16 autopsies) and 14 non-fatal. Tardieu differentiated between abuse by neglect and abuse by violence; emphasized the importance of establishing patterns and chronology of abuse; recognized torture and identified causality between the shaking of a baby and nerve damage with or without cranial hemorrhage; alerted the medical community to the discrepancy between parental explanation of trauma and clinical tableau; recognized sexual abuse; understood the judicial ramifications of his role as medical examiner; stressed the sociological, cultural and demographic context of abuse; and optimized autopsy techniques in fatal abuse cases. Yet, not confined by his practice only to the dead, he readily addressed the emotional crippling of abuse victims. Tardieu's extraordinary vision at a time when clinical diagnosis was not technologically dependent (the x-ray had yet to be

discovered) is truly humbling. No doubt Tardieu was a man of great intellect imbued with the concept of forensics in service to the community, capable of aiding the living as well as advocating for the dead. His great success was due in no small part to the French legal system that was already deeply committed to the welfare of its children with a sophisticated acknowledgement and understanding of child abuse. Of no less importance was the social and cultural readiness to accept his actions and intent, serving as a catalyst to his medical abilities and inherent humanitarianism. Meanwhile in New York City (1874), eight year-old Mary Ellen Wilson remained tied to a bed, malnourished and beaten, until the cruelty to animal laws were applied to her situation.

One hundred years have passed and we have re-invented the wheel. Since Dr. Kempe coined the term "battered-child syndrome" in 1962, abuse has been defined as physical, emotional and sexual abuse and abuse by neglect. The definitions are now clear; the challenge is to be as involved within the home to the same extent as Dr. Tardieu.

Translations of his observations will be presented through photos from our recent cases. A more daunting challenge may be his other 1200-page work on toxicology.

Child Abuse, Forensics, Legal Medicine

G79 Coming of Age in Memphis... How Our Children Die

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This paper reviews the fatalities between birth and 18 years of age investigated by the Shelby County, Tennessee Medical Examiner from 1991 to 2001. The goals of this project are: 1) to identify trends in natural, accidental, homicidal, and suicidal deaths, 2) to examine the circumstances surrounding each to understand the surrounding cultural and social environment, 3) to evaluate the validity of forensic investigators linking age with the behavior defined parameters of childhood.

This study reviews 1,363 cases. Manner of death indicated 43% were natural; 33%, accidental; 19%, homicidal; and 5%, suicidal.

Half of the 586 natural deaths were diagnosed as Sudden Infant Death Syndrome (SIDS). Black babies (79 %) were more likely to be affected than white (20%), male (60%) more than female (40%). Non-SIDS natural deaths represented a diverse pathology.

Of the 448 accidental deaths 70% were traffic, and 30% non-traffic. Vehicular accidents were 70% automobile, 2% motorcycle, 2% train and 1% bicycle. Seventy-three pedestrians (23%) were struck by automobiles, and 6 by train. Only males were casualties of train, motorcycle and bicycle accidents, with a higher median age of 15 years for 10 whites and 12 years for 5 blacks. A difference also existed among pedestrians. Black children made up 70 % of all pedestrian deaths with a median age of 5, white 29% with a median age of 10. The 219 automobile accidents affected males (61%) more than females (39%). There was a significant contrast in gender following repartition within age intervals. From birth to 14 years, the difference between genders is nil, but skews significantly in the 15-18 year interval with 66% male and 34% female. This contrast reflects a change among individuals still legally defined as children, but who no longer behave as such. Of 148 casualties between 15 and 18 years, 38% were drivers and 61% passengers. Males predominate with 74% driving, 60% riding, and a balanced distribution in relation to ancestry (54% white, 46% black driving, evenly divided for passengers). Alcohol or drug use was not found in any case through the age of 15. But results in 18% of all vehicular deaths in the 16 to 18 year age group, (24% of white male, 24% of black male, and 4% of white female but no black female) were positive.

Of the 136 non-traffic accidental deaths, 25% resulted from drowning, 21% asphyxia, 15% fire-related, 11% poisoning, 10% gunshot

wound, 9% blunt trauma, 3% hanging and 2% hyperthermia. Drowning under the age of 2 takes place within the home with gender and ancestry ratios nearly equal. Drowning of older children occurred outside the home, mostly while unsupervised (70% male, 30% female: 83% black, 17% white). Asphyxia in 28 cases was linked to various mechanisms. Aspiration of gastric content, 13 cases, was the leading cause, followed by 10 instances of positional asphyxia, 4 of overlying and 1 post-surgical. The highest incidence of gastric aspiration peaked around 2 years of age and primarily affects black boys, 12 cases (92%). Positional asphyxia (median age 6 months) and overlying (median age 4 months) affected even young demographic groups. Racial distribution reveals a similar prevalence among blacks (71%). House fires resulting in burns or carbon monoxide inhalation victimized more blacks (81%) than whites (19%). Significant socio-economic unevenness between the various demographic segments may be reflected in these ratios. Poisoning (15 cases) was sorted out according to type. Chemical agents such as cleaning products were responsible for 3 deaths under the age of 2 years, 1 sniffing and 5 medication deaths between 2 and 15 years. Illicit drugs (MDMA, cocaine) overdose and sniffing affected 6 whites, (4 males and 2 females) between 16 and 18 years of age. Accidental gunshot wounds killed 12 males and 2 females, 10 blacks and 4 whites with a median age of 14 years. Accidental blunt trauma lead to the death of 12 children, 9 males and 3 females, 9 blacks and 3 whites; the median age was 2 years.

Death by suicide involved 75 children, gunshot wounds (83%) were the primary cause of death, followed by hanging (6%) and drug overdose (4%). Gender and ancestry showed 56 males (28 white, 25 black, 2 asian, 1 hispanic) and 19 females (14 white, 3 black and 2 hispanic). Although 2 were 12 years old, the greatest incidence of suicide was found at a median age of 17 years for gunshots, 16 for hanging and 18 for drug overdose. Circumstances surrounding suicides involved failing relationships, parental divorce, and/or family turmoil. Variation in incidence between genders, and among females suggests differential coping skills based upon gender, cultural and behavioral differences.

258 juvenile deaths were ruled homicide. Causes of death include 182 cases (70%) of gunshot wounds, 36 (14%) blunt trauma, 16 (6%) sharp force, 6 Shaken Baby Syndrome, 3 drowning, and 3 cases of maternal demise. It is imperative for any analysis of violent death to go beyond global statistical calculations. Overall, it appears that children are most often murdered by gunfire. However, taking into account age distribution, guns were used in 9 deaths (5%) in children under 10 years, all of them bystanders. By contrast, 173 (95%) homicides between 11 and 18 succumbed to gunshot wounds, with few bystanders. All gunshot wound victims under 10 years were black, with an even distribution between males and females. Older victims were predominantly black (94%) and male (95%). In many respects, circumstances leading to sharp force injuries were analogous to firearm deaths. Although the instrument of death varied, the demography did not. In contrast, while blunt trauma is responsible for only 14% of all juvenile homicides (36 cases); 86% (31 cases) of these occur under the age of 3. Whereas street violence and use of weapons kill the older, it is domestic violence using hands or instruments of convenience that kill the younger. These are children, acting like children, powerless as children, with a median age of 18 months, and a peak incidence at 2 years. From birth to 18 months, incidence among males (59%) was higher than among females (41%). The ratio, however, reversed in the interval between 18 month and 3 years (43% male and 57% female); blacks (81%) still remained more likely to be victimized than whites (19%). This latter distribution was found among the 6 cases of Shaken Baby Syndrome as well. Blunt trauma and Shaken Baby Syndrome can be taken as part of the same modality both in regard to circumstances and mechanisms of death. This conclusion is reflected in the frequent finding of both forms of injury in the same victim.

Although legally defined as children, analysis of how they die identifies behavioral differences within the first 18 years of life with a clear schism between youngsters who behave like children and those who assume adult conduct. Patterns of accidental, suicidal, and homicidal death

clearly reflect these behavioral differences. Realizing this difference is the first step to breaking down the concept of a homogeneous category of victims known as children. Focusing on specific age groups and their unique behaviors may provide the opportunity to design solutions to specific problem areas rather than emphasizing one solution for all.

Child Abuse, Homicide, Death

G80 Bruises in Infancy: How Many Are Too Many?

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The goal of this research project is to emphasize the rarity of accidental contusions in infants less than nine months of age.

Bruises may be noted on young infants as incidental findings during well-child exams or at autopsy. The presenter will review several recent studies indicating that accidental bruises of any sort are rare in the first eight months of life. Bruises of the face, trunk, and upper extremity are even less common.

In 1999 Sugar et al (1) reported the results of 973 children under 36 months who were examined during well-child visits. The presence, site, and number of bruises were recorded. Developmental stage, particularly the ability to walk along furniture ("cruising") or independently, was noted. Children with known medical conditions causing easy bruising and children in whom abuse was suspected for any reason were excluded from the study. Only 2 of 366 children under 6 months of age (0.6%) and 8 of 473 children under 9 months of age (1.7%) had any bruises. Bruises were noted in only 2.2% of children who were not yet cruising, but in 17.8% of cruisers and 51.9% of walkers. Bruises of abdomen, buttocks, hands and feet were rare in all age groups. Bruises of trunk, upper arm and face were extremely rare in non-cruisers.

In 2001 Labbe and Caouette (2) reported the results of 2,040 examinations of 1,467 children aged 0 to 17 years who were seen at well-child visit or in a hospital emergency department. Children seen in emergency departments were excluded if they had presented because of trauma. Children were also excluded from the study if they had a neurologic disorder which affected mobility, medical conditions causing easy bruising, were deemed "unstable" or were suspected of having been abused. The majority of children older than 9 months (76.6%) had at least 1 recent skin injury; predominantly bruises. In contrast, only 11.4% of infants 0 – 8 months had any skin lesions; these were predominantly scratches. Only 3 of 246 infants under 9 months of age (1.2%) had any bruises.

Two recent cases in our office illustrate the importance of investigating bruises.

Case 1: A 5-week-old infant was brought to his pediatrician's office with a complaint that he "fell off the couch." He had a hematoma on the pinna of his left ear and a subconjunctival hemorrhage of the right eye. No report was made to child protective services. Two months later, the child was brought to a local hospital in full cardiorespiratory arrest. History provided was that the child was being fed and burped and then became lifeless. He was briefly resuscitated, but died of multiple organ system failure. Postmortem examination revealed multiple subgaleal hemorrhages, thin film subdural and epidural hemorrhages, a torn corpus callosum, severe cerebral edema with tonsillar herniation, bilateral diffuse retinal hemorrhages with retinoschisis and diffuse subdural hemorrhage of the spinal cord. Bruising was seen externally over the right face and pinna, extending onto the right scalp. A similar distribution of bruising was seen on infrared examination on the other side of the face.

Case 2: A 3-month-old child was noted to have multiple bruises while being bathed by her grandmother. She appeared otherwise well. She was brought to the hospital for evaluation. Pattern bruises were found to the abdomen, upper arm, neck and face. Skeletal survey revealed 3 ages

of rib fractures, and a compression fracture of L2. None of these skeletal injuries was suspected on physical examination.

In conclusion, the presence of any bruises in a child who is not yet walking along furniture is concerning. Bruises in unusual sites, such as the abdomen, face or upper arm, should lead to a child protection referral to investigate the possibility of inflicted trauma.

Contusions, Child Abuse, Skin Pathology

G81 Child Abuse Autopsy Technique... What Works for Us

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The goals of this research project are to: 1) become familiar with the application of new autopsy techniques designed to enhance their ability to observe, record and present these findings, and 2) actual case studies will demonstrate how to perform these procedures.

Autopsies on victims of child abuse are more involved than most assault cases. The question of neglect, past physical abuses, torture, sexual abuse, instrumentality, timing or sequence of injury and dating of wounds is further complicated by the fact that children are not small adults. Growth and developmental processes from the epiphyseal plates in long bones, unfused sutures in cranial bones, degree of central nervous system myelination, susceptibility to certain forms of injury and basic considerations of size and weight are all differences requiring special or modified autopsy procedures. Over the years of autopsy service provided by the University of Tennessee, Memphis and the Regional Forensic Center, certain techniques have been employed to maximize the discovery, documentation, and demonstration of injuries. Some of these methods will be discussed using case based examples and include:

Epiluminescence is a dermatologist's aid utilizing the optical properties of oil applied to the skin surface to enhance the observation of injuries at or just below the epidermis.

Casting of the skin surface using elastomeric materials to preserve toolmark/bite mark impressions.

Angiography for the assessment of vascular patency and distribution. Post-mortem carotid catheterization and instillation of radio-opaque dye can be performed simply in the autopsy suite followed by standard x-ray views to record the vascular changes. Coronary angiographies may be performed *in situ* or *ex vivo* and x-rayed in any position.

Ocular Special procedures demonstrate retinal and optic nerve hemorrhages, *in situ* and by histology. Borrowing from eye donor protocols, circumferential incision of the limbus under suture traction allows gentle removal of the cornea followed by separate excision of the iris and lens. The vitreous is used to maintain the retina in place and utilize its optical properties to obtain clear photographs of the retina in place while maintaining the orientation of its landmarks. Hemorrhages and folds are readily demonstrated. Following this, the globe remnant is excised and retina and optic nerve removed for histological evaluation.

Skeletal assessment by physical examination techniques, radiographic protocols, anthropologic evaluation, histology and preservation as evidence. The rib cage is x-rayed using oblique views to enhance pre autopsy diagnostic accuracy. After thoracic evisceration, inspection and palpation are performed passively and under stress loading to identify well approximated and nearly bloodless fracture sites. The external surfaces are surgically freed to aid this. Injured ribs and those immediately adjacent are excised since occult fractures and green fractures are likely to escape any other method of detection. Fractures indicating any likelihood of age beyond immediately prior to death may be sectioned in part for histological dating with correlation by anthropological methods. All excised bone is processed for evidentiary retention by mild digestive techniques.

Wound dating or sequencing techniques correlate histological appearances with chronology or clinical history. The process of inflammation and repair is a phenomenon that proceeds along a well defined pathway, but progresses at a rate affected by its circulation, any interference with that blood supply, episodes of pre-existent shock, magnitude of the injury and area of injury examined and effects of decomposition.

Bronchoscopy evaluation of the airway in fire, asthma and pneumonia deaths. Persons receiving an endotracheal tube as a result of medical intervention prior to death are very amenable to bronchoscopic examination utilizing the lumen of the tube. Greater skill is required to examine the patient in rigor without a tube. Asthma patients show typical mucus plug formation; gastric aspiration is accompanied by a rapid onset mucosal erythema and pneumonia patients frequently exhibit purulent material. Smoke inhalation is easily diagnosed by the presence of soot deposits, while those dead before the fire have none.

Organ and tissue donor programs take precedence over medical examiner jurisdiction in Tennessee. As a result of good cooperation and mutual support of activities, no forensic autopsy has been compromised and tissue recovery has soared. The actual practice involves both parties, acting together in concert or sequentially to identify injuries prior to harvest and preservation of those areas of forensic interest. An exchange of pathology reports between donor agencies and the medical examiner completes the pathologic examination by our office while the donor agency determines suitability for transplant based in part upon our reports.

With these tools, the ability to record, describe and present injuries effectively is enhanced before families, attorneys and juries alike. Additionally, opposing experts get to review higher quality material that is less ambiguous.

Child Abuse, Autopsy, Organ Donor

H1 Falls From Cliffs: Reconstructing Individual Death Histories From a Perimortem Fracture Pattern

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The attendee will become familiar with a diagnostic pattern of fractures associated with feet-first falls from heights. This poster has four objectives: (1) to present three unusual cases in which skeletonized human remains were found at the bases of cliffs; (2) to display the observed perimortem fractures in these cases and discuss the reconstruction of impact sequence from these fractures; (3) to suggest a diagnostic "suite of fractures" consistent with these vertical impacts; and (4) to approximate the impact velocities experienced by the victims in these cases.

In the following cases, skeletonized human remains were recovered from remote areas and submitted to the anthropologists. A primary goal of the skeletal analyses was to assess the perimortem fractures in order to reconstruct the individual death histories. The observed patterns of blunt trauma were consistent with known vertical deceleration injuries. Therefore, the likely etiology of the traumata in each of these cases was an impact following a fall from a cliff.

Case 1: In July of 1993, the skeletonized remains of an adult male were recovered by the FBI from the base of a bluff in the village of San Carlos, AZ. This bluff was estimated to be approximately 60 feet high. Extensive perimortem fractures were observed in the areas of the ankle, knee, pelvis, chest, elbow, and shoulder. The death was believed to be accidental.

Case 2: In November of 1993, while in the Superstition Mountains just north of Phoenix, AZ, hikers discovered the skeletonized remains of an adult female lying face down beside the trail at the base of an escarpment that was estimated to be 100 feet high. Because of the remoteness of the area, the Pinal County Sheriff's Office employed the police helicopter in the recovery. The most striking aspect of these incomplete remains was the presence of numerous perimortem fractures in the areas of the foot, ankle, knee, pelvis, chest, and shoulder. The death was considered an accident.

Case 3: In October of 1993, the partial skeleton of an adult male was recovered from the ledge of a cliff in a remote part of the Waihee Valley on the island of Maui. The skeletal remains were submitted to the Army Central Identification Laboratory. The cliff was 2,300 feet high and the ledge where the remains were discovered was approximately 1,700 feet high. The total distance of the fall was estimated to be 600 feet. Perimortem fractures were displayed in the regions of the knee, pelvis, thorax, and head. The death was ruled a suicide.

By analyzing the perimortem fractures in each of these cases, it was possible to reconstruct the impact sequence including how the victim landed and which leg took most of the impact. The pattern of fracturing suggested that all three individuals impacted feet first, as evidenced by the numerous compression fractures displayed in the ankle, knee and hip. The leg that received the most vertical force exhibited a greater amount of fracturing in these areas. This distinctive pattern of fracturing was predictably different than the pattern displayed by the other leg.

Furthermore, a primary "suite of fractures" consistent with feet-first falls from heights was identified from these cases. This suite included the following: a fracture of the talus referred to as "aviator's astragalus," a "pilon fracture" of the distal tibia, a "plateau fracture" of the proximal tibia

and fibula, subtrochanteric spiral fracture of the femoral shaft and a complete fracture of the femoral neck, a T-fracture of the acetabulum coined the "exploding acetabulum," a transverse compression fracture of the sacrum, and a compression fracture of a vertebral body.

A secondary suite of fractures observed in these cases provided evidence of the side of the body to which the victim fell after initially impacting feet-first. This suite included transverse fractures of the ulna, an oblique fracture of the medial humeral condyle, a Hill-Sachs fracture of the proximal humerus, numerous rib fractures, and fractures in the cranium and mandible.

Finally, the severity of fracturing displayed by these skeletal remains can be attributed to the heights of the cliffs, which were estimated to be 60, 100, and 600 feet high. The maximum velocities of the victims at impact were approximately 42, 55, and 134 miles per hour, respectively. Biomechanically, these are considered high-speed accident scenarios.

Falls From Heights, Fracture Patterns, Impact Sequence

H2 A Semi-Circular Argument: Patterned Injuries Explained by an Unusually Large Murder Weapon and Its Method of Use

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The goal of this research project is to present a homicide case where patterned injuries were produced by a very large weapon that was used in an atypical manner.

While patterned injuries and homicidal deaths due to blunt-force trauma are neither rare nor unusual, a case is presented where the murder weapon left patterned injuries that would later be explained by its seemingly unwieldy size and the unusual manner in which it was utilized. This poster chronicles a case from March 2001 where the victim suffered blunt-force trauma to the head and face from an assailant who utilized an unusually long piece of metal pipe as a murder weapon. The man who was a known transient in the Spokane, WA area, was found lying under a freeway overpass where acquaintances of the victim said he usually slept. The victim was discovered severely beaten but still alive in the early morning hours by some passers-by only moments after the attack. He died minutes before paramedics arrived at the scene. He had been struck in the head and face multiple times with a blunt object. It appeared that the victim had been attacked while he lay sleeping, as he was found lying on a makeshift bed of flattened cardboard boxes, and his body and face were covered with blankets. One of the blankets recovered at the scene, which was covering the decedent's face, displayed semi-circular cut patterns, suggesting to police that a piece of pipe had been used in the attack, though none was found at the scene.

At autopsy, arced and semi-circular patterned injuries sustained by the victim further substantiated the suspicion that the weapon might have been a piece of pipe. These injuries were similar in appearance to the defects noted on the blanket recovered at the scene. One well-defined, semi-circular injury was apparent on the left cheek. If this semi-circular injury were completed into a circle, it would have formed a circle with a diameter of two inches.

Several days later, police discovered an approximately seven-foot long, two-inch diameter piece of pipe commonly used in the construction of cyclone or chain-link fencing. This was found approximately one city block east of the murder scene. Apparently, prior to the commission of the crime, the pipe had been removed from a temporary fencing barricade surrounding a construction site that was located a short distance away from

the murder scene. This pipe contained traces of blood and tissue, both of which matched that of the decedent. Thus, this was determined to be the murder weapon.

In light of the fact that the pipe was too long and awkward to be swung back-and-forth, effectively clubbing the victim to death, it was surmised that it had to have been held with both hands by the assailant in front of his body in a vertical orientation, and used in an up-and-down plunging motion. This helped to explain the patterned injuries observed on the decedent and the defects to the blanket. As the end of the pipe was coming into contact with the victim, the curved and semi-circular patterning resulted rather than flat defects that would have resulted from impacts from the side of the pipe.

Homicide Investigation, Patterned Injuries, Blunt-Force Trauma

H3 Hyperextension Trauma of Upper Cervical Vertebrae

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The participant will become familiar with an unusual upper cervical fracture and the possible circumstances that could have caused the damage observed.

This poster has three objectives: (1) to present a case involving upper cervical fractures in an individual who was found dead in a park with no ready mechanism to explain the trauma, (2) to provide a scenario that could explain the mechanism causing the fractures observed, and (3) to illustrate the importance of an interdisciplinary approach to autopsies, including the forensic pathologist, neuropathologist, and anthropologist and a scene visit, to accurately interpret the trauma.

Case History: On the morning of March 25, 2001, a yet to be identified white man was found face down and unconscious in a park on 108th Street and 51st Avenue in Queens, NY by a passerby who called EMS. EMS responded to find the man in cardiac arrest. Advanced Cardiac Life Support was initiated and he was transported to a nearby hospital where he was subsequently pronounced dead. The scene detectives or emergency department staff noted no visible injury or trauma. The decedent was identified as a 58-year-old man who was known to drink approximately 5 to 6 'large' beers a day. According to his roommates, the decedent usually returned home every evening; however, on the morning before the above stated date, the decedent left his residence but did not return.

Autopsy and Neuropathology Examination: There was a 1" abrasion above the lateral aspect of the left knee and two small superficial abrasions below the left knee. A 1 1/3" laceration without surrounding contusion was located over the right posterior parietal scalp. There was a 1/2" x 3/16" superficial abrasion at the vertex, with a small underlying patch of subscalpular hemorrhage. A 1 1/2" x 1 1/4" circular patch of scalpular and subscalpular hemorrhage was in the left occipital region. There was slight to moderate hemorrhage of the anterior paraspinous muscles in the region of the high cervical vertebrae. There were no hemorrhages in the muscles of the posterior neck. Four fractures were noted in the first cervical vertebra (atlas), and the odontoid process was detached from the second cervical vertebra. There was moderate posterior paraspinous soft tissue hemorrhage (right greater than left). There were no skull fractures, and there was no intracranial, subdural or epidural hemorrhage. The remainder of the autopsy described no injury of the trunk or thoracic and abdominal viscera. The subclavian blood alcohol concentration was 0.29 g%.

The cervical and upper thoracic spinal cord as well as the brain were fixed in formalin for further examination. The brain had no recent trauma. The spinal cord, from the upper cervical to thoracic levels, had focal epidural hemorrhage of the dorsal rostral one third of the cervical cord.

Anthropology Examination: The first cervical vertebra as well as the odontoid process of the second cervical vertebra were removed during autopsy and submitted to anthropology for fracture analysis. The specimens were cleaned of soft tissue. The first cervical vertebra was fractured in five locations: (A) There was a fracture to the posterior edge of the left superior articular facet from the occipital condyle. This fracture is consistent with being crushed from the occipital condyle rocking forcefully back onto the facet during hyperextension. (B) There was a wedge fracture at the midline of the anterior arch, with the wedge being displaced superiorly. Anterior arch fractures can be produced by hyperextension when the arch of C1 abuts the dens of C2, because the atlantoaxial joint is fixed. (C) The posterior arch was fractured in three places, at midline and on the right and left sides of the arch where it joins the lateral masses. These fractures are consistent with injuries usually seen with hyperextension of the head and neck. The posterior portion of C1 is compressed between the occipital and the arch/spinous process of C2. The dens, or odontoid process of C2 was fractured at the isthmus, or waist, posteriorly. Posterior displacement of the dens is consistent with hyperextension and displacement of C1 posteriorly.

The fractures of C1 and C2 are consistent with hyperextension of the head and neck, forcing the occipital condyle down onto the superior facet of C1, lifting the anterior arch of C1 up against the dens and fracturing the arch and the dens posteriorly, while forcing the posterior arch of C1 down onto C2 and fracturing the posterior arch of C1. These findings also are consistent with the anterior cervical hemorrhage found during autopsy.

Scene Investigation: For a more accurate interpretation of the positioning of the victim, the Medical Examiner was escorted back to the location where the decedent was found. The small neighborhood park is well maintained with many park benches and small sections with vegetation. The areas of vegetation are sectioned off with wooden beams; perpendicular to the wooden beams are multiple curved segments of metal bars to create a fence-type border/barrier. The metal bars vary in height, with the highest approximately 12-14" off the ground. The decedent was found face down with his head near a tree and the lower part of his lower extremities draped over the fence. The fence was lightly painted white and has a chalky, white-washed appearance. There was faint, chalky white material found on the lower part of the back of the hood, above where the hood meets the neck of the jacket. There were also smudges of black material on the back left side of the jacket. White chalky material was also noted on the right upper back. From the description of the scene, the decedent's high blood alcohol concentration, the patterns found on the jacket and the extent of the hyperextension injuries, the most likely reconstruction of events is that the man fell backwards and hit the back of his neck along the fence causing the extreme hyperextension trauma and scalpular abrasion and contusions.

Hyperextension, Cervical Vertebrae, Neuropathology

H4 Can Sharp Force Trauma to Bone Be Recognized After Fire Modification? An Experiment Using *Odocoileus virginianus* (White-Tailed Deer) Ribs

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The goals of this research project are to: 1) define and illustrate morphological characteristics associated with sharp force trauma on White-Tailed Deer ribs, and examine the preservation of such features following exposure to intense heat; 2) offer criteria for differentiating between postmortem heat alterations and perimortem trauma on bone; and

3) reaffirm the benefits of proper recovery and curation protocols concerning fire-modified bone.

During the course of their analyses, forensic anthropologists routinely face the task of identifying and interpreting taphonomic events surrounding the death of an individual. At times they are called upon to analyze remains that have been modified by fire. Fire modification of bone can obviously hinder the analysis of the remains. Trauma analysis in particular is often rendered more difficult. Diagnostic characteristics of perimortem trauma can become obscured or even destroyed by fire-related changes in bone morphology. These changes also make it difficult to distinguish perimortem from postmortem trauma. Although this is a common conundrum faced by forensic anthropologists, research on the topic is limited and has only recently been investigated.

All categories of trauma to bone have the potential to become obscured by fire modification; however, this poster will focus primarily on sharp force trauma (SFT). Sharp force trauma is often characterized by subtle marks left on the bone that even experienced analysts may have difficulty identifying. If postmortem destruction of the bone occurs, then those subtleties are even more likely to remain undiscovered.

Using both experimental data as well as case studies, the characteristics of sharp force wounds such as up-curling, notching, shaving, puncture marks, cutmarks, and linear incisions that sever the bone, are defined and illustrated. An experimental model for testing the preservation of these perimortem sharp force wound characteristics after exposure to fire was designed and implemented using *Odocoileus virginianus* (White-Tailed Deer) ribs. Grossly, *Odocoileus virginianus* ribs are similar in size and morphology to human ribs, and therefore represent a valid model for anthropological research. In an effort to inflict a variety of SFT types, the torso of a recently deceased (PMI of 1 to 2 days) adult deer was stabbed multiple times at a variety of angles with a large, sharp, non-serrated kitchen knife. Each of the affected ribs exhibiting SFT defects was then dissected out of the torso, and adhering soft tissue was removed manually. The traumatic lesions were comprehensively described and thoroughly documented using digital photography. Next, the ribs were burned in semi-controlled, outdoor wood fires. The fire was ignited in a shallow pit, the floor of which was comprised of a sandy soil. Small dry sticks fueled the fires; the ribs were laid on top of a small bed of sticks and additional sticks were occasionally added on top of the bone as the fuel was consumed. Firewood was added until the bone was partially calcined, a process which typically required approximately 30 minutes. The remains were then carefully removed from the fire pit, and observations made concerning the survival and possible modified SFT wound characteristics. Taphonomic observations concerning the overall condition of the bone after burning (i.e., warpage, fracturing, discoloration, etc.) will be presented.

Diagnostic perimortem SFT characteristics were found to remain visible after being subjected to an intense fire. Relatively shallow cutmarks, for example, persist even on the calcined cortical surfaces and can be differentiated (both macroscopically and under low-power magnification) from transverse and longitudinal fractures created during the burning process. Cutmarks are characterized by V-shaped cross sections with the occasional uplifting of a thin layer of cortical bone adjacent to the groove. Whereas fractures created by heat alteration are characterized by jagged, more irregular defect walls.

In some instances the trauma was completely destroyed, while in other cases it was obscured and only became visible following careful laboratory reconstruction of the bone remains. For example, wounds that completely transect the bone or result in the significant removal of bone (such as shaving or notching type events), are often subject to further separation and fragmentation during the course of the burning process. This may be due to the fact that the biomechanical integrity of the bone has been compromised and fractures are more easily propagated at those locations.

In order to preserve the potential evidence of this nature, it is necessary that careful recovery, documentation and curation techniques be

employed. When remains are extremely fragmentary, the bone (and any additional evidence) should be collected from smaller subunits within each unit. For example, a traditional 1 by 1 meter unit can be demarcated into 10cm by 10cm units. This enables more exact provenience data to be collected for each fragment and thus facilitates subsequent conjoining efforts.

It is imperative that proper handling protocols are followed to ensure that further damage does not occur. In some cases it may be appropriate to apply a consolidation agent (i.e., water diluted polyvinyl acetate) before attempting to move the remains. Additionally, remains must be properly packaged for transportation. This may involve wrapping individual bones in paper or foam and placing them in boxes or rigid containers. While this will take additional time in the field, it will greatly reduce the chance of losing or destroying small fragments that may contain evidence of trauma.

This study suggests that evidence of sharp force trauma experimentally created on deer ribs can be preserved after exposure to fire. However, evidence of these wounds are extremely transient and are easily destroyed or overlooked if proper documentation, recovery and curation efforts are not undertaken.

Taphonomy, Sharp-Force Trauma, Forensic Archaeology

H5 A Comparison of the Cranial Wounding Effects of .22 and .38 Caliber Bullets

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The goals of this research project are to recognize variation in the cranial wounding effects of .22 and .38 bullets from contact and/or close contact shots.

This presentation compares the cranial wounds created by .22 and .38 caliber bullets by examining the size of the entrance defect and the fracture types located on the cranium of suicide victims. Thirty calottes exhibiting gunshot trauma were obtained for analysis from the William F. McCormick skeletal collection located at the University of Tennessee. The sample consisted of eleven .22s and sixteen .38s. In order to be considered for this study, the entrance wound along with an overall image of the fracture pattern must have been observable from the calotte alone. In addition, because distance of shot and location of the entry are factors known to affect wound formation, only subjects who committed suicide with the bullet entering along or near the squamosal suture (that is, on the temporal bone above the zygomatic process, on the parietal bone inferior to the temporal line, or on the sphenoid) were used in this study.

An ANOVA procedure found a strong correlation between caliber and minimum diameter of the entrance defect ($F=37.96$; $p<.0001$). The mean minimum diameter of entrance wounds created by a .22 caliber bullet was 6.57, while the mean for .38 caliber bullets was 12.49. The strong correlation between caliber and minimum entrance diameter agrees with the findings of Berryman et al. (1995) and Ross (1996) who also found that larger caliber bullets create larger entrance wounds. This study is unique in that distance of shot and location of entrance wound were held as a constant.

Fractures present on the thirty calottes were examined and categorized as primary, secondary, or tertiary, according to the criteria described by Smith et al. (1987). Calottes were considered to exhibit primary fractures if there was an entrance defect and no linear fractures. Secondary fractures were those where an entrance wound was present, in addition to at least one linear fracture that either radiated from the entrance wound or was present at some other location. The tertiary fracture category consisted of calottes that exhibited an entrance wound, radiating linear fractures, and horizontal fractures that connect and intersect the radiating fractures.

Using a greater chi-squared statistic, it is possible to obtain the maximum probability of each caliber creating each of the fracture types in an effort to discover differences in the fracture formation of .22 and .38

caliber bullets. The results show that given a cranium shot at contact/close contact range that exhibits a primary fracture on or near the squamosal suture, the maximum probability that a .22 could create the wound is 0.14, while the maximum probability that a .38 could create the wound is 0.10. Given a cranium that exhibits secondary fractures, the maximum probability that a .22 created the wound is 0.99, and 0.95 for .38 calibers. A major difference between the wounding effects of .22 and .38 caliber bullets is observed when considering the presence of tertiary fractures. If tertiary fractures are present on a skull, the maximum probability that a .22 created the wound is 0.23 while the maximum probability that a .38 created the wound is 0.87.

This study reinforces past research on the correlation between caliber and size of entrance wound and also examines the effects of caliber on fracture type to aid the forensic anthropologist with the interpretation of cranial gunshot trauma.

Forensic Anthropology, Terminal Ballistics, Cranial Gunshot Trauma

H6 Forensic Anthropology and Fire Investigation: Learning About Burning Using Non-Human Models

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By attending this poster presentation, the participant should expect to learn: 1) the value of collaborative research with investigators; 2) about the challenges involved in identifying trauma on burned remains; and 3) the importance of reconstructing burned bone for interpretation of perimortem versus fire-related trauma.

Training courses involving forensic anthropologists and investigators provide an opportunity for exploring issues regarding fire-related death scenes. As it is not uncommon for arson to be used to conceal evidence of a homicide, the close examination of the death scene becomes increasingly important. Fire and death scene investigators are often responsible for the recovery and collection of evidence, although many are not trained in recognizing calcined and highly fragmented remains. Contextual information is lost when burned elements are disturbed at the scene, information which often cannot be later recovered. Poor recovery methods and documentation also hinder attempts at personal identification. For example, fragmentary elements missed during recovery may prevent the accurate determination of sex, age, ancestry, stature, and trauma.

While the forensic anthropologist can offer assistance at the fire scene, many only become involved after the skeletal elements and/or calcined bones are collected by investigators. Limited financial resources, personnel availability, and a lack of experience with forensic anthropologists have been cited as reasons for the non-involvement of anthropologists at the initial stages of the investigation. Fire training exercises can provide an opportunity for investigators to observe the effects of fire to non-human carcasses, and to aid investigators in the recognition of highly fragmented and calcined skeletal elements. Additionally, anthropologists can use these exercises as an opportunity to perform experimental research to aid in understanding the effects of fire to human remains.

This study reports on two pigs (*Sus scrofa*) that were burned in a single-story structure fire as part of a fire-fighting training exercise in Northern California. A forensic anthropologist and graduate students from CSU Chico provided the pig carcasses to simulate intact human bodies. Fire-fighters, fire scene investigators, and law enforcement personnel participated in various aspects of the training exercise. Because experimental research on burned bodies is logistically difficult, this exercise served as a means to study whether evidence of perimortem trauma would survive a

thermal event.

Pig #1 was placed on a couch in a room toward the back of the structure. Similarly, Pig #2 was placed on a bed in a front room of the structure. Both pigs were struck several times (prior to the fire) using an ax, a machete, and a knife. The structure was then set afire with the aid of accelerants and was allowed to burn for approximately 25 minutes before being put out by firefighters. The pigs were externally examined for fire damage by participants, and then were recovered from the burned structure using standard archaeological techniques.

The burned carcasses were bagged separately and delivered to the CSU Chico Physical Anthropology Human Identification Laboratory (PAHIL) for analysis. Each carcass was defleshed of soft tissue and all skeletal elements were examined for signs of trauma. Mikrosil™ forensic casting material was used to make impressions of potential trauma sites. Gross morphology and microscopic analyses were used to categorize trauma as being perimortem or from fire-induced checking.

Pig #1 exhibited signs of sharp-force trauma at the left occipital condyle, the inferior portion of both left and right mandibular bodies, the costal groove of a left rib, on four unisided rib fragments, and on an unidentified bone fragment. Suspicious sharp-force trauma sites on pig #2 were observed on the right femoral midshaft, right innominate, and on the inferior body of the right mandible. Additionally, an unisided rib exhibited a typical butterfly fracture, while the right petrosal portion of the temporal bone showed signs of fracture. The majority of these injuries occurred to unburned bone or portions of bone that were protected by adjacent soft tissue. Some abnormal burn patterns were observed in areas affected by trauma, most likely due to direct exposure of bone to the fire. This preliminary study shows that in instances where remains are incompletely burned, trauma can often be easily identified on non-burned portions of bone. Although many fires are unsuccessful in destroying evidence of a homicide, injuries to heavily charred and calcined portions are generally the most difficult to identify and reconstruct.

Since 1997, TAM (author #2) has accepted seven cases involving burned human remains at the PAHIL. Vehicular fires accounted for four of these cases, with only one representing a house fire. Additional cases involved an individual found in an unusual burned out residence (a redwood tree stump), and one cremains case involving several commingled individuals. With the exception of the cremains case, all involved suspicious circumstances surrounding the death scene. In only three instances did forensic anthropologists participate in the recovery, and only after investigators processed the initial scene.

These case studies will be used to address the limitations of osteological analyses in instances where remains were disturbed or incompletely recovered from the scene. The challenges of reconstructing evidence of trauma in calcined remains is further addressed using these examples.

Fire training exercises are one method in which anthropologists and investigators can work together to understand the effects of fire to human remains. These exercises open further opportunities for experimental taphonomic research involving the alteration and destruction of bone in a fire. Preliminary research from this study and from the presented case studies indicates that trauma can often be identified and reconstructed in charred and calcined bone.

Anthropology, Fire Deaths, Sharp-Force Trauma

H7 The Effects of Temperature on the Decomposition Rate of Human Remains

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The goals of this research project are to test the success of a new method of estimating the postmortem interval from decomposing human remains using accumulated degree-days and a quantified, point system approach of scoring decomposition.

Forensic anthropologists are frequently called upon to assist in the recovery and analysis of recently dead individuals. Estimating the post-mortem interval, or PMI, is an important part of a forensic anthropologist's job. The PMI is important for a number of reasons. Estimating the PMI can narrow down the potential pool of missing persons and ultimately help identify the remains. The PMI can help with interpreting the scene. Knowing approximately how long remains have been *in situ* can help establish a timeline of other events that may have affected the remains.

There are many methods from the disciplines of botany, entomology, and biochemistry to estimate the PMI, but the decay and decomposition of soft tissues is perhaps the most used body of data by forensic anthropologists for estimating the PMI. Forensic anthropologists rely on a general knowledge of the decompositional process as well as experience with decomposing human remains in their specific geographic region to estimate the PMI. Qualitative "stages" of decomposition generally correspond to the PMI and have served as a guide for most PMI estimates made by forensic anthropologists. Forensic anthropology could benefit from applying quantitative methods to the study of decomposition to understand the relationship between decomposition, temperature, and the PMI.

Forensic entomologists use insects attracted to decomposing remains to determine the time since death. Fly larvae (maggots) associated with decomposing remains grow and develop in increments or "instars." Maggot development is almost entirely dependent on ambient air temperature. Accumulated degree-days (ADD) and accumulated degree-hours (ADH) are heat unit values calculated from ambient air temperatures. Forensic entomologists use ADD and ADH to measure the energy requirements of developing maggots. Could forensic anthropologists use ADD to measure the energy requirements needed to propel decomposition? Do quantified stages of decomposition correlate with ADD? Is this method a reliable alternative to qualitative assessments of decomposition? Alternatively, is it possible to quantify soft tissue decomposition in a fashion that would allow for better estimates of PMI without going through the process of calculating ADD? The results of this research will enable forensic anthropologists to supplement current strategies of estimating the PMI with a new method utilizing a quantitative approach to soft tissue decomposition.

From March until June of 2001, the author selected human remains cases to be used in this study from the case files of Dr. Stephen Nawrocki, a forensic anthropologist at the University of Indianapolis, and from the case files of Dr. Neal Haskell, a forensic entomologist at St. Joseph's College in Rensselaer, IN. Seventy-two human remains cases were selected for this study. Cases were selected based on number of criteria such as no burned, buried, or submerged remains were used and all remains were complete with no missing body parts. All cases had a known PMI. Other variables analyzed in this study included month of death, average temperature throughout the entire postmortem period, latitude in which the remains were recovered, and details of the recovery site such as sun exposure.

All cases used in this study had adequate photographs of the remains *in situ*. Decomposition was scored from photographs using a point-based scoring method. Stages of decomposition were developed to reflect the sequential process of decomposition. Each stage of decomposition was given a point value so that decomposition could be expressed numerically. Decomposition was scored independently for three areas of the body: the head and neck, the thorax, abdomen, and pelvis, and the limbs including hands and feet. The decompositional scores of the three anatomical regions were combined to produce a total body score (TBS).

Accumulated degree-days were calculated from average daily temperatures recorded by the National Weather Service Station nearest to where the remains were recovered. When D = average daily temperature $^{\circ}\text{C}$, the equation used to calculate ADD is $(D-0^{\circ}) + (D-0^{\circ}) + (D-0^{\circ})$ for all days from death until discovery. Zero degrees Celsius (0°) is the base temperature or temperature at which decomposition essentially stops. Although subtracting 0°C from the average daily temperature did not substantially affect the calculation, a base temperature is essential for

calculating ADD. Accumulated degree-days are a measure of heat units necessary to propel decomposition and only temperatures above 0°C were used to calculate ADD. Temperatures below 0°C did not affect ADD (i.e., negative temperatures are not subtracted from the ADD calculation). Forensic entomologists also subtract a base temperature from ADD calculations depending on the temperature below which maggots cease to develop.

The TBS was analyzed for its ability to predict the PMI. In addition, ADD were analyzed for their ability to predict the TBS. Statistical procedures performed included correlation, regression, ANOVA, and ANCOVA. Preliminary results indicate a strong positive correlation between ADD and TBS (r -value = 0.72) and a strong positive correlation between PMI and TBS (r -value = 0.67) significant at the $p = 0.05$ level. Regression analysis indicates that TBS is good predictor of PMI. Regression analysis also indicates that ADD is a good predictor of TBS, and further tests will conclude if using ADD to estimate PMI based on the TBS would be better than estimating PMI based on the TBS alone. The TBS appears to be good indicator of the PMI, and this method of quantifying soft tissue decomposition is a reliable alternative to qualitative methods of assessing decomposition and estimating the time since death.

Decomposition, Postmortem Interval, Accumulated Degree-Days

H8 Forensic Applications of Ground Penetrating Radar in Florida

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The goals of this research project are to familiarize the audience with the utility of using ground-penetrating radar for forensic applications. Participants will gain an understanding of the general characteristics of ground penetrating radar anomalies and how grave anomalies change over time.

The application of geophysical methods in the search for clandestine graves has become a valuable tool for forensic investigators. This has led to actualistic research that tests the efficacy and applicability of different geophysical technologies under controlled conditions in the detection of buried bodies and crime paraphernalia. Overall, it has been concluded that ground penetrating radar (GPR) was the most important geophysical method used to delineate graves under controlled conditions (France et al., 1997). This study tests the applicability of using GPR in Florida to detect buried bodies and crime scene paraphernalia. The following four questions were addressed: (1) How does the GPR anomaly of a pig burial change over time due to decomposition of the body and compaction of the backfill? (2) Is soil type a factor in the efficacy of producing a distinctive grave anomaly? (3) How does pig cadaver size affect the grave anomaly? (4) Are relatively high-resolution antennae, such as 900-MHz, useful for locating forensic burials and other crime scene paraphernalia?

A total of twenty-four pig cadavers were monitored on a monthly basis. Pigs of two average weights (65 and 140 lbs.) were buried at one of two depths (50-60cm or 100-110cm) for up to 21 months. Twelve control burials were also constructed. The majority of these pits consisted of backfill in order to determine the contribution of the disturbed soil to the grave anomaly. Two different soil types were utilized in this study: one soil type was comprised solely of stratigraphic horizons made up of sand, and the other was comprised of clay horizons that began at a depth of approximately 94cm. Furthermore, additional forensic targets that are representative of typical crime scene paraphernalia (e.g., knives and clothing) were also buried and monitored with the GPR to determine if they could be detected.

GPR surveys were performed on a monthly basis by profiling the length and width of the graves with both the 900- and 500-MHz antennae using the Subsurface Interface Radar (SIR) 2000 that is manufactured by Geophysical Survey Systems, Inc. This unit is powered by a 12-volt

battery and consists of a digital control unit and keypad, a VGA color monitor, and an internal hard drive. The hard drive stores the data (real-time) for either immediate playback in the field or further computer processing in the lab using RADAN.

Preliminary results indicate that the anomaly produced by only a buried body in a grave may be initially comprised of three components: the decomposing body or skeletal remains, the disturbed backfill, and the distinctive outline of the grave feature. For the duration of this study, the grave anomaly became less distinctive over time due to decomposition of the body and compaction of the backfill. Soil type and antenna were both major factors in this study. As the anomaly became less distinctive over time, it became more difficult to recognize the deep burials that were within clay using a 500-MHz antenna. Conversely, due to the greater detail produced by a 900-MHz antenna, graves were periodically more discernable in clay using this antenna. Although there were also changes to the burials that were in sandy soil, they were recognizable during the duration of the study using both antennae. Pig size was not a factor in this study. The anomaly that was produced from a child-size pig cadaver had the same general characteristics and was detected for the same duration of time as a larger pig cadaver. In addition, it was possible to detect buried crime scene paraphernalia such as knives and clothing with both antennae. Unfortunately, due to the small size of the knives, these items easily can be missed during a GPR survey if a tight grid is not utilized.

Geophysical Methods, Ground Penetrating Radar, Anomaly

H9 Predicting Mitochondrial DNA (mtDNA) Recovery by Skeletal Preservation

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Those attending this presentation can expect to learn about the relation between gross skeletal preservation and mtDNA recovery. In addition, the prediction of mtDNA recovery based on macroscopic observation of human skeletal remains is discussed.

Development of the Polymerase Chain Reaction (PCR) has influenced many scientific disciplines because of its ability to amplify trace amounts of biomolecules. Of particular interest to the U.S. Central Identification Laboratory, Hawaii (CILHI) is the application of PCR-based mitochondrial DNA analysis from skeletal remains recovered throughout the world. Over the last decade the CILHI has used mtDNA analysis performed by the Armed Forces DNA Identification Laboratory (AFDIL) to complement odontological and anthropological identifications of unidentified U.S. service members. Last year alone 58% of all CILHI individual identifications were assisted by mtDNA sequence data.

MtDNA extraction from osseous material is not entirely new and has been applied previously to many archaeological, museum, and forensic specimens. Some researchers suggest that osseous material is an important source of DNA due to the physical durability of bone and the ability of hydroxyapatite to bind DNA, thus protecting DNA from degradation. Despite advances in forensic research by interfacing anthropology and molecular biology, the extraction of endogenous human mtDNA from bone is far from routine given myriad factors that influence both gross osseous preservation and mtDNA recoverability. Few studies have begun to explore mtDNA recovery from varied states of preserved skeletal material. In these, however, the equitable and small sample sizes restrict conclusions about the relation between bone and mtDNA preservation and thus warrant continued research.

Current practice at the CILHI dictates a visual inspection of all skeletal remains turned over to the laboratory. It is recommended that preliminary analysts indicate potential for mtDNA recovery. To an anthropologist, gross preservation of bone depends on its completeness and overall weathered characteristics. The qualitative measure of how bones

look to determine mtDNA recovery potential is not well defined. At the CILHI, skeletal samples subject to varying depositional environments in various preserved states have been sampled for mtDNA analysis. Given the data shared between the AFDIL and the CILHI, there is a unique opportunity to provide significant information to ancient DNA studies.

This paper presents findings on the relation between gross skeletal preservation and mtDNA recovery as well as the ability to predict mtDNA recovery potential by macroscopic observation. The percentage of mtDNA base pairs obtained per sample is regressed against gross skeletal preservation as indicated on an ordinal scale.

Skeletal Preservation, mtDNA, CILHI

H10 Masking Identity: The Effects of Corrosive Household Agents on Soft Tissue, Bone, and Dentition

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The goals of this research project are to familiarize the audience with the affects of common household corrosive substances (Both acids and bases) on soft tissues, bones and dentition. Participants will gain insight into the criminal use of corrosive substances utilized with the intention of masking identity or destroying evidence.

Short of making a body disappear with its DNA, disintegrating a corpse or portions of one in acid can be one of the most thorough and seemingly foolproof methods of body disposal. A recent forensic case from Florida exhibited what appeared to be evidence of corrosive post-mortem modification. Dark discoloration was noted on the right frontal and zygomatic bones. Also noted was substantial erosion of the maxilla and mandible, resulting in the exposure of tooth roots. Both maxillary and mandibular dentition exhibited varied degrees of staining, in conjunction with significant erosion and pitting of the enamel on the anterior dentition. A literature search yielded only three published cases with information regarding the use of corrosive substances on human bone as a potential masking tool. One of the sources does not specify the corrosive substance used while the remaining two publications present the use of sulfuric acid as the corrosive agent used to destroy the remains. However, sulfuric acid is not readily available to the common consumer. The purpose of this pilot study is to determine which of the readily available household corrosive agents are capable of destroying skeletal and dental features.

Four complete adult pig heads (including all soft tissue) obtained from the local butcher were used for this project because of the similarity between human and pig tissue structure. All four pig heads weighed between 25 and 35 pounds. Each pig head was assigned to a ten-gallon bucket. Four household products were purchased from the local home improvement store. These included two acidic products (muriatic acid and an industrial strength toilet bowl cleaner, both popular hydrochloric acids) and two alkaline products (oven cleaner and plumbing clog remover). The molar concentrations of the acidic products were different, and the chemical compositions of the alkaline solutions were also different (both chosen for their different effect on proteins). Each product was poured into a bucket to a level that covered the anterior portion of the pig's head. In order to quantify corrosion over time, four initial craniometric measurements were taken with sliding calipers, and tissue depths were documented using a 22-gauge needle. Additional measurements were taken five times over a period of seven hours to assess the amount of corrosive activity. Qualitative data was also obtained through photographs and written observations at every measurement interval.

Although all the chemicals tested demonstrated some level of tissue corrosion, the muriatic acid (hydrochloric acid, commonly used for cleaning pools) was clearly the most effective and efficient in soft and hard tissue destruction. After the first hour of submersion the pig head in the muriatic acid showed significant tissue destruction, exposing bone and dentition. By the end of the experiment the dentition exhibited substantial enamel and dentin erosion, with only small sharp protrusions of dentin remaining. Based on metric analysis and visual observation the oven cleaner (an alkaline solution) displayed the least amount of tissue damage. The alkaline solutions tested in this experiment had mostly soft tissue effects whereas the acids (even in small concentrations) contributed to both soft and hard tissue erosion. Based on this pilot study the corrosive lesions occurring on bone and destruction of the dentition resultant from exposure to muriatic acid most closely resembled the postmortem modifications noted on the aforementioned forensic case.

Corrosive Substance, Taphonomic Modification, Masking Identity

H11 Excavation and Analysis of Four Homicide Victims From Shallow Graves in Bartholomew County, IN

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This poster underscores the importance of controlled archeological excavation methods at the crime scene.

In mid-September of 1998, local authorities discovered the shallow graves of four individuals buried along the East Fork of the White River in Waynesville, Bartholomew County, in central Indiana. The victims had last been seen a month previously and were thought to have been planning a camping trip to the approximate area where their remains were eventually located. The four individuals included a young adult female, her two children aged 8 months and 2 years, and a family friend, a female aged 12 years. Personnel at the University of Indianapolis Archeology & Forensics Laboratory were contacted to conduct the recovery effort, which took the better part of three days.

The remains were located at the intersection of a fallow field and a wooded strip that borders the river. While camping was common in the area, the scene is fairly remote and was shielded from view by passersby, being separated from the main road by cornfields. Three of the victims, the mother and her two children, were buried in three separate graves that lay within a few meters of each other, just outside the tree line. The grave of the adolescent lay about 25 meters west of the others, within the woods. Miscellaneous evidence, including personal effects and portions of remains scavenged by carnivores, were found strewn in the fields and woods surrounding the burials.

A standard baseline and two primary excavation grids were established to ensure proper archeological control. A transit was erected over the datum point to allow for detailed mapping of dispersed evidence. Excavation proceeded first by cleaning the area of vegetation and plant debris. From there, excavators began to map and then remove the "halo" of disturbed subsoil matrix that was scattered on the ground surface surrounding each grave. Soil within the graves was then removed to uncover the remains, leaving the boundaries of the original grave shafts intact. The maximum depth of any of the graves was 34 cm to the bottom (the adolescent), and that of the adult was so shallow at the foot end that the toes of her boots protruded. Mounds of soil were clearly evident over the graves of the adult and the adolescent.

From an archeological standpoint, this case presents a number of "classic" or textbook examples of how careful recovery methods can maximize evidence and information retrieval at the scene. For example, items found within the halos included pocket change presumably dropped by the assailant while digging the graves. Numerous toolmarks were noted in each grave, allowing identification of the class of instrument used and its tentative association with a shovel found in the defendant's possession. The direction that the assailant was facing when digging could be reconstructed for each toolmark in each grave. A number of "false-starts" were identified where the assailant began digging a grave but then changed his mind and relocated to a different spot. A "borrow pit" was identified immediately adjacent to the adult's grave, where the assailant removed soil to cover the victim after it became obvious that the original hole was not deep enough to conceal the body. A cloth impression was discovered at the side of the adolescent's grave, probably where the assailant knelt at its side. An intact shell of soil was found surrounding the outline of the adolescent's limbs even though the soft tissues had decomposed and pulled away from the soil. Preservation of these types of ephemeral evidence was facilitated by the fact that the clay soil was slightly wet when the burials were constructed and it had not rained in the ensuing month before recovery. Soil samples taken from the defendant's shovel matched soil collected at the scene but not soil from the defendant's yard. Finally, a fiber found on an infant blanket recovered from the scene matched fibers from the defendant's vehicle.

All of the graves had been disturbed by carnivores to varying degrees, and at least some of the remains had been pulled from the ground in each. Those of the young children were affected the most, and no bones were still in situ for the youngest individual. The two-year-old was buried face-down and was undisturbed above the waist. The adult was intact below the waist but the torso, arms, and head had been pulled up out of the grave, and most bones of the arms and hands were scattered or missing. The adolescent was disturbed the least, with only her right leg having been pulled up from the grave. According to the police, buzzards had been chased from the scene upon discovery. All individuals displayed an advanced state of decomposition, although preservation was better for the adolescent because her grave was deeper and was better shaded than the others. Mummified skin and muscle was present on each, although no internal organ tissues remained. Both live and preserved insect evidence was collected, although no active maggot masses were present.

Biological profiles generated during the laboratory analysis of the remains assisted in the identification of the victims. At least some carnivore damage was noted on bones from each individual and had to be distinguished from perimortem blunt force trauma, which was present on the two youngest individuals. Sharp force trauma was identified on all but the youngest of the victims. The adult displayed at least three knife stab wounds to the back of the thorax. The adolescent had a single plunging knife wound to the neck that split the first two cervical vertebrae. The older child had a single knife wound that completely separated the left temporal bone from the cranium, bisecting the external auditory meatus and severing the left sigmoid sinus. Unfortunately, the weapon that created these wounds was not recovered.

Complex cases such as this underscore the degree to which forensic anthropologists can assist the medicolegal system in both field and laboratory situations. Clearly, thorough training in archeological techniques is critical for the collection of evidence from burial scenes and to the reconstruction of assailant activities in the immediate postmortem interval. Documentation of the original positions of the body and of all postmortem disturbances to the grave can significantly aid in the interpretation of skeletal trauma later in the lab. Knowledge of farming practices, botany, soil science, erosion, site formation processes, and carnivore behavior all contributed significantly to the successful mitigation of this scene and to the presentation of the resulting evidence in court.

Forensic Archeology, Taphonomy, Sharp-Force Trauma

H12 Homicide for the Holidays: Linkage Through Multidisciplinary Teamwork

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After viewing this presentation participant should be better able to team specialist such as forensic anthropologists and dog handlers with traditional forensic investigators in order to link multiple complicated crime scenes.

Just before Christmas 1999, an A&W employee discovered plastic bags that did not belong in his "grease only" dumpster in Dearborn, MI. The bags contained right and left upper and lower extremities that were then brought to the Wayne County Medical Examiner's Office in Detroit, MI, where Dr. Cheryl Loewe determined that the remains were human. Dr. Loewe further stated "In consideration of the autopsy findings and circumstances surrounding death, the manner of death is a homicide."

Around New Year's Day 2000, a headless, limbless torso was found in a field in Ottawa County, OH, and was brought to the Lucas County Coroner's Office in Toledo, OH (60 miles south of Detroit) where Dr. James Patrick determined that the remains were that of a human female and the manner of death was "homicide - by undetermined violent means."

Inasmuch as these finds might be related, and Frank and Julie Saul are forensic anthropology consultants for both offices, the extremities were brought to Lucas County so that they could be directly compared.

The Sauls created separate biographic profiles for the Michigan extremities and for the Ohio torso that were essentially the same (a "white" female in her mid to late 30s, somewhat overweight). A direct comparison of the "cut" surfaces of the humeri and femora of the extremities with the "stumps" of the equivalent bones of the torso revealed equivalent cortical bone thickness and shape, cross-sections, saw striae and hesitation kerfs.

The Sauls prepared the cut surface specimens for submission to Dr. Steven Symes, a specialist in tool marks on bone (especially saw and other sharp force), to see if he could provide more information on the tool used for dismemberment as well as the dismemberment process itself.

The Sauls also suggested that since Lt. Wayne Carroll (Plymouth) and D/Sgt. Paul Keiper (Dearborn) thought that the unknown victim seemed to fit the description of a missing Plymouth, MI, woman, they might consider using Sandra Anderson and her death investigation dog, Eagle, to find the primary crime scene (in the home from which she had gone missing).

The authorities had no basis for a search warrant, as the remains were not yet positively identified, but were given permission by Dr. Azizul Islam, a chemist, to enter his (and the missing estranged wife's) home. Dr. Islam also gave permission for Eagle and Sandra to enter providing the dog did no damage to the premises. Immediately upon entering, Eagle ran downstairs to the basement which was filled with strong bleach and paint fumes associated with patches of recently painted floor. Eagle methodically indicated that he had human death scent on a paint roller and tray as well as other locations now covered with paint. Eagle's indication is a "down" followed by a "woof" with no disturbance of the "remains." While Eagle was indicating the presence of human remains in the basement, Lt. Carroll was having an initially calm conversation with Dr. Islam upstairs. Lt. Carroll told us that Dr. Islam was very startled ("he jumped out of his chair") by Eagle's first indication and was increasingly disconcerted and sweating (in January) by subsequent indications from below.

Eagle's indications enabled the investigators to obtain a full search warrant, and technicians from Dr. Steven Lorch's Michigan State Police Laboratory collected specimens (blood) that verified Eagle's indications.

Although the Sauls attempted to positively identify the victim using antemortem chest films, the films proved to be inadequate and supported only a strong presumptive identification. Positive DNA identification was made using blood samples from the victim's children. The blood samples from the basement were also determined to be those of the victim.

Dr. Islam was arrested and subsequently brought to trial in Wayne County Michigan in October 2000. The blood evidence together with strong circumstantial evidence resulted in his conviction.

It is interesting to note that Dr. Islam's defense attorneys kept police investigators on the stand for exceedingly long periods by questioning every bit of documentation of the chain of evidence. However, testimony concerning the linkage of the sets of remains by Dr. Frank Saul and the identification of the cutting tool as a small dovetail hand saw by Dr. Steven Symes caused the defense attorneys to attempt to rapidly stipulate findings that they had refused to stipulate for several months. The judge allowed the prosecutors to proceed as planned, and the Saul and Symes testimony demonstrated for the jury how "up close and personal" the dismemberment procedure must have been.

It is said that other prisoners "woof" at Dr. Islam in prison as if to remind him of how he got there.

Dismemberment, Death Investigation Dogs, Primary Crime Scene Detection

H13 The Impact of *Daubert* on Testimony and Research in Forensic Anthropology

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The goals of this research project are to present the forensic anthropological community with a summary of important rulings regarding the admissibility of scientific testimony (particularly *Daubert v. Merrell Dow Pharmaceuticals, Inc.* 125 L. Ed. 2d 469 1993) and the impact of these rulings on anthropological testimony and research.

The pursuits of forensic scientists differ from those of academic physical anthropologists in that, in addition to performing scientific research and acquiring knowledge as an end unto itself, the application of our science to legal matters must be considered. One important way that physical anthropological knowledge enters the legal system is through expert witness testimony. Although forensic anthropology is a relatively young discipline, testifying as an expert witness has become an important and increasingly accepted role. One must remain acutely aware of how methods and techniques are viewed by the legal system in order to ensure that they are admissible in a court of law.

In 1923, the first ruling of admissibility was granted to an expert witness. The case was *Frye v. United States*, and the court rendered a 2-pronged ruling stating that the information in the testimony must be (1) beyond the general knowledge of the jurors, and (2) based on scientific techniques that are generally accepted as reliable within the relevant scientific community. The "*Frye* Rule," as this general acceptance test came to be known, became the dominant standard for determining admissibility of evidence in the majority of courts. However, over time and with the advancement of science, many courts began to modify or ignore the standard. Furthermore, new scientific evidence, though sound, often failed to survive the *Frye* standard.

In 1975, Congress enacted the Federal Rules of Evidence, which was the first modern and uniform set of evidentiary rules for the trial of civil and criminal cases in federal courts. Rule 702 specifically addressed expert witness testimony, stating that "If scientific, technical or other specialized knowledge will assist the trier of fact to understand the

evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training or education may testify thereto in the form of an opinion or otherwise.” This rule addresses two important issues: *relevance* (the information must facilitate an understanding of the facts) and *reliability* (the testimony must be based on a reliable foundation of knowledge). However, rather than clarifying the issue of admissibility, the Rules appeared to only raise more questions including: To what degree must the testimony assist the jury? Who is considered qualified as an expert? And, perhaps most important, what is considered scientific knowledge? Furthermore, the Rules did not address the *Frye* standard, leading to a mixed use of *Frye*, the Rules or some hybrid.

In the case of *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, the Court was called upon to determine the standard for admitting expert scientific testimony in a federal trial. The Court ruled that what was needed was an assessment of reliability rather than general acceptance, and thus the Federal Rules of Evidence supplanted *Frye* and provide the standard. They went further, providing an interpretation of Rule 702 in the form of four guidelines for judging the validity of scientific testimony placing a “gatekeeping” role on the Court who must assess whether the guidelines are met. These guidelines state that the content of the testimony must: (1) involve testing via the scientific method, (2) be subject to peer review, preferably in the form of publication in peer-reviewed literature, (3) provide known or potential error rates, and (4) be generally accepted within the relevant scientific community (essentially the *Frye* Rule). The Court indicated that the “rigid and absolute general acceptance” test should not be the standard in order that a reasonable minority opinion may be admitted into evidence, usually in the form of new and emerging research based on reliable, well-designed studies.

Many state courts have adopted the *Daubert* standard, though some have rejected it, continuing to stick to the *Frye* Rule, or other state test. However, given that this is the current standard for federal courts, it provides the most appropriate guideline for research. Given the relative nascency of the field coupled with the rate of scientific progress in general, many techniques testified to by anthropologists may, indeed, fall under the category of “new and emerging information.” One must therefore be particularly cautious that studies are well-designed and adhere stringently to the scientific method. This is not to say that anthropological research has been or is lacking in scientific rigor, but forensic anthropology has frequently not met the *Daubert* test. *Daubert* standards should thus be consciously considered when designing and conducting research when the potential exists for the resulting technique to reach the ears of the federal court.

Expert Witness Testimony, *Daubert*, Forensic Anthropology

H14 Challenges of the Haitian Courtroom

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The goal of this presentation is to offer a view of unique solutions designed for presenting evidence in an unusual Haitian courtroom. Flexibility is required on an expert witness.

The Raboteau trial was the largest and most complicated in Haitian history. It was the first time military leadership had been tried for human rights violations and the first time that physical evidence was brought into serious consideration. The slide presentation gives an overview of the investigation leading to the trial and a closer look at the trial itself. The work was begun with the Haitian Truth Commission and completed with the aid of the United Nations.

The trial was the culmination of events beginning on September 30, 1991, when the Haitian army ousted Jean-Bertrand Aristide, Haiti’s first democratically-elected president. Tens of thousands of Haitians demonstrated for democracy and demanded the return of Aristide, but the military maintained a reign of terror. They quelled demonstrations and

kept the people suppressed by shooting into unarmed crowds and killing hundreds of people at a time. Families were not permitted to collect the dead, and most were discarded by truck loads in city dumps where they were scavenged by dogs, pigs, and other animals.

The fishing village of Raboteau was undeterred. They were known for their resistance even during the Duvalier dictatorship. The military planned and carried out a major massacre on 22 April 1994. People fled to the sea to escape by boat, but the soldiers blocked the escape route and shot the people in the water. As before, the military prevented relatives from claiming the bodies; however, several were buried by paramilitaries in shallow graves on the beach. These bodies made the difference in the trial that followed six and a half years later.

The individuals buried at the water’s edge were exhumed and described in 1995 by an international team of investigators documenting war crimes. Two more trips and several years were required to obtain sufficient evidence from informants. Two individuals were positively identified by means of mt-DNA. Location of wounds, description of clothing, and ropes used to bring the floating bodies to shore were consistent with verbal testimony. A key was found in the pocket of one victim. Metal oxide from the key stained both the clothing and the femur beneath. One of the disappeared was known to be using a seaside house for hiding, and the key fit the lock.

The official proceedings took place in French, but the anthropological testimony was given in English so that it could be translated into Creole for the jury. It was impossible to display slides, so the bones of the deceased were brought into the courtroom. Gunshot wounds and other evidence were shown directly to the judge and jury. The door of the house was also displayed in the courtroom so that the key could be taken from the stained femur and clothing to the lock where it functioned normally.

Of the twenty-two former soldiers and paramilitaries in custody, sixteen were convicted. Thirty-seven were convicted in absentia, including the leaders of Haiti’s 1991-94, military dictatorship and the heads of the paramilitary. The Haitian justice system is continuing to pursue those convicted in absentia.

The Raboteau case demonstrates that justice can be accomplished in spite of enormous obstacles, and the techniques of the forensic sciences can be used to facilitate democratic transition.

Skeletal Identification, Human Rights, Expert Witness

H15 The Effective Forensic Investigation of Human Rights Violations: A Model for Training

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By attending this presentation, forensic scientists will understand how to proceed in the forensic investigation of violations against International Humanitarian Law and how to present the evidence to Court. This example also serves as a model for institutions engaged in training for the forensic science community.

After the collapse of the last civilian dictatorship of the South American continent, Peru faces the investigation of human rights abuses committed over the last twenty years. Current calculations estimate that the number of dead after twenty years of counter-subversive activities may be close to 30,000 while the number of “missing” people is between 4,000 – 6,000. Most of the remains of the “missing” are thought to have been disposed of into mass graves.

The newly created Peruvian Forensic Anthropology Team (Equipo Peruano de Antropologia Forense-EPAF) organized a workshop for Public Prosecutors, the Office of the Ombudsman, and human rights activists (Lima, Peru, 18-21 February 2001). This paper discusses the

achievements of such a unique activity as well as its potential in creating awareness of the importance of forensic archaeology and anthropology in the investigation of human rights violations. The objective of the workshop was to introduce to those who would be involved in the investigation of human rights violations the do's and don'ts of forensic recovery of human remains (i.e., mass graves) and the interpretation of the evidence to be presented to Court as part of a case. The workshop consisted of three parts, namely the introduction to forensic sciences and its applications to human rights investigations, crime scene recovery and reconstruction, and the presentation of evidence to Court.

To that purpose, five identical "mass graves" were prepared. Each contained two layers of "bodies" (life-size dummies) representing two interment events. The bottom layer had been "finished off" in the grave with a 9mm pistol while the second layer had been shot outside the grave with an AKM assault rifle. At the end of the theoretical and practical modules, all five groups were merged and divided into Defense and Prosecution teams. A mock-trial with three judges was prepared and each group accredited six delegates to the Prosecution and Defense respectively.

The "defendant," a former police lieutenant, was charged with the forceful abduction of 50 people from a party and the execution in the field where the bodies were found. The charges were listed as kidnapping, torture, extra-judicial executions, and illegal burial of human remains. Both Prosecution and Defense had each between 20 and 30 minutes to present their arguments.

In forensic terms the Prosecution demonstrated that people disposed of into the grave were killed with two different kinds of weapons (pistol and rifle). The Prosecution also demonstrated that the graves were dug by hand, and that a ticket from the party found in one of the graves established the link between the place from where the victims were kidnapped and where they were killed. Interestingly, the finding of the ticket was completely fortuitous but helped to expand and reinforce the narrative of the case.

The Prosecution failed on two points that were swiftly picked up by the Defense. First, the defendant was referred to as Captain instead of Lieutenant, and second, the element of time was an issue. This was due to the fact that two layers of people were disposed in the grave. Considering that the first layer of victims was "finished off" with pistol rounds implied that they were brought alive to the site and then killed in situ. However, the total number of people killed in this fashion was 25 and not 50 as claimed by the Prosecution. While both Prosecution and the Defense reconstructed the narrative of the events as accurate as the perpetrators (i.e., organizers of the workshop), the "defendant" was not charged with all counts of murder (i.e., 50 people), but only for 25 cases.

The goals of the workshop were met, namely, the understanding of recovery and analysis of a crime scene which involves multiple human remains, it is a complex process that takes time, and a number of inferences can be drawn from the proper recording and recovery of those contexts.

Human Rights, Mass Graves, Training

H16 Confronting the Past in Guatemala: A Challenge for Forensic Science

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The goals of this research project are 1) to teach the forensic community how society must accept the responsibility for the victims of a civil war, by devolving to its governmental agencies appropriate means in the recovery of human remains, from individual and mass graves in the aftermath of war in the 80s in Guatemala; and 2) to emphasize the cultural characteristics that are involved in such a recovery.

In 36 years of civil war in Guatemala more than 200,000 persons disappeared due to actions of both the Guatemalan Army and the Guatemalan "guerrillas." After a Peace Treaty was signed in December 1996, a period of solidarity was established and the search for historical truth began. It is also at this point where the forensic community was called upon to play an important role.

This presentation will focus on the multidisciplinary work in Guatemala since 1996 performed by social anthropologists, forensic anthropologists, and forensic archaeologists in the recovery of evidence; it also will reference one of the most important key factors of success in accessing this underground world.

Finding the hidden cemeteries was an arduous task. Once found, the forensic experts attempted to recover the skeletal remains (articulated, disarticulated, cremated). Their work involved the archaeological methodologies of excavation (with the appropriate photographic documentation); the handling of the evidence; the collecting of human bones, personal artifacts, bullets, lassos (one of the methods of torture); the identification of sex, age, stature, physical and pathological characteristics of the remains; the causes and manner of death; and, a reconstruction of perimortem and postmortem events.

Acts of violence, whether directed at entire communities because of religious or ethnic implications, or toward women, children, and old persons, resulted in extra-judicial executions, death as results of persecution, massacres, sexual assaults, tortures, and so forth.

In the process of anthropological forensic investigations in the early years of the 90s, fear decreased and, after 18-20 years living in a state of terror, survivors felt secure enough to begin to do the following: to recover their children, fathers, and mothers; to learn what happened to their loved ones; to ascertain that these family members did indeed die; to place blame on the culpable; and, to establish a precedent that this kind of horror never happen again.

Moreover, it is to the forensic team where praise is given; their challenge was considerable as they set about in identifying human remains and giving to each a name.

This investigation will present the process of excavation, recovery of physical evidence from graves, and the ritual that is involved in the final inhumation of the victims.

Forensic Anthropology, Ritual, Social Anthropology

H17 Human Remains Sold to the Highest Bidder! A Snapshot of the Buying and Selling of Human Skeletal Remains on eBay®, an Internet Auction Site

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The primary purposes of this paper is to inform the forensic community of the selling of human skeletal remains - old and new - on the eBay internet auction site, as well as to advise forensic scientists that this site does not, to the best of the author's knowledge, utilize a forensic anthropology advisor to assess the pictures of skeletal materials posted for subsequent sale to the general public.

This paper addresses several different types of skeletal materials—older recovered prehistoric, historic, commercial and perhaps even modern forensic materials—skeletal materials sold on eBay. The purpose of this paper is to inform forensic anthropologists and other forensic specialists about the buying and selling of human cranial and postcranial skeletal materials every day on eBay. While these materials may be old from prehistoric and historic contexts, it is also possible that some may be new, and of forensic significance. Moreover, it is important to state that it is unknown if eBay employs a forensic anthropology advisor, or if the sale

of human skeletal materials is considered to be an issue. In all cases, if one desired to evaluate skeletal materials, one would have to do so from the pictures posted to the site. Direct examination would require purchase of the human skeletal materials, or their seizure by law enforcement personnel acting under warrants.

As there are no rules on eBay governing the sale of human skeletal remains for instructional purposes, all materials are posted for instructional use only. According to eBay rule #42020018 regarding prohibited items, including human parts and remains, "Items that contain human hair (e.g., lockets) as well as skulls and skeletons that are used for educational purposes may be listed on eBay." Moreover, the only rules or laws that eBay enforces are the following: "eBay does not permit the sale of Native American skulls, bones, or other Native American grave related items, as the sale of such items may violate federal law. For more information on eBay's rules regarding the sale of such items and the Native American Grave Protection and Repatriation Act (NAGPRA)..."[1]

As human skeletal materials of any kind—old or new—can sell at auction for 500 - 2000 U.S. Dollars or more, an enterprising person could advertise these remains as modern whether they were or not. For example, one particular skull was advertised with a bullet hole through the zygomatic bone (i.e., "> REAL Bone Human Skull w/ Bullet Hole <: Item # 115871-9226"). Such sales may generate interest in stealing human remains from graves, mortuaries, hospital, or county morgues, or perhaps even worse. Because of the unregulated sale of human remains on auction sites, such as eBay, federal laws need to be drafted and enforced that limit sale of human skeletal remains on the internet.

<http://pages.ebay.com/help/community/pgn-remains.html>

Forensic Science , Forensic Anthropology, Human Skeleton

H18 Forensic Application for Evaluating Cranial Trauma Cases From the Iron-Age Site of Alfedena, Italy

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Upon completion of this presentation, the participant will understand how the application of forensic analysis of cranial trauma can be applied to proto-historic skeletal remains.

This presentation will offer insights on how forensic analysis of cranial trauma can be successfully applied to proto-historic burials. The population studied is the Alfedena, an Iron-age skeletal population from the 6th and 5th centuries B.C.

This skeletal population was excavated during the 1973 -74 field seasons from the Abruzzi region of Italy. Macchiarelli and co-authors first examined the skeletal population of Alfedena for cranial trauma in 1981. They found four cases with cranial trauma specific to inter-personal conflict indicating that four percent of the burials represented individuals with cranial trauma. This well-documented Italian population was recently re-examined for cranial and post-cranial trauma. Of the 95 individuals examined, representing a total of 87 skulls, 18 adult individuals (18.9% of them) exhibited intentional trauma. Twelve individuals, or 13.8 percent of the population exhibited cranial injuries. The findings suggest that inter-personal conflict had been grossly under-estimated for Alfedena in the 1981 publication. A break down of cranial trauma by sex shows 18% of the males and .04% of the females suffered intentional trauma, resulting in antemortem healing and perimortem injury and death. The findings under-score the violent circumstances experienced during the Iron-age proto-history of Italy, period of time which is characterized by considerable population growth related to improved agricultural practices. Males were more likely to exhibit cranial trauma than females, suggesting that external social pressure for resources was considerable. The archaeological record supports this position.

This material was compared to a second cranial population consisting of 108 individuals also from the Alfedena necropolis. This material had been excavated during the late 19th and early 20th centuries and had not been examined for trauma prior to our research. In the second cranial collection, an additional 14 intentional, interpersonal injuries were found, 12 of them to the cranium, representing 12.9 % of the collection. In summary, of the 195 skulls examined, 26 individuals (13.3 %) exhibit cranial trauma. Each Alfedena collection shows similar trauma patterns with males more often than females exhibiting cranial trauma.

Post-cranial trauma consists of cut wounds to the legs and back region of the skeleton. This line of evidence suggests that for several individuals with perimortem cranial trauma, that they may have been stabbed several times to incapacitate them before the final cranial blow occurred.

The specific types of cranial trauma found include sword cuts, depressed fractures, and small circular holes with radiating fracture lines and beveled endo-cranial edges. It is with this last trauma type that forensic analysis in cranial trauma was most useful. The small hole trauma with radiating fracture lines were produced with slings tossing small round projectiles with significance force enough so to mirror gunshot trauma to the cranium. It is these specific trauma patterns that will be the focus of this presentation.

Cranial Trauma, Iron-Age Skeletal Population, Italy

H19 One Unlucky Punch: The Etiology of a Fatal Depressed Skull Fracture

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This paper has three objectives: (1) to present an unusual case in which an assailant's punch produced a fatal depressed skull fracture; (2) to demonstrate biomechanically that a punch could have produced the fracture; and (3) to explore the role that the victim's individual life history played in his death.

Introduction: This case report illustrates how the forensic pathologist and forensic anthropologist worked in tandem to sort out and ultimately understand a complicated combination of evidence, including antemortem trauma, perimortem trauma, and neurosurgical efforts to save a man's life. In addition, the contribution of a biomechanics expert in this case was paramount in assessing a punch as the possible etiology of the perimortem blunt force trauma.

Case report: A 33-year-old man, intoxicated with alcohol, was involved in a fistfight with another man. Witnesses report that during the altercation, the subject fell to the ground with the left side of his face against the asphalt surface of a parking lot. The assailant reportedly punched the subject two or three times on the exposed right side of the head. The fight ended shortly after these blows were struck, and the subject stood and walked into his apartment. Roommates who saw the injured subject upon his return home reported that he acted confused and spoke very little, but that he maintained he was okay. He went to bed shortly, and a roommate found him unresponsive a number of hours later. At the hospital where he was treated, he presented with a Glasgow coma scale of III. The CT scan showed a right-sided intracerebral hematoma. Emergency neurosurgical efforts to save the man's life were unsuccessful.

Pathology: Examination at autopsy showed a well-healed C-shaped scar on the right temporoparietal region of the scalp. Overlapping this scar and extending into the frontal region of the scalp was a recent C-shaped incision secured with staples. Hemorrhage extended through the scalp and the underlying soft tissues of the right temporoparietal region. Beneath the recently fractured bone fragments, the dura mater contained an oval defect secured with sutures. The brain exhibited fracture lacerations and fracture contusions. A cavitary defect with features of a "burst lobe" in the right temporal and parietal lobes of the cerebrum communicated with a

three centimeter defect over the temporal portion of the brain. The cause of death was certified as being due to craniocerebral injuries and the manner of death as homicide.

Anthropology: Evidence of healed antemortem trauma was observed on the right side of the cranium, where a surgically repaired, roughly circular plaque of bone involved portions of the right temporal and parietal bones. This plaque measured approximately 55 mm antero-posterior and 53 mm superior-inferior, and exhibited healed margins around its circumference.

Perimortem trauma was observed within this plaque of bone. At least one blunt force impact site resulted in three linear fractures. The margins of these fractures displayed no evidence for osteogenesis or healing.

Cranial evidence of recent neurosurgical intervention included the following: four titanium Synthes plates and screws that attached the plaque of bone to the surrounding bone; newly drilled holes adjacent to the margins of the temporoparietal plaque for surgical sutures to tack down the dura; an arching, semi-circular craniotomy connecting two burr holes which were 96 mm apart; and two more Synthes plates that stabilized one of the fractures.

Biomechanical Analysis: The etiology of the perimortem blunt force traumata was a key element during the trial of the assailant. The victim had been witnessed getting punched with a fist. Therefore, a primary question in the case was whether the temporoparietal fractures could have been produced by a punch to the victim's head as he lay against the asphalt surface. To test the hypothesis that the assailant could have produced the injury with his fist, biomechanical data were gathered from a number of sources and various assumptions were made concerning the potential blows to the victim's right temporoparietal region. Data on the force required to fracture the skull via blunt impact was the starting point. It has been experimentally shown that a linear skull fracture in the temporoparietal region will occur at forces ranging from 2,110 - 5,200 N (mean = 3,630 N). To determine the potential for fracture of the temporoparietal region from a single blow, experimental data were gathered on the range of velocities of various punches thrown by amateur boxers. Another important piece of data was an estimation of the mass of the arm and hand.

In order to estimate the range of forces that could have been produced in a punch to the head, rigid-body mechanics were employed. During the impact event, the momentum (mass times velocity) of the upper extremity changes from a maximum at the peak velocity (near contact with the head) to zero at the end of the event. Using the concept of impulse-momentum, and assuming the force-time pulse from other experimental data, the peak contact force was estimated to be approximately 3,160 N for a "jab", and 4,930 N for a "hook." These peak forces fell within the range required to fracture the temporoparietal region of a normal skull under blunt impact conditions.

Individual Life History: Approximately 10 years before his death, the decedent had been in a motor vehicle collision resulting in the need for a craniotomy. As a result, the thickness of the right temporoparietal region was half that of the non-injured left temporoparietal. Biomechanical studies report that a thinner than normal skull increases the potential for fracture. Therefore, it is believed that the decedent's medical history further predisposed him to sustaining the fatal, depressed fracture.

Conclusion: Severe blows to the head with blunt instruments are known to cause depressed skull fractures with associated fracture lacerations of the brain, cerebral contusions typically most severe beneath the location of the blow, and occasionally intracerebral hemorrhage, as seen in this case. Typically, blows resulting in these injuries are delivered with an object other than a fist. Although a depressed skull fracture is not "diagnostic of" a punch from a fist, it was determined in this case that the trauma was "consistent with" a punch from a fist. The biomechanical data, in combination with the individual's life history, suggested that a single punch to the rigidly supported head of the victim could have generated the fractures observed in the right temporoparietal.

Punch, Skull Fracture, Biomechanics

H20 Fracture Pattern Interpretation in the Skull: Differentiating Blunt Force From Ballistics Trauma

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The goal of this research project is to illustrate an alternative technique of determining the mechanism of trauma to the skull by fracture patterning. The research discussed verifies that blunt force and ballistics trauma can be significantly differentiated by the beveling direction of concentric fractures.

This presentation will demonstrate that the mechanism of trauma to the skull can be diagnosed by fracture patterns. Specifically, this study will examine the direction of beveling in concentric fractures to the skull in order to differentiate blunt force from ballistics trauma. An in depth analysis of tertiary (concentric) fractures will allow for an easier determination of the mechanism of trauma when the impact site is missing due to taphonomic or other processes. This research is important to osteological studies, because fracture patterns in blunt force and ballistics trauma have similar appearances. This presentation will provide essential information to the genre of fracture interpretation, in turn enabling researchers to differentiate between these two mechanisms of trauma with comfort.

Concentric fractures to the skull form if the linear fractures do not provide enough relief from the kinetic energy produced by the striking object. These fractures are semicircular and form perpendicular to the radiating fractures, which gives the injury a spider web-like appearance. In some cases, concentric fractures may form in the absence of radiating fractures. These fractures are created before a projectile has an opportunity to exit, as in the case of gunshot wounds.

Blunt force and ballistics trauma produce concentric fractures in dissimilar ways causing the bone to break or bevel in variant directions. In concentric fractures produced by blunt force trauma, tensile forces increase on the outer table while compressive forces increase on the inner table. Since bone is weaker in tension than compression, the bone will fracture on the outer table first and travel to the inner table, creating an internally beveled appearance.

In concentric fractures produced by gunshot wounds, intercranial pressure is greatly increased. The increased pressure causes the inner surface of the skull to be under increased tension while the outer surface is under increased compression. The plates of bone formed by the radiating fractures are then elevated, causing the fractures to begin on the inner surface and travel outward, thus producing externally beveled concentric fractures in both entrance and exit wounds.

For this presentation, skulls exhibiting blunt force and ballistics trauma were examined for concentric fracture patterns. The concentric fractures were morphologically analyzed to determine the direction of beveling. In total, 211 injuries were inspected. External beveling included any cases where more of the outer table than the inner of the fracture surface was present, while internal beveling was judged as the opposite of this. Undetermined beveling included cases that were ambiguous or did not exhibit any trace of beveling. Fractures exhibiting internal beveling were classified as blunt force trauma and those which were externally beveled were classified as ballistics trauma. Furthermore, measurements to both the inner and outer fracture surfaces were made in order to determine if direction of beveling may be metrically determined.

The data set used included specimens from the following institutions: (1) the Regional Forensics Center in Memphis, Tennessee; (2) the National Museum of Health and Medicine (NMHM), which is affiliated with the Armed Forces Institute of Pathology in Washington, DC; and (3) the Smithsonian Institution's National Museum of Natural History in Washington, DC. The collection housed at the Regional Forensic Center consists of evidence retained from autopsies in the Memphis area and surrounding counties. The three collections used from the NMHM consist of the Milton Helpem, MD, New York City Medical Examiner Collection (1940-1970), the Indian Wars collection which includes the U.S. Army

soldiers at U.S. forts during the Indian Wars (1866-1900), and the Civil War collection (1862-1865). Additionally, several collections from the Smithsonian were used, including the Terry, Peruvian and Native American collections.

Chi-square tests were run on SPSS 9.0 to determine if there was a relationship between the direction of beveling and the mechanism of trauma. Then, contingency coefficient tests were run on the same statistical package to determine the strengths of this relationship. All tests indicated a highly significant relationship between the two factors. Discriminant analysis was performed on the measurements, which also displayed a statistical significance.

The research conducted in this study illustrates that mechanism of trauma may be determined in the absence of impact site. Further research is needed to fully explore the complete importance of fracture interpretation. The complete relevance and details of these findings will be discussed in depth in the presentation.

Ballistics Trauma, Blunt Force Trauma, Concentric Fractures

H21 Determining Direction of Fire: An Anthropological Analysis of Gunshot Wounds to the Chest

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The goal of this research project is to present the forensic community with information that can be obtained by an anthropological evaluation of gunshot wounds to the chest. Specifically, this presentation will show that gunshot wounds to the chest frequently leave distinctive markers on the bones that indicate the direction of fire.

Traditionally, the primary task of forensic anthropologists has been to establish a biological profile of a decedent. However, increasingly they are being called upon to provide expert opinions about skeletal trauma. If remains are severely decomposed or skeletonized, soft tissue analysis is difficult, if not impossible. In such cases the forensic anthropologist's expertise in human osteology is a valuable investigative tool. Nonetheless, even in cases where soft tissue is available for diagnosis, the anthropologist's evaluation of skeletal trauma can provide additional, useful information to the medical examiner's report. Consequently, forensic anthropologists should possess a thorough understanding of trauma in all areas of the skeleton.

The primary objectives of this study were to: (1) determine if there are distinct and/or patterned fractures associated with gunshot wounds to the thoracic region, and (2) ascertain whether or not the direction of fire can be established from skeletal evidence alone. In order to answer these questions, the researcher used only those cases that were clearly documented by the medical examiner. Fifty-three cases with gunshot wounds to the thorax were selected for analysis from the evidentiary archives at the Regional Forensic Center in Memphis, TN. Additionally, one case from the Louisiana State University forensic anthropology laboratory was examined, thus making a total of 54 cases. Some of these individuals had received only a single gunshot wound to the chest, whereas others had multiple gunshot wounds. In all, 85 gunshot wounds were analyzed in this study, and 130 bones had bullet injuries: five scapulae, six clavicles, 11 sterna, 10 thoracic vertebrae, one lumbar vertebra and 97 ribs. Because the ribs were the most frequently injured bones, this analysis concentrates on the characteristics of gunshot wounds in the ribs.

Of the 85 gunshot wounds in this study, 38 involved only one bone, 29 involved two bones, five involved three bones, one injured six bones, one injured 13 bones, and 11 did not strike any bone. A .308 caliber rifle inflicted the injury involving 13 bones. The weapon that injured six bones was not reported in the autopsy protocol. The bilateral distribution of the gunshot wounds was almost even, with 52 on the right side of the body (54%) and 45 on the left side (46%). The sixth rib and the eighth rib were

hit more frequently than any other ribs. The twelfth rib, on the other hand, was not injured in any of the cases in this study, and the eleventh rib was hit only three times. The researcher also documented the vertical distribution of the gunshot wounds. In order to do so, the thoracic cage was divided into three equal sections as follows: the upper section consisted of ribs 1-4, the middle section included ribs 5-8, and the lower section was comprised of ribs 9-12. The middle section received the most damage (42% of all injuries), followed by the upper section (36%). Finally, the lower section suffered the least damage (22%).

Microscopic examination of the entrance and exit defects on each rib revealed several reoccurring features that indicate the direction of fire. The entrance defect exhibited one or more of the following characteristics: a typically round defect with a sharply defined rim, radiating fracture lines, depressed fractures of the bone surrounding the defect, and/or bone splinters displaced in the direction of fire. The exit defect was usually larger than the corresponding entrance defect. Other exit-associated characteristics included radiating fracture lines, trabecular bone exposed around the defect (i.e., beveling), and out-bent bone fragments. Note that these characteristics are similar in many respects to those associated with the flat bones of the cranial vault. The best way to determine which of these characteristics is present at the site of trauma is to examine the defect closely under an operating scope. In some cases, reconstruction of the rib with Superglue® or Duco® cement facilitates more complete inspection.

In summary, this study has shown that gunshot wounds to the chest can leave evidence on the bones that indicate the direction of fire. The bones that are hit most frequently in gunshot wounds to the thoracic region are the ribs. Accordingly, this analysis focused on the characteristics associated with entrance and exit defects on ribs. This researcher observed several characteristics that could aid the forensic anthropologist in evaluating gunshot trauma in ribs, including depressed fractures, displacement of bone fragments in the direction of the bullet's path, and beveling. Although the forensic anthropologist can ascertain the direction that a bullet traveled through a given rib, (s) he should use caution and should not extend her interpretations past their limit of validity. A number of factors can affect a projectile's behavior in the body (e.g., velocity of the bullet at the point of entrance, the distance between muzzle and target, the position of the body at the time of impact, bullet tumbling, etc.). These variables plus, in some cases, the absence of soft tissue evidence, make gunshot wound evaluation especially challenging for forensic anthropologists. Even when soft tissue is present, the forensic anthropologist should be called in to inspect bone trauma carefully. By combining their expertise, forensic anthropologists and forensic pathologists can provide a more complete picture of the events surrounding a victim's death.

Forensic Anthropology, Gunshot Wounds, Thorax

H22 Burning Observations of the Head: An Experimental Model

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After attending this presentation participant will understand: 1) normal destruction to the fleshed cranial vault in a fire, and 2) progressive stages of thermal destruction to both the soft and hard tissues of the head.

Traditionally, the concept that an intact skull 'explodes' into miniature-sized bone pieces when subjected to heated gases has served as a standard anthropological theorem. Compromise of the structure by either ballistic or blunt force trauma is believed to react differently than an intact vault. Fractures or openings provide areas of stress relief for the venting of moisture, gases, and internal pressures of the brain. However, it is claimed to explode and project into numerous fragmentary pieces due to the release of these pressures if the vault remains a closed system (no

trauma). This assumption may discourage further investigation of trauma if one assumes that the skull fragments indicate the absence of preexisting trauma.

In an effort to observe normal stages of skull destruction from fire, different theories were tested through a series of actualistic studies that used combinations of human and non-human crania in controlled fire environments. Special measures were taken to accurately simulate and document some of the variables typically encountered in structural or vehicular fires. Controlled simulations of fires made it possible to observe and document progression of thermal destruction to soft and hard tissues of the head to understand the thermal processes that create fragmentation and eventual destruction of the skull.

In order to accurately reproduce fire victim situations, researchers utilized fully fleshed, unembalmed human cadaver heads formerly preserved at -10 degrees Fahrenheit. Soft tissues were thoroughly thawed and placed in a variety of thermal events controlling for time, temperature, intensity, duration, materials, and other variables encountered in fires (accelerants, wood, fibers, water, natural gas). Progressive stages of thermal destruction to soft and hard tissues were documented with 35mm slides, digital, video, and written observations at timed intervals.

Variations of temperature and materials influenced the time and rate of burning for each experiment. Independent of rate and intensity of each fire, thermal destruction followed a consistent pattern based on protective and insulating properties of soft tissue (skin, fat and muscle) on the face and head. Duration of experiments ranged from 10 minutes to 60 minutes in order to express the full range of thermal destruction that could be expected in a burn victim.

A continuum of change occurs as follows:

- Skin becomes glossy with moisture, skin and facial features become tight, skin begins to darken, lips retract, tongue forms a plug in the lips.
- Exposed anterior teeth begin to darken, skin quickly becomes blackened, skin splits in multiple areas, face begins to bloat and bubble grease, skin of the forehead splits and retracts, exposed bone darkens, and then begins to blacken from charring.
- Charring of bone progresses over exposed areas, heat fractures become visible in charred bone, skin continues to burn away on the face, charred areas become calcined (white, gray), outer table begins to fragment and burn away to expose diploe, inner table and brain in some cases.
- The brain experiences a variety of reactions from heat that included shrinking, expansion and fungates, or oozes from preexisting openings.

Firings ranged from incomplete to complete incineration, with an emphasis on the window of time between early charring (black) and calcination (white). Organic degradation from heat makes bone brittle and eventually shrinks, typically producing heat-induced fractures and deformation. Of particular interest were heat-induced fractures and delamination. This widespread application of heat over a large area of exposed bone creates separation and destruction of the outer table, exposing diploe, inner table, and brain.

In all of the firings, areas of the vault simply fragmented and delaminated from gradual destruction of heat with pieces dropping directly below their point of origin or pulled away by muscle. Introduction of water, handling, and removal of burned bone increased fragmentation of this brittle structure and may account for some of the shattered appearance when removed from the fire scene context. However, abundant heat fractures should not dissuade the investigator from making assumptions about the presence or absence of trauma.

The goal of this research is to signal caution to those who investigate fire-related deaths and create an awareness of normal burning patterns in order to recognize deviations in these patterns as may be caused by malicious intentions to destroy a body or by preexisting trauma. Belief in the exploding skull concept is an invitation to error. If fragments of the skull are distant from the head, then another process must explain the finding.

Either trauma or some other event within or following the fire caused fragments to be displaced. Observation and documentation of these studies will be presented to illustrate progressive stages and variations of thermal destruction to the head.

Fire Investigation, Burned Bone, Cremation

H23 Age Estimation of the Immature Individuals Starting From the Ratio Epiphysis Width/Diaphysis Width of the Bones of the Hand and the Wrist

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The goal of this presentation is to introduce a new method for age estimation.

The authors introduce a method of age estimation of immature individuals starting from the measurement of the ratio: epiphysis width/shaft width of metacarpals, ulna and radius. This approach was developed on a study of x-rays of the hand of individuals of known sex and age between 1 and 18 years. The widths of the epiphyses and the diaphyses were measured for each osseous element. These measurements are possible from the appearance of the cores of ossification of the epiphyses of the metacarpals and of the radius towards 1-2 years up to complete fusion epiphysis-diaphysis of radius around 18 years.

The results highlight a correlation between the ratio epiphysis width / shaft width and age. This ratio increases with age. The r^2 of each measurement are between 0.65 and 0.85. The correlations with age are more significant of men. The use of all measurements makes it possible to obtain a coefficient of correlation with a $r^2 = 0.89$ in male sampling. This method appears interesting notably in forensic medicine for age estimation of the young individuals whose date of birth is dubious.

Estimation, Metacarpals, Radius

H24 Contribution of Numeric Measurements to Fetal Sex Determination

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Sex estimation is one of the most frequently encountered issues in forensic medicine. While in the case of adults, this determination is essentially based on iliac bones and provides a rather reliable classification. There are fewer studies conducted on fetuses and the results are often contradictory.

Therefore, the authors examined 83 pairs of fetal iliac bones in the Hungarian collection of Fazekas and Kosa and searched for metric criteria that can best be applied for determining sexual dimorphism. During this research, methods were tested for fetal iliac bones and others used particularly in the case of adults.

For this reason, the authors set up and validated a protocol of taking photographs, as well as a measurement technique developed for numeric pictures with the help of two software programs: Adobe Photoshop 6® and SigmaScan Pro 5® (SPSS).

The results showed an excellent reliability and an excellent correlation between real size and numeric measurement. Therefore, more than providing very reliable measurements that can be applied on previously published sex determination formulae, this methodology will allow the investigation of new measurements, such as area and perimeter.

Fetus, Sex, Ilium

H25 Modern Oral Piercings: The Application of Their Dental Wear Patterns for Forensic Anthropology

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The goals of this research project are: 1) identify the variety of oral piercing among modern pop sub-culture, 2) illustrate patterns of dental wear and/or chipping associated with these oral piercings, and 3) provide a starting point for future research to develop standards to be used in forensic identification.

The growing trend of body ornamentation in modern-day pop culture calls for research on the effects of these decorations on the hard tissues of the human body. In this study, the effects of modern oral piercings on the dentition are evaluated in a context that could be utilized in the future to assist in identification.

In forensic anthropology, the teeth are of great importance in identification for several reasons. First, the enamel that forms the outermost layer of the tooth crown is the hardest substance in the body. The durability of the dentition owes to the microscopic structure of enamel. The heavily mineralized, non-cellular enamel is deposited in layers of prisms by cells called ameloblasts in a process known as amelogenesis. Thus, the combination of the structure of enamel and its mineral components often makes teeth the best preserved part of a decomposed or destroyed body. Another important characteristic of enamel tissue is that it does not regenerate like other tissues in the body. Enamel is laid down when the crowns of the teeth are formed and will not be replaced once worn off or broken off. Thus, any wear patterns left from idiosyncratic behaviors are permanent.

In addition, the dentition is important in positive identification of individuals because antemortem dental records are more common than skeletal radiographic records. Thus, a great deal of attention is given to the dentition in forensic cases. Peculiar wear patterns from bruxism, occupational activity, overbites, underbites, or even wear from oral ornamentation may be noted in these records and could be useful in leading to a positive identification.

The authors using interviews and visual examinations of living subjects conducted research focusing on modification of the oral cavity through piercings. Morphological modifications of teeth, (*e.g.*, inlays, sharpening, cross-hatching, grooving, ablation, etc.), and surgical modification of soft tissue (*e.g.*, bifurcation and lengthening of the tongue, etc.) were not included.

The variety of modern oral piercings can be grouped into two types: fixed and non-fixed. Fixed oral piercings have a position in the oral cavity

where its relation to the dentition is fairly constant. More common fixed piercings include scrumpers and lowbrets. The teeth affected by fixed piercings are usually limited to those in immediate contact with the piercing. A scrumper, also known as a smiley, is a piercing that passes through the central webbing between the upper lip and the alveolar soft tissue just above the upper incisors. A scrumper through the lower lip webbing is called a frowny. Jewelry commonly used for scrumpers are rings with a small ball centered between the incisors. Dental wear associated with scrumpers is grooving of the labial surface of the upper central incisors caused by the ball. The grooving is circular, and in cross-section, is U-shaped. Another common fixed piercing is the lowbret, a studded jewel or barbell placed from the internal aspect of the oral cavity through the exterior soft tissue above the mental eminence. Its low position makes this piercing relatively immobile and usually results in abrasion of the lower incisors.

More common than fixed piercings are non-fixed piercings; these have a position in the oral cavity where the relation to the dentition is movable as a result of the flexibility of the soft tissue in which the piercing is located. The teeth affected by non-fixed piercings are not limited to those immediately in contact with the piercing and are affected by the individual's penchant for moving the piercing around the mouth. The most common non-fixed piercing is a barbell stud through the center of the tongue. Less common tongue piercings are located anteriorly/superiorly and horizontally. Ring piercings through the tongue are usually placed at the anterior tip. Given the wide range of motion of the tongue within the mouth, dental abrasion and chipping caused by these piercings can affect almost every tooth in the arcade, including the molars. The lingual and occlusal surfaces, however, tend to be the most commonly affected. The second most popular non-fixed piercing is a lip ring, a single-hole piercing through the upper and lower lip. Though the dentition immediately internal to the piercing is most susceptible to abrasion and chipping, the flexibility of the lip results in wear to both upper and lower teeth, as well as to those within a two or three tooth-distance from the piercing. Finally, a well-known prehistoric piercing popular today is the labret. Similar to the lowbret, a labret is placed just below the lower lip, although it is higher and therefore more movable than the lowbret. Variations to its vertical and/or horizontal position are common. Given that ornamentation of the labret is external, the internal aspect is usually a simple stud or fishtail hook. This piercing results in general abrasion of the labial surface of the lower anterior teeth.

Types and severity of dental wear are described in greater detail in the poster presentation, as well as other types of oral piercings. The following are the more influential variables that can affect the type and severity of dental wear: 1) the length of time since the initial piercing, 2) the type of jewelry (*e.g.*, barbells, barbell studs, safety pins, paper clips, etc.), 3) the complexity of the piercing (*e.g.*, a single piece of jewelry connecting two or more piercings, or a single piercing with several exit holes), 4) the size of the piercing and jewelry, 5) the degree to which the individual moves the jewelry within his/her mouth, 6) the material of the jewelry (organic vs. forged metal), 7) sudden physical pressure that may lead to extreme dental trauma such as a blow to the chin, and 8) rejection of the piercing, which may lead to shifting or even expulsion of the jewelry.

Directions for further research on this subject include a longitudinal study that would follow individuals through time just prior to the piercing event. This would provide a timeline for the development and degree of wear observed on the dentition over time with different types of piercings as well as further understanding of the variables that effect severity and types of wear.

In modern popular culture, body decorations such as oral piercings have broken out from an underground sub-cultural practice to become a more commonplace fad resulting in a greater number of people with possible physical alteration to their teeth. In turn, this creates an increased potential for the use of dental modification produced by oral piercings in forensic anthropology.

Forensic Anthropology, Dental Wear, Oral Piercing

H26 Robber's Personal Identification by Morphometric Analysis of Recorded Images

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The goal of this research project is to have participant follow a guideline for a correct personal identification of living person by the analysis of recorded images.

The author describes an objective technique for personal identification of living persons using morphometric analysis of images recorded both on files and on videotape of bank or store robbers.

The complete technique involves three steps: The **PREPARATORY PHASE** is necessary to study and to improve the robbery recorded images. The images showing a sharp location of the thief in the robbery place are selected and objectively improved. Then images showing a close up of the face of the robber are researched and, if available, are objectively treated and enlarged.

The **SUPERIMPOSITION PHASE** is the second step. It must be performed in the place where the robbery took place. The suspect must be cooperative. In this phase the suspect must be located exactly in the same place and with the same posture of the robber in the compared image. To carry out this second phase it is necessary to have complete access of the location where the robbery occurred and to use the same TV cameras that filmed the robbery. The TV camera must be placed exactly in the same position present as at the time of the robbery. Then the suspect can be filmed in the same location, position, and attitude of the robber in the frame analyzed. Thanks to a continuous mixing video, the image of the robber and the on time image of the suspect can be mixed, superimposed, and recorded. The suspect must be moved as a dummy to let him assume the same spatial attitude of the robber in comparison. The goal is to prove at first the somatic correspondence between the robber and the suspect. Then, if positive, the superimposition between the robber and the suspect facial images (if available) can be performed. Only in this way will it be possible to document an objective correspondence or a definite discrepancy. Limits and peculiarities of this phase are then described in detail.

The **METRIC IMAGE ANALYSIS** is the third step. It can be performed on the best output of the superimposition phase. Quantitative comparison can be done between the image of the robber's face and the image of the suspect's face. To perform this step it is necessary to clearly recognize at least five reference points on the robber's face using a suitable calculation program. The same points are marked on the image of the suspect's face obtained at the end of the best superimposition. The absolute and relative distances between the marked points, the perimeters and the areas of the triangles obtained by connecting the points and the compactness indices are automatically calculated on both images in analyses. So two series of five sets of numerical parameters can be obtained (absolute distance, relative distance, areas and perimeters of triangles, indices of compactness from both the faces of the robber and the suspect). The five sets are then compared to calculate the correlation coefficients. If the values of all the four correlation coefficients is > 0.99 a personal identification can be formulated on a mathematical basis between the suspect and the robber. When the numerical comparison phase cannot be carried out (i.e. when the robber's face is not so sharp to allow to mark the reference points), no sure and objective personal identification results can be lay out. A superimposition correctly conducted is essential for the following metric analyses of compared images.

The technique described is objective, repeatable, and not destructive. It is a necessary technical skill; no improvisation can be allowed.

The results obtained by the straight application of the described technique are considered as a proof by Italian Courts.

The author will report the results of 140 investigations on bank robberies carried out between 1991 and 2001.

Bank or Store Robbers Recorded Images, Forensic Image Analysis, Personal Identification

H27 Comparison of CT and MR Imaging Techniques to Traditional Radiographs in Human Identification

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The participant will have a better understanding the protocol and utility of three non-invasive imaging techniques: traditional radiography (x-ray), computed tomography (CT), and magnetic resonance imaging (MR). The goal is to demonstrate that the application of these techniques in establishing positive identification may vary when the investigator is presented with isolated bony elements compared to a situation in which the remains are fully fleshed or even partially decomposed.

Over time, there has been an increased likelihood that forensic investigators will encounter traditional radiographic images (x-ray) as well as images from more advanced imaging techniques, i.e., CT and MR, in the antemortem record. Therefore, it is imperative that the forensic investigator has an understanding of these image types, is able to recognize their antemortem and postmortem signatures, and can incorporate these images in their investigation. In a previous work by Slemmer and Marks (2000), a three-way comparison of imaging techniques was performed on isolated skeletal elements to identify inter-imaging techniques for estimating positive identification. A comparison of the antemortem and postmortem record generated from each imaging technique (x-ray, CT, and MR) revealed that of the three methods, x-ray provided the most accurate and simple means of estimating positive identification. Thus, postmortem imaging should not be more advanced than antemortem imaging when determining identification from isolated bony cranial and postcranial elements.

However, the forensic anthropologist is oftentimes presented with a fully fleshed or partially decomposed individual for identification. This situation may permit the investigator to utilize imaging techniques that better reveal soft tissue landmarks rather than bony or dental landmarks. In conjunction with the efforts of the medical examiner and law enforcement, the forensic anthropologist may find that in such cases, CT or MR operates with greater efficacy than traditional radiographs.

This study examines five fully fleshed and five partially decomposed individuals donated to the Forensic Anthropology Center at the Department of Anthropology of the University of Tennessee. An antemortem record for each individual was created at the University of Tennessee Medical Center in Knoxville using MR, CT, and x-ray images of the frontal sinus, dentition (root development and restorations), the knee (trabecular bone patterning), and at the location of any orthopedic therapies. A comparative framework of both soft tissue and bony structures was generated to correlate signatures across techniques. Next, the donated individuals were transported to the Anthropological Research Facility of the Department of Anthropology at the University of Tennessee for decomposition. Following this, a postmortem record was created for each individual by taking x-ray, CT, and MR images in the anatomical regions previously selected. An effort was then made to correlate bony structures across image types. Finally, imaging signatures in the antemortem and the postmortem records were compared.

Despite the limitations of traditional radiography, this image type again proved most useful in establishing identification from dental material and trabecular bone patterning when comparing the antemortem and postmortem records. This observation corroborates findings discussed in the clinical and academic literature. As a series of x-rays at specific intervals, computed tomographic images may be easily interchanged with traditional radiographic images in some cases. However, artefact glare from dental restorations and other therapies in CT images can significantly compromise image quality. Due to its very nature, MR may have the most limitations in a forensic setting. Magnetic resonance

imaging provides excellent detail in the areas where bone and soft tissue interface, but it is not well suited for use with skeletonized remains. With the increased commonality of non-invasive imaging techniques in the antemortem record, and their proven utility in a forensic investigation, a familiarity with both simple and more advanced imaging methods is essential for the forensic investigator.

Computed Tomography, Magnetic Resonance Imaging, Human Identification

H28 A Comparison of Facial Approximation Techniques, Part 2

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This study is an attempt to compare the different techniques for approximations, including drawings and computer-generated faces in two dimensions and models in three dimensions. These approximations include various techniques of artists from countries other than the United States.

After most methods for attributing personal identity to a set of remains have been exhausted, the most common final attempt is to manufacture an approximation of the face either in two- or in three dimensions. These approximations are then broadcast to the public over television and newspapers in an attempt to trigger recognition and clues to identity.

Identical plastic skull replicas of an identified individual were sent to volunteer artists, or were handed to them at the 2001 Academy meetings. The standard forensic anthropological parameters of the individual represented by the replica (age range, sex, ancestry) have been supplied to the artists, though the antemortem photographs will be withheld until the Academy meetings. The artist has been asked to use the technique most familiar to him or her. The approximations will be displayed at this year's meetings, and general attendees will be asked to complete a short questionnaire concerning the techniques used.

Facial Approximation, Human Identification, Facial Reconstruction

H29 A Comparative Study of Mammalian Cortical Bone

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The objective of this research is to present any potential statistical differences in the histological features of mammalian cortical bone.

The poster presentation will document the research done by Harald Horni for his Master's Thesis in Anthropology. This ongoing yearly research is an attempt to increase the available methods that can be used in identifying human remains. This study pertains to the forensic cases in which there is so little skeletal evidence (i.e., potential human remains) that identification of the remains cannot readily be done in the field.

Mammals found in the surrounding area of Lubbock, Texas were used in this study and include armadillos, cats (domesticated), coyotes, deer, goats, and pigs. In addition, human samples were also collected. Samples from all the major long bones, the humerus, the ulna, the radius, the femur, and the tibia, were used. These bones were used as they have a substantial amount of cortical bone cross-sectionally. The fibula was excluded. Teeth were also excluded, as their gross and microscopic morphologies are quite distinct from that of all other skeletal material. Though teeth last longer when exposed to the elements, the cortical bone was utilized as the research material as both human and non-human cortical bone is very similar at the gross morphological level. Thus, the distinction between human and non-human bone can be made.

These bones were cut into thin sections, using a standard bone cutting saw, and ground on a rotating polishing/grinding table. When the desired thickness of the thin-slides was achieved the samples were mounted onto microscopic slides for microscopic viewing. Under the microscope, histological features of the bone were studied. These features include the Haversian canals, osteons (primary and secondary), and the osteocytes. In an attempt to create a life-like scenario, as remains found in the field will be of unknown origin, sample areas were collected randomly from cross-sectional areas from all the long bones. These randomly selected areas, such as osteon densities, Haversian canal densities, and the osteocyte densities in all the respective mammalian samples were used in the data collection. Additionally, in cases where plexiform bone (which appears like stacked layers) was found, it was noted in which species it appeared, and a new random location was selected. This was done in order to assure human-like conditions throughout the samples, as plexiform bone does not appear in human bone.

The data collected from each species were then calculated, averaged, and standardized. The results of the non-human animal species were comprised into one average (\pm the standard deviation), as it was not the purpose of this study to calculate species-specific values from the non-human samples. Once this average was calculated, the non-human mammalian species were compared to the averages from the human data. The method of statistical differentiation can then be applied to the identification process using only limited amounts of bone. Hence, when in doubt about whether or not bones that are found are human, and, in association with a forensic/homicide case (as well as in archaeological scenarios), the bones can potentially be told apart using histological features. The histomorphological technique mentioned can be used to determine the difference between a potential legal investigation and that of a natural deposition of animal bone.

Bone Histomorphology, Human/Non-Human Identification, Human Remains

H30 Ankylosing Spondylitis in Three Forensic Cases

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The goals of this research project are to present the osteological marker of ankylosing spondylitis and the degree of variability noted in three forensic cases from the C.A. Pound Human Identification Laboratory.

Ankylosing spondylitis (AS) is the most clinically studied disease of all spondyloarthropathies (Ascari et al., 2001; Yacyshyn & Cohen 1999). Genetic studies have revealed that nearly 300,000 Americans exhibit AS with the HLA-B27 antigen being present in approximately 10% of healthy white Americans and nearly 3% of healthy black Americans (Laval et al., 2001; Ascari et al., 2001). Clinical studies have shown that males develop the disease two to three times more often than females and that males typically exhibit the most severe forms of the disease (Ascari et al., 2001; Yacyshyn & Cohen 1999). Ankylosing spondylitis usually begins during adolescence or young adulthood and rarely begins after 40 years of age (Yacyshyn & Cohen 1999).

Ankylosing spondylitis is characterized by inflammation and calcification of the axial skeleton and sacroiliac (SI) joints (Yacyshyn & Cohen 1999; Aufderheide & Rodriguez-Martin 1998). Hallmarks of this disease are unilateral or bilateral fusion of the SI joint (Ascari et al., 2001; Yacyshyn & Cohen 1999), calcification of the longitudinal ligaments, and bridging vertebral syndesmophytes (Aufderheide & Rodriguez-Martin 1998; Ortner & Putschar 1985). The latter two characteristics produce "squaring off" or "flaring" of the vertebral bodies, which give the spine the appearance of bamboo (Ortner & Putschar 1985). Spinal mobility becomes severely limited, being most evident as a decrease in extension and lateral flexion, loss of lumbar lordosis, thoracic kyphosis, and atlanto-

axial subluxation (Yacyshyn & Cohen 1999). Secondary manifestations of AS include diarthrodial fusion of rib heads to their adjacent vertebra, calcification of the costosternal junctions and roughening of the iliac crests, ischial tuberosities, and spinous processes (Yacyshyn & Cohen 1999).

From July 2000 through May 2001, three of ninety-six skeletal cases examined at the C.A. Pound Human Identification Laboratory exhibited either calcification of the axial skeleton, fusion of the SI joint(s), and/ or diarthrodial fusion of the ribs. All three cases were of elderly males, two being of European ancestry and the other being of African ancestry. The skeletal pathologies noted on these three individuals are characteristics consistent with the clinical and paleopathological markers of AS.

The first case was of an elderly black male who exhibited bilateral sacroiliac fusion and yet presented the least severe form of ligament calcification. Although no vertebral or rib ankylosing was noted, extensive calcification of the apophyseal joints of the lumbar vertebra and many of the other vertebral bodies was present. There was an absence of rib head to vertebra fusion. Secondary AS characteristics included marked roughening of the iliac crests and ischial tuberosities.

The second case was of an elderly white male who displayed the prototypical “bamboo-like” spine as a result of the nearly complete fusion of his spinal column. Extreme vertebral kyphosis was also present as was unilateral fusion of the SI joint, pronounced calcification of the thoracic supraspinous ligament and diarthrodial fusion of the left 12th rib. Interestingly, complete calcification of the transverse ligament for C1 led to ankylosing of this vertebra to the axis. Additional AS characteristics included associated changes to the ischial tuberosities and iliac crests. Proliferative calcification of the costal cartilage with fusion of two true ribs was also observed. Pronounced arthritic lipping, macroporosity, and deep grooves were present on the zygapophyses of L5 and S1. Such arthritic changes were possibly due to the AS induced spinal fusion.

The third case was also of an elderly white male. In this instance, however, the spine exhibited profuse vertebral fusion and “bamboo-like” spine. Marked kyphosis, scoliosis, and calcification of the thoracic segment’s supraspinous ligament were also observed. Extensive rib head to vertebra fusion (right ribs 6-10 and left ribs 8-10) and calcification of the costosternal cartilage were present. Of note was the absence of ankylosing spondylitis’ hallmark characteristic of sacroiliac joint fusion. Secondary AS characteristics included roughened ischial tuberosities and iliac crests. In addition, the odontoid process was fractured and did not unite to C2. The trauma to this bone may have been due to AS.

These three cases have presented a unique opportunity to observe the various skeletal manifestations of AS in a modern forensic sample.

Ankylosing Spondylitis, Bamboo Spine, Sacroiliac Fusion

H31 Forensic Anthropology in Portugal: The State of Knowledge

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The goals of this research project are to present to the forensic community the state of knowledge of forensic anthropology in Portugal.

With the recently creation of the National Institute of Legal Medicine in Portugal, forensic anthropology is witnessing an important new development. In the present paper we present how their service is organized, highlighting the most relevant cases analyzed. We are creating a forensic laboratory, and adopting standard protocols for the analysis of every set of non-identified human remains. The examples provided, namely three cases of positive identification, show the importance of the interdisciplinary work in the field of forensic anthropology.

Forensic Anthropology, Positive Identification, Portugal

H32 Thousands Dead: The Use of Stature in Individual Identification

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Upon completion of this presentation, the participant will understand the problems underlying the usefulness of stature in human identification in mass fatalities, such as those originated in cases of violations to International Humanitarian Law.

The role of forensic anthropology in the investigation of violations against International Humanitarian Law has become increasingly prevalent and important since the International Criminal Tribunals were established. Since 1996 the International Criminal Tribunal for Rwanda and that for the former Yugoslavia have examined thousands of cases representing approximately 5000 people from Rwanda, Bosnia and Herzegovina, Croatia and Kosovo. The role of anthropologists in these missions have ranged from the recovery to the analysis of human remains, and, in some cases, to the collection of antemortem (AM) information to be compared with AM and postmortem (PM) records. Some of the parameters usually compared include basic elements of the biological profile of the victim, such as age, sex and stature. The value of stature as a cornerstone of the biological profile of an individual rests on the assumption that there is a record against which an estimation of that stature can be compared. It has been shown, however, that the records generally do not accurately reflect the real stature of an individual (Snow and Williams 1971, Willey and Falsetti 1991). Moreover, if the self-perception of stature is potentially biased, how unbiased is the perception of an individual’s stature by others? In contexts outside the US, in the so-called Third World, for example, where all violations against International Humanitarian Law take place, the existence of documents of the deceased is more than often scarce and if present, serious doubts regarding the recorded stature should be cast. In these situations, the AM information is collected from survivors or relatives of the victims. For example, the relative being interviewed may say, “My father was as tall as you are.” In that case, the interviewer will make an estimate of the stature being referred to and write it down as such. The remains of the victims that we examine may carry ID papers; however, it is not certain whether those papers belong to that individual, the information in those papers varies and may or may not include stature, and most often victims of Human Rights violations have their identity papers taken from them.

The sample consists of cases from throughout Kosovo who were killed during the conflict between 1998-1999 (n= 83). Data was collected by international organizations from relatives or friends of the victims. The stature of each individual was calculated from the length of the femur and using three different stature formulae, including two that have been derived from population samples in the Balkans and one from an American Caucasoid sample. The mean stature derived from each formula was compared against the reported stature using one-sample t-tests. All three anthropological stature estimates differ significantly from the reported antemortem stature (p = <.000).

It is our view that the usefulness of stature in identification is not a mathematical but a theoretical problem. In other words, there should be a paradigm shift away from applying the methodology used in American casework to Human Rights cases. The estimation of stature should focus on developing an emic approach to the concept of identification, that is, one that eliminates the assumptions that everybody is killed with an ID paper, that the paper states the stature, that the paper is their own, that the survivors know the stature of the victims, or, that the number and identity of victims are known. The fact remains clear that the stature being referred to is an abstraction of the “perception” of stature by the person being interviewed. Therefore, the weight given to the stature estimate in these cases should be shifted away from the “four cornerstones” of individual identification to a secondary role, one in which the group identity is

outlined first (i.e., discriminating the very tall from the very short) and from where individual identification can start using other parameters that relate more directly to witness statements (i.e., old trauma, clothing, etc.). This would mean first creating group identification (i.e., younger aged males, between such-and-such age and height) and later individual identification. The views expressed herein are those of the authors above and do not necessarily reflect the views of the ICTY or the UN in general.

Stature, Mass Graves, Identification

H33 The Analysis of Ancestry From Skeletal Remains and the Treatment of the Race Concept by British Forensic Scientists

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This presentation reviews the treatment of the concept of human races, the analysis of morphological variation, and the use of principle division of racial variation and ancestral affiliation among British forensic scientists. Data concerning these issues were obtained from responses to questions on a questionnaire survey administered during early 2001. The discussion will also provide insight on the evolving role of forensic anthropology in medical-legal casework in the United Kingdom.

The concept of race as a taxonomic reflection of human biological variation has been abandoned by many anthropologists, including but not exclusively by anthropologists involved in teaching or research in human identification of forensic remains. Critical discussion of the validity of the race concept has been focal to American forensic anthropology, while it has been relatively ignored by British and Continental forensic scientists. This undoubtedly stems at least in part from the Eugenics movement in Europe in the early twentieth century, and as a result of the holocaust and other atrocities committed during the Second World War. However, since the 1950s the United Kingdom has experienced an influx of immigrants from former colonies of the British Empire, especially from the Indian subcontinent and Africa, and more recent immigration from the Caribbean and the former Yugoslavia. This has led to an increased use of racial and ethnic identifiers by the British Foreign and Home Office, Police and the public in general. As Kennedy (1995) and Sauer (1992) have pointed out, scientists involved in forensic identification are required to use biological characteristics of unidentified skeletal remains to derive a race term or designation that was culturally applied by friends, relatives and others to a missing person in life.

The current study consisted of a questionnaire survey completed by the University of Bradford Department of Archaeological Sciences in early 2001. The study consisted of a series of 16 direct and interpretative questions in a yes/no and multiple-choice format. The questionnaire was sent via e-mail and mailed to 50 University lecturers and professors in the United Kingdom (England, Scotland and Wales) and to a small number of privately employed osteologists and biological anthropologists. University lecturers were targeted primarily in departments offering biological anthropology or osteology courses. A small number of forensic pathologists and odontologists were also included in the survey. Responses were received from 20 of the 50 scientists surveyed, yielding a 40% return rate. While this is not ideal, it is an acceptable rate of response for mail questionnaires among specialist populations (Moser and Kalton 1997).

Results of the study were mixed since not all respondents chose to answer every question on the questionnaire. For example, the third question "Do races exist (e.g., as a reflection of the biological variation in human populations)?" was answered by less than half (45%) of respondents. To this question, approximately 77.8% of the scientists said yes, while 22.2% said no. On the other hand, 85% of respondents chose to answer question 8a "Do you think racial/ancestral assessment of uniden-

tified skeletal remains is a scientifically useful concept?" To this question, approximately 53% of scientists said yes, approximately 29% said no, while 18% of the scientists remained neutral. The second part of this question "Do you feel it (race/ancestry assessment) is necessary as part of your analysis of unidentified skeletal remains?" was answered affirmatively by approximately 57% of the scientists, negatively by 11%, while 32% answered neutral. A majority (58%) of the scientists stated that they had undertaken forensic casework for the police or other medical-legal agencies, while 42% had no experience. Of the 45% of scientists who answered question 5a, approximately 55.6% stated that they relied principally on the cranial skeleton for racial assessment in forensic casework, while approximately 44.4% of scientists relied on both the cranial and postcranial skeleton. However, only 25% of the scientists chose to answer question 5b on the specific features or traits of cranial remains most relied upon. For question 5c "In your analysis of racial variation and/or ancestral affiliation, do you emphasize three or more principle divisions?" approximately 44.4% of scientists use the three principle divisions Mongoloid (southeast Asian), Caucasoid (White), Negroid (African/Black) in forensic casework, while 55.6% used more than three racial subdivisions.

In answer to Question 6a "In your teaching do you emphasize the concept of biological variation by race and/or ancestry?" approximately 65% of scientists answered yes, while approximately 35.3% answered no. Of those scientists who teach the race concept, approximately 28.6% emphasize the three principle racial divisions while 71.4% emphasize a greater number of subdivisions. However, only a minority of respondents (35%) chose to answer this question. Finally, question 7 "Do you think the use of principle racial and/or ancestral divisions is beneficial to the analysis of skeletal remains (e.g., for the determination of a biological profile)?" was answered affirmatively by approximately 58.8% of scientists, while approximately 11.8% answered no and 29.4% answered neutral.

These results are preliminary because of the relatively small sample of scientists who participated in the survey. However, the results suggest that, of the respondents to the questionnaire, the majority of British scientists teach some form of the race concept within the field of human biological variation. A smaller majority of these scientists assess the race or ancestry of unidentified skeletal remains in their forensic casework, although even fewer of these scientists consider the concept of human races to be scientifically valid. This study may prove useful as a baseline for a more detailed future questionnaire survey, with increased sample size and response rate, and for comparison with the larger American forensic anthropology community.

Forensic Anthropology, Race Concept, Questionnaire Survey

H34 Differences in the Os Coxa Between Blacks and Whites

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Attending this presentation the participant will: 1) achieve a greater appreciation for racial variation in the size and shape of the os coxae between blacks and whites through the use of measurements previously applied in studies of sexual dimorphism, and 2) explore logistic regression modeling as an alternative approach to traditional discriminant function analysis in predicting group membership.

Literature review of the anatomical and sports and exercise science journals presented evidence of musculature size and/or distribution differences between blacks and whites. Based on a specific research finding of increased cross-sectional area of the psoas major muscle in blacks when compared to whites and an understanding of the relationship between the pelvic musculature and the os coxa, a hypothesis was presented that the os coxae of black individuals will display greater depth and/or distance

measurements along select points of the anterior border and iliac fossa while taking into account racial size differences in the os coxa.

The psoas major muscle originates from the transverse processes, bodies, and intervertebral discs of the twelfth thoracic through the fifth lumbar vertebra. The iliacus muscle originates from the iliac fossa and is closely related functionally to the psoas major muscle. The fibers of the iliacus and psoas major muscles join together to pass under the inguinal ligament and over the anterior border of the os coxa to become the iliopsoas muscle, and inserting by way of a common tendon onto the lesser trochanter of the femur.

To test the hypothesis, the os coxae of 41 modern American black males and 61 white males from five separate donated and forensic collections—the William M. Bass Donated and Forensic Skeletal Collections at the University of Tennessee, Knoxville; and the skeletal collections housed at the Hamilton County Office of the Medical Examiner in Chattanooga, Tennessee, the FACES Laboratory at Louisiana State University, Baton Rouge, and the Office of the Chief Medical Examiner in Chapel Hill, North Carolina—were analyzed for racial differences. Nineteen length and depth measurements were taken with a coordinate caliper or osteometric board and eight indices computed. The nineteen measurements were subjected to discriminant function analysis and the total canonical function evaluated for overall os coxa shape differences. The twenty-seven variables were then subjected to t-tests on the means and variable selection techniques to obtain an optimal model for group separation. Two separate methods of functional modeling were employed for classification—discriminant function analysis and logistic regression—and the cross-validation classification of the two functions were compared to see which form of modeling produced the greatest accuracy.

The statistical results of this study reflect both size and shape differences in the os coxa between blacks and whites. Overall increases of size and robusticity of the white pelvis, compared to the black, have been reported by several researchers. This was verified by the statistically significant size increases in white males for fourteen of the nineteen variables. Variables that showed nonsignificant increases were the distance from, and the depth of the notch between, the anterior inferior iliac spine to the iliopectineal eminence ($p=0.7085$ and $p=0.9119$, respectively), and the depth of the notch between the anterior superior iliac spine and the iliopectineal eminence ($p=0.4673$). A nonsignificant decrease was found in the distance between the anterior inferior iliac spine and the iliopectineal eminence ($p=0.9383$) and a small, however nonsignificant, decrease was found in the depth of the notch between the anterior superior and inferior iliac spines ($p=0.0803$). With the exception of the depth of the notch between the anterior superior and inferior iliac spines, these measurements all lie in the central portion of the os coxa where the iliopsoas muscle passes over the anterior pelvic brim.

Both stepwise discriminant analysis and logistic regression using stepwise selection selected the same four variables for the construction of an optimal model for group prediction. These variables emphasized the greater distances in whites between the anterior superior and inferior iliac spines and between the anterior superior iliac spine and point ilioauricular—a point on the ilium where the iliac tuberosity, fossa and auricular surface meet—the greater depth of the iliac fossa as projected between the anterior superior iliac spine and ilioauricular points, and the lesser depth of the notch between the anterior superior and inferior iliac spines when compared to blacks.

Evaluation of the four-variable model for prediction accuracy using the discriminant function resulted in correct classification of 75.6% of black males and 90.2% of white. In comparison, a logistic regression model resulted in correct classification of 73.2% of black males and 93.4% of white.

Conclusions: 1) Although the os coxa of white males was significantly greater in almost all dimensions measured, an increase in overall size did not result in a corresponding size increase in the central portion of the os coxa. 2) Based on only four measurements on the os coxa and using

cross-validation, discriminant function analysis classified 82.9% of males correctly and logistic regression 83.3%. These accuracy rates have only been equaled by measurements of the cranium or femur, or surpassed by using a combination of postcranial elements.

Discriminant Analysis, Logistic Regression, Os Coxa

H35 An Assessment of Craniofacial Nonmetric Traits Currently Used in the Forensic Determination of Ancestry

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The primary goal of the current study is to provide more precise anatomical description and distribution of five craniofacial nonmetric traits commonly used in ancestry determination.

The determination of ancestry in the human skeleton – almost exclusively, the cranium – relies upon the combination of the assessment of the configuration of a number of unique morphological features (nonmetric traits) and the metric analysis (especially multivariate analyses) of the shape of the skull. Although nonmetric traits have proven rather effective in predicting the ancestry of an individual skull, success often relies almost exclusively on the experience of the observer rather than on objective comparisons to rigorous, well-conceived descriptions. Considering these deficiencies in the existing body of data, 17 cranial nonmetric traits were carefully documented for 762 individuals from 25 populations throughout the world (Caucasoid, $n = 185$; Mongoloid, $n = 397$; Negroid, $n = 180$) curated at the Smithsonian Institution and the Mercyhurst Archaeological Institute of Forensic Anthropology/Osteology Laboratory. In this presentation, discussion will focus on the morphological variations and distributions of five of the better known cranial traits. The traits include the *inferior nasal aperture morphology*, *nasal bone external surface contour*, *nasal aperture width*, *interorbital breadth*, and *post-bregmatic depression*. Each of these traits has been used extensively in ancestry determination, however, there has been only minimal effort to: 1) describe the morphological variants (i.e., character states) of each of these characters; 2) analyze the distribution of these character states within each defined population; and 3) provide correlation quotients for multiple traits. The range in variation of these characters is often not considered in the analysis of ancestry. This is inappropriate due to the fact that nonmetric traits are the result of polygenic control, and, therefore, consist of high inter- and intra- population variability.

The analysis consisted of a number of stages. First, each major trait was examined and common variants (character states) were determined. Next, new anatomical terms were developed, where necessary, for character states not previously described. Each major trait was scored on a 5-level scale which allowed for the scoring of a range of intermediate morphologies. In this manner, each trait was scored progressively (i.e., inferior nasal aperture morphology was scored: gutter = 0; incipient gutter = 1; straight edged, or blurred = 2; partial sill = 3; and sill = 4). Finally, in an attempt to quantify this morphological variability, standard distribution frequencies for each of the character states were calculated for the populations. In addition, tetrachoric correlation computations for all traits were used to determine population inter- and intra-variability.

Results indicate that the more common nonmetric cranial traits historically used in the determination of ancestry do correlate well with the three main ancestral groups. The nasal bone external surface contour of the Mongoloid sample ($n = 397$), for example, revealed somewhat expected results. Generally thought to possess nonmetric traits intermediate to Caucasoid and Negroid, nasals of the Mongoloid sample scored highest in the following variants: intermediate quonset [1] (27.4%), tented [2] (23.3%), or vaulted [3] (34.1%), where vaulted refers to a steep sided, flat nasal bone structure intermediate to tenting and steepled. Initial

results also indicate high correlations for most traits between ancestry groups. For example, the tetrachoric correlation of inferior nasal aperture configuration and nasal bone external surface contour in Caucasoids and Negroids is statistically significant ($r = 0.727$; $p < 0.05$), indicating a strong correlation between the two main variations found in each group – specifically, nasal guttering with quonset hut nasals in Negroids (66%), and nasal sill with steeped nasals in Caucasoid (60%). It is suggested here that those traits that show statistically significant correlations can be used to develop suites of characteristics which can be utilized to increase the probability of correctly placing unknown crania into their proper ancestry affiliation. Although such suites of characteristics exist in the literature, no attempt has been made to pool various traits which show statistical significance in their frequencies within a given population.

The production of much more detailed, anatomically-established descriptions representing the range of variation in the morphologies of these particular traits, combined with an understanding of the distribution frequencies of both the individual traits, and the traits in combination, has the potential to greatly enhance the forensic anthropologist's ability to determine ancestry from the human skeleton. This research has been partially funded by the Forensic Sciences Foundation in the form of a Lucas Research Grant.

Ancestry, Nonmetric Traits, Cranial Variation

H36 Population-Specific Identification Criteria for Cuban Americans in South Florida

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The goals of this research project are to present results of 3-D scaling procedures for the mid-face of Latin American populations and discuss how they relate to the identification of unknown human crania.

Learning Objective: to present results of 3-D scaling procedures for the mid-face of Latin American populations and discuss how they relate to the identification of unknown human crania.

Identification criteria, specifically discriminant function formulae derived from traditional craniometrics, currently used in South Florida for Cuban Americans and other "Hispanic" groups, are unsuitable to provide adequate biological profiles due to complex biological histories as well as widely diverse geographic origins. Florida's total population is approximately 16 million (15,982,378) individuals. Of the total population 2,682,715 or 16.8 percent % are self-identified as "Hispanic." South Florida (herein defined as Miami-Dade, Broward and Collier Counties) is home to 60 percent % of the total Hispanic population of Florida with 1,291,737 (48.15 percent%) residing in Miami-Dade County.

The Hispanic population of Miami-Dade County makes up 57.0% percent of the total population of 2,253,362 million. Each recognized sub-group of Hispanics (Mexican, Puerto Rican, and Cuban) includes its own geographic point-of-origin and population history. Cuban-Americans (arriving in the late 1950's and early 1960's) make up the largest sub-population of Florida's Hispanics in any county and in Miami-Dade number 650,601 or 50.51 percent of the total Latin population. The arrival of over 124,000 Marielitos between April and September of 1980 greatly increased the phenotypic (and geographic) diversity among South Florida's Hispanic groups. Additionally, as in other agricultural states, Florida has a very large population of un-documented workers who primarily arrive from Texas and points south of the Straits of Florida.

Thus, the application of the available traditional craniometric and non-metric methods are not appropriate for South Florida's Latin population. In order to address this issue in relation to South Florida's Cuban population, we present an analysis of the among-sample shape -

cranio-facial shape variation within and among a 19th Century Cuban sample (N=20), 17th Century Spanish sample (N=94), a prehistoric Cuban sample (N=22), and Terry Blacks for comparison using methods from the geometric morphometrygeometric morphometric methods. Procrustes superimposition and the thin-plate spline (tps) approaches analysis (a deformation based technique) were applied to investigate levels of admixture in contemporary Cubans. A Microscribe 3-D digitizer was used to collect Cartesian coordinates for 25 homologous cranio-facial landmarks using the software *3-Skull-FORDISC*, developed by Stephen D. Ousley.

Following After digitizing the skulls, it was necessary to translate, scale, and rotate each configuration of points so that all skulls would be of comparable size, location, and orientation. To perform these transformations, a generalized least squares (or GLS) approach superimposition was used that minimizes the sum of squared distances between homologous landmarks for all skulls. The GLS superimposition and tps analysis were performed by using *Morpheus et al.*, a cross-platform program written by Dennis E. Slice, which is and available for downloading from the SUNY-Stony Brook Morphometrics homepage. The significant biological shape differences are presented using 2-D graphical representations. Sample covariance structure was compared and In addition, a non-parametric MANOVA was performed on the scaled, translated, and rotated coordinates to test for among-group variationmean shape differences. Significant biological shape differences and patterns of variation are presented using 2- and 3-D graphical representations.

Identification Methods, 3-D Coordinate Data, Hispanic Populations

H37 Age Estimation by the Examination of the Endocranial Sutures Closure: A North-African Adult Population Study

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This presentation represent an anthropological study of the evolution of the endocranial sutures closure, according to the age, in a North-African adult population and its eventual application as a method of aging.

Our study is a prospective (between October 1998 and May 2001) of endocranial sutures of 259 skulls of persons of a known age at the time of death. 236 of them were adults (15 years or older). The endocranial sutures were divided in segments: four segments for the sagittal suture, three for the coronal suture, three for the lambdoid suture, two for the frontal suture and one for the temporoparietal suture. Each skull was observed by two examiners and a quotation from 0 to 4 was assigned to each segment of suture according to its degree of closure (degree 0 corresponding to a completely open suture, the degree one corresponding to a beginning of synostosis, degree two corresponding to a synostosis with visible traces, degree three corresponding to a blurred suture, degree four corresponding to completely closed suture without visible traces). The software EPI-INFO version 6.04bft studied the statistical data. According to khi2-test, a correlation between endocranial sutures closure and age was considered statistically significant for a value of $p < 0.05$.

Results: The degree 2 of one segment closure of the sagittal, coronal or lambdoid sutures was significantly correlated with age between 16 and 30 year-old ($p < 0.0000001$). For persons older than 50 year-old, the degree 4 of closure of three segments of the skull, involving the sagittal, coronal and/or the lambdoid sutures had a significant correlation with age ($p < 0.0000001$). There was no statistical difference between males and females. Endocranial sutures closure was not correlated with age ranges from 31-50 years. Examination of the frontal and the temporo-parietal sutures cannot be used in age estimation in adults because of their early closure.

Conclusions: A correlation between endocranial sutures closure and age was found for some age ranges. Nevertheless, this study has shown that age estimation by cranial sutures closure is not always reliable and that it must be combined to other methods for a better approach of this evaluation.

Forensic Anthropology, Age Estimation, Endocranial Suture Closure

H38 Accuracy of Age at Death Estimates Derived From Human Cementum Increments

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Upon completion of this presentation, attendees will understand how to present the results of research into the use of human cementum increments for age at death estimates and offer direction for future research.

Physical Anthropologists have greatly improved the accuracy of age at death estimates throughout the last century; however, adult age estimation remains to be one of the most problematic aspects of skeletal analysis. In the search for improved techniques, many researchers within the past 20 years have obtained promising results counting the incremental lines found in human dental cementum, a method borrowed from wildlife biology. The application of this technique to human remains is controversial due to conflicting results by various researchers, as well as the unknown etiology of cementum increments. Unfortunately, studies have utilized very different methodologies limited by the cost and availability of equipment, making comparison of results difficult. In addition to the technical difficulties, no study, to date, has tested the technique on a large well-controlled sample of forensic origin (the target population). Past samples have generally been clinical in nature.

In order to assess the accuracy and feasibility of using cementum annulations in the routine forensic setting, a forensic sample of 52 first mandibular premolars, from known white males ranging in age from 18-62 years (mean age 36 years), was tested using what were purported to be the most reliable methods available. Demineralized, 5 μ m longitudinal sections, stained with cresyl fast violet were analyzed with a Zeiss standard trinocular light microscope at x400 magnification. Specimens were analyzed in four different groups, progressively weeding out those with conditions that have previously been shown to affect the growth of cementum (such as periodontal disease and caries) as well as those exposed to heat or chemicals which might affect their affinity for the stain. Results were poor relative to many previous studies. Correlation coefficients ranged from only $r=0.45$ to $r=0.72$ for the groups analyzed, progressively improving as those with previously mentioned conditions were removed from the sample. Although p-values significant at the $P>0.05$ level for three of the four groups analyzed support the presence of a relationship between number of incremental cementum lines and age at death, the relationship is not strong enough to be of value to forensic anthropologists. Intraobserver error for the number of incremental lines counted was also problematic. The correlation coefficient between counts was only $r=0.72$. This is due to the poor affinity for the stain in many specimens.

It is the opinion of the authors that the poor results obtained in the present study reflect the importance of testing methodologies on the target population. The methodology utilized by this study, as well as many other investigations of cementum increments, is reliant on the integrity of the soft tissue component of the tooth, collagen. Although most of the collagen is most certainly present, the slightest chemical alteration may affect the ability of a stain to clearly differentiate the histologic structure in question, especially when such a high degree of resolution is necessary. Innumerable variables may affect the physical and chemical properties of skeletal material during the postmortem interval. With the exception of Condon and colleagues (1986), samples for previous studies, obtaining

much better results, were composed almost entirely of clinical extractions which had been immediately fixed in formalin. The postmortem interval, prior to fixation, for the specimens tested in this study was well over a decade for 46 of the 52 specimens. It is felt that future research utilizing hard tissue techniques (i.e., acid-etched thick sections) and a large sample of forensic origin would provide the most insight into the utility of this technique.

Age Determination, Cementum, Cementum Annulations

H39 Age Estimation From Long Bone Lengths in Forensic Data Bank Subadults: Evidence of Growth Retardation and Implications of Under Aging

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This presentation examine the aging of subadults utilizing long bone diaphyseal lengths in the Forensic Data Bank (FDB) and comparing them with previously published longitudinal and cross-sectional data. This study finds that the FDB subadults exhibit growth retardation which may lead to under aging.

In the identification of subadults, lack of secondary sexual characteristics can make sex estimation difficult, even impossible leaving age estimations critical in order to search through missing children reports. Measurements of the long bones may accurately be used to assess the age of subadults when the dentition or epiphyses are not present (Hoffman 1979, Pfau and Sciulli 1994, Ubelaker 1974). The samples from which these standards are derived are often population specific with regards to ethnic affiliation and socioeconomic class. Hoffman found diaphyseal long bone length to be a good age estimator for individuals between the ages of two months to twelve years, a technique that correlates well with dental development. However, Hoffman uses long bone lengths from white middle class subadults attained from the Denver Human Growth and Development Longitudinal Study (McCammon 1970) to assess the age of subadult forensic skeletons. This is a technique which only ages children 2 through 12 years and may not correctly age subadults from differing socioeconomic classes.

The initial phase of this research compared the FDB subadult long bone lengths to long bone lengths obtained from the Denver Human Growth and Development Longitudinal Study (McCammon 1970). The FDB sample consists of cross-sectional data with 46 positively identified white children, 17 males and 29 females with known ages at death ranging from 0.3 to 18 years of age, the majority being homicide victims. The long bone lengths for the FDB come from maximum lengths taken directly from the humerus, radius, ulna, femur, tibia and fibula. These measurements were taken by various researchers from around the country and sent to the FDB. The Denver Growth Study sample consists of longitudinal data for 334 individuals comprised of healthy white males and females from 0.2 to 18 years of age. Long bone lengths of the humerus, radius, ulna, femur, tibia and fibula for the Denver sample were obtained from radiographic measurements taken "parallel to the long axis of the bone from the most proximal edge to the most distal edge of the diaphysis (McCammon 1970:161)." Corrections were made for radiographic enlargement. Up to the age of 12 years, bones were measured with epiphyses, and, at 12.6 years, without epiphyses.

The Denver study contains only means, standard deviations and percentiles. Therefore, the Forensic Data Bank long bone lengths were plotted against the Denver data. Plotting the known ages at death of the FDB sample against the Denver sample indicates the FDB sample is not normal regarding long bone length, with the exception of the radius and ulna. FDB male long bone lengths tend to fall within the normal range before the age of 12. begin to fall below the mean. After the age of 12 the females tend to fall within normal range before the age of 9, and to fall below the mean after age 9 begin.

Since the Denver data stems from a healthy middle class sample, a more socio-economically diverse sample was obtained from the Franklin County Coroner in Ohio (Pfau and Sciulli 1994). The Ohio sample consists of radius, ulna, tibia and fibula long bone lengths taken from radiographic measurements of children who died from all manners of death during the months of July 1, 1990 through June 30, 1991 (Pfau and Sciulli 1994). Only the accident victims, 30 white males and 7 white females, were used in this sample with the reasoning that they are less likely to suffer nutritional or physical stress, which could possibly cause growth retardation (Floud, 1992, Wales 1992).

The comparison of the FDB subadult sample to the Denver and Ohio samples demonstrates that the FDB is not a normal sample. Female FDB long bone length observations start out in the Ohio range and begin to fall below the Ohio observations around the age of 9. Male FDB long bone lengths start out below and stay below the Ohio observations.

Analyses of FDB, Denver, and Ohio subadults conclude that the FDB subadults exhibit growth retardation in long bones, and aging them with non-diverse samples with regards to socioeconomic class and manner of death could lead to under aging.

Subadult, Growth Retardation, Age Estimation

H40 Quantitative Analyses of Human Pubic Symphyseal Morphology Using Three-Dimensional Data: The Potential Utility for Aging Adult Human Skeletons

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The goals of this presentation are to present results of on-going research attempts to quantify the age-related skeletal changes that occur to human pubic symphyses.

Forensic anthropology traditionally relies on 2-dimensional (2D) techniques to analyze the complex 3-dimensional (3D) shape of human bones. Standard osteometric equipment includes sliding calipers, spreading calipers, osteometric boards, coordinate calipers, and the head spanner. This equipment is insufficient for adequately measuring, recording, classifying, and representing complex 3D data.

The Partnership for Research In Stereo Modeling (PRISM) at Arizona State University is currently undertaking the 3-Dimensional Knowledge (3DK) and Distributed Intelligence project. The focus of this project is on researching and developing the technology required to aid in the acquisition, representation, query, and analysis of 3D information. The Kernel represents a software library being created by PRISM to facilitate analysis of 3D data sets. Automation of tedious data processing tasks and the ability to support new techniques for the visualization, modeling, and quantification of 3D data are provided by the computational and analytical power of the Kernel. One aspect of on-going research at PRISM applies to forensic anthropology. Specifically, morphological bone features currently best described as qualitative data are targeted and methods are developed to enable successful extraction of quantitative data.

Establishing the age-at-death of an individual from skeletal remains is a critical component of forensic anthropology. One of the most reliable methods for estimating age-at-death of adults is based on the morphological changes of the pubic symphyseal face. Several aging methods based on pubic symphysis morphology have been presented over the past eighty years, however, the majority of these represent refinements of the original method described by Todd (1920). Today, especially in North America, the Suchey-Brooks method of aging the os pubis is the most widely accepted and utilized. Their method involves the use of special casts that illustrate the bony changes through different age categories for males and females respectively. There are twelve casts for each sex and these are subsequently divided into six age stages with an early and late stage of development represented.

This paper presents the results of analyses attempting to quantify the age-related changes that occur to the human pubic symphysis as displayed by the Suchey-Brooks casts. The age changes examined in this study include the following qualitative features: ridge-and-furrow system, dorsal margin, dorsal platform, ventral rampart, ossific nodules, rim, and delimited extremities.

The analyses were conducted in the following manner: first, all twenty-four male and female pubic symphysis casts developed and described by Brooks and Suchey (1990) and Suchey and Katz (1986) were scanned using a 3D laser scanner to accurately acquire the 3D data; second, each pubic symphysis was geometrically modeled from the scanned images enabling essential shape characteristics, including curvatures, of the scanned cast to be extracted and quantified; finally, the resulting virtual 3D symphyseal faces were analyzed using various geometric analytical techniques in an attempt to extract quantitative data best representing the qualitative features of interest. Using a common set of algorithms, complex 3D features can be consistently extracted in the form of workable quantitative data. The paper will present preliminary results from the quantification of these 3D bone features. The utility of a quantitative approach and how 3D analyses can simulate the accuracy levels of experienced forensic anthropologists qualitatively aging human skeletal remains will also be discussed.

The ability to quantitatively describe the age-related changes to the pubic symphysis may provide the potential for future refinement of the method. Other subjective aging methods (e.g., use of the auricular surface) may also be better understood through 3D analyses. In its continuing research, PRISM plans to develop a computerized database of 3D pubic symphyseal faces from individuals of known age-at-death, sex, and biological affinity. It is hoped that this work will lead to further refinements of the pubic symphysis aging method, especially in regard to differences between populations, as well as serving as an education and research tool.

Skeletal Aging, Pubic Symphysis, Adult Age-at-Death

H41 A Refinement of the Todd Method on a Sample of Modern Humans

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The goals of this research project are to determine if numerical scoring of traits used in the Todd method for estimating age at death from the pubic face could increase the accuracy of estimates of this demographic parameter.

Research was undertaken to provide more verification of the reliability of the Todd method for estimating age from changes in the symphysis of the pubic bone. Data were gathered on 124 pelvises from persons of known age at death from the Maxwell Museum of Anthropology's osteological collection housed at the University of New Mexico. Approximately two-thirds of the samples were male, with the remaining one-third female; in addition, roughly three-quarters were of White ancestry, one-quarter Asian, and less than one percent Black. The features of the os pubis (e.g., symphyseal face, upper extremity) were broken down into component parts (e.g., dorsal aspect: outline, plateau, ridge) and were then assigned a number corresponding to their degree of development. These numerical scores were compared with both Todd phases and age-at-death to determine if this method could improve age assessment. On average, estimates of Todd phases derived from analysis of pubic faces coincided well with given age. Also, there was good agreement between phases derived from the left bone when compared with that estimated from the right bone. Other findings, as well as problems encountered, are described.

Todd Method, Pubic Face, Age-at-Death

H42 Age Estimation From Pubic Symphysis

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The goals of this research project are to present to the forensic community the usefulness of the pubic symphyseal surface as a reliable criteria of age estimation and to present the variations observed when the western standards are applied to Indian bones.

Establishment of the identity of an individual is of utmost medico-legal significance. Age is an important criterion for identification. The present study was carried out to study age-related metamorphic changes at the symphyseal surface of pubic bones in Indians and to see whether they show a similar variation when compared to western standards. These changes have been compared with that of Todd's phase system for white males, McKern and Stewart's three component system with five active developmental stages for males, and the method of Hanihara and Suzuki who studied Japanese pubic bones using multiple regression analysis and quantification theory model.

Eighty-two pairs of male pubic bones were collected from autopsy cases at Lady Hardinge Medical College and Associated Hospitals. The age was precisely recorded from the police records and further verified from municipal corporation records. The following features were recorded on the symphyseal surface: (1) Ridges and furrows, (2) Dorsal margin, (3) Ventral beveling, (4) Lower extremity, (5) Ossific nodule, (6) Upper extremity, (7) Ventral rampart, (8) Dorsal plateau, and (9) Symphyseal rim. Varying combinations of these features were used as criteria for age estimation of the subjects.

The sample spans a range of 12-75 years with the highest concentration in the twenties (38%). It was found that the symphyseal surface remains convex up to 19 years and becomes flat after 27 years. The ridges and furrows are distinct till 17 years of age in males. The furrows become shallow between 18 to 26 years and disappear after 27 years. The dorsal margin appears by 12 years in males and is complete after 18 years of age. The dorsal plateau starts forming from 18 years in males and is complete after 35 years of age. The ventral beveling starts forming after 20 years in males. The ventral rampart appears after 20 years in males and is well developed after 35 years of age. The inferior extremity shows its definition after 18 years in males and is well defined after 30 years. The superior extremity starts its definition after 22 years in males and is well defined after 35 years. The symphyseal rim starts its formation by 12 years in males from the lower part of the dorsal border. It starts on the ventral half after 20 years in males and is complete by 39 years. The rim starts to break down after 30 years, with 65.5 % of males over 39 years showing this feature. The ossific nodules are observed from 18 to 50 years in males. Lipping on dorsal is observed above 30 years in males with 72.7 % of case above the age of 45 years showing this feature. The disfigurement appears in 3.5 % of males above the age of 40 years. Variations on the two sides right and left, are noted in 34.1 % of males. The variations observed in the progression of metamorphic features can be attributed to environmental and dietetic factors.

By comparing the progression of various metamorphic changes, it was found that Todd's criteria tended to over age the Indian bones. When compared to McKern and Stewart's Component stages, the development of dorsal margin is earlier in Indian bones. However, the completion of the dorsal plateau is delayed. The completion of ventral beveling and rampart is delayed against the formation of symphyseal rim, which starts earlier, but completes later in Indian bones. According to McKern and Stewart's Symphyseal Score method the metamorphosis in our series sets in earlier by 1-3 years, but the various bony features like dorsal plateau are found at a later age. When compared to the method of Hanihara and Suzuki using MRA, there is an over estimation until 30 years of age and under estimation between 31 to 39 years, The estimation becomes unreliable after 39 years of age. By using QM 1 method of Hanihara and Suzuki, the ages are overestimated until 30 years of age, while they are underestimated between 31 to 39 years of age.

Age, Pubic Symphysis, Parameters

H43 Aquatic Decomposition Rates in South Central Louisiana

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The goals of this research project are to track aquatic decomposition rates in the southeast.

Currently, little existing data provide insight into the postmortem interval (time since death) of human remains found in an aquatic environment in the southeastern United States. Though limited research on aquatic decomposition has been conducted in South Carolina and Tennessee, neither of these studies addressed such decay in a natural, freshwater setting, a lake. Therefore, this project focused on freshwater decomposition rates in subtropical Louisiana and also evaluated the effect of geographic location and temperature on such decomposition.

Decomposition studies using pig carcasses began in early February 2000. The site chosen for the project was the Louisiana State University Aquaculture Research Facility. The lake at the facility is a seventeen-acre, man-made lake stocked with perch, bass, catfish and various other animal life associated with a lake environment. The second area where research was conducted is a pecan grove located one half mile from the Aquaculture Center. This site is a sparsely wooded farming area with a creek bed located along the edge of the property. Both sites have cow pastures situated approximately 800 feet from the study area.

One month prior to the beginning of the project, a 40-foot dock was constructed on the northeast side of the 400-foot-wide X 2000-foot-long lake. Two male and two female domestic pigs, *Sus scrofa*, were used in this project. The four 40-pound (18.14 kilograms) pigs were injected with 4cc of Benthanasia-D®. A cage mechanism, attached to a winch on the end of the dock, housed one of the four pigs. The second and third pigs were placed in the lake without a cage and were rowed to their respective locations. The manner in which the second and third pigs were placed symbolized a homicide situation. Nylon rope was tied around their mid-section and two front legs. One pig had a cinder block tied to the opposite end of the rope to simulate a victim being weighted down before being dumped. The other pig had a buoy tied to the end of a rope. The buoy was lightweight and helped to track the pig. This third pig represented a victim who might be thrown into the water and left to the natural elements. The fourth pig was placed in a cage located in the pecan grove. Daily observations were recorded for the first two weeks, followed by observations every other day for two weeks, and finally, once a week for the last eleven weeks of the experiment. Visual observations were recorded for all four specimens; however, the only carcass that was physically touched was the land pig in order to record various species of arthropods beneath the remains. The water pigs were photographed but not disturbed because additional movement might have produced trauma to the water specimens that could accelerate their decay process. Ambient temperature was collected from the Louisiana State University Climate Center, which accessed a weather station located on the Ben Hur Research Facility. Additionally, a Hobo® logger calculated water temperature.

Results of this study showed that, as expected, the land specimen decayed faster than the three water specimens. Arthropod activity for the land pig included *Musca domestica*, *Phormia regina*, *Dermestes maculatus*, and *Solenopsis invicta*. Also, decomposition of the land pig followed stages similar to those of other researchers: fresh, bloat, dried remains, and skeletonized remains. For the land pig, the time elapsed from fresh to skeletonized remains with only desiccated skin left was 21 days. Ambient temperature for these days ranged from 62.9°F to 88.8°F.

The decay rate for the pigs in the water was slower than that of the land pig. Though some flies hovered over the water pigs once they surfaced, no continuous, long-term arthropod activity was noted; nor were larvae found associated with the segments of these pigs that showed above the water line. Three main stages were recognized for the water pigs:

fresh, bloat, and reduction. A fourth and final stage for the water pigs varied for each water specimen: sunken remains (cinder block/weighted pig), desiccated skin (pig at the dock), and relocated remains (buoyed pig, which washed to shore). Fresh stage to the final stage of decay in the water varied by specimen from 37 days to 72 days. Temperature and climate did affect the rate of decay and adipocere formation with adipocere forming after approximately two months for the water pigs and not at all in the land pig.

This study provides new data on decomposition to assist with the determination of postmortem interval for those remains found in a freshwater aquatic environment in the southeast region of the United States.

Freshwater Decomposition, Entomology, Louisiana

H44 The Role of Clothing in Estimating Time Since Death

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The goals of this research project are to present to the Academy research results which show how clothing affects the process of human decomposition and how it also influences the process of estimating time since death.

This presentation will familiarize the forensic community with current research on the effects of clothing on human decomposition and time-since-death estimation. Time-since-death estimation is an enigma that has plagued law enforcement, medical examiners, and the forensic community for years. An accurate estimate is critical for medicolegal purposes as it is often used in defense of an alibi. It may serve as a preliminary screening tool to eliminate putative killers who may or may not have had access to the body. More than half of the cases performed by The Forensic Anthropology Center at The University of Tennessee Knoxville require time-since-death estimates. Additionally, the success or failure of a criminal investigation may hinge directly upon accurate estimation.

Several studies have been conducted at the Anthropology Research Facility located at The University of Tennessee, Knoxville, which longitudinally examine the process of human decomposition. However, to date, no study has focused exclusively on clothing as a variable in this process using human subjects. Furthermore, few studies have been performed using animal models. Recent research demonstrates conflicting results regarding the effect of clothing on decomposition. Some authors conclude that clothing accelerates decomposition, while others maintain that it retards the process. The goal of this study is twofold: first, the process of decomposition of clothed human subjects will be documented; second, it will be determined whether clothing accelerates or retards the process of decomposition. This will be accomplished by comparing accumulated degree-days for clothed cadavers with those of nude cadavers.

This research is the culmination of a year-long project using six unembalmed, clothed cadavers placed at the Anthropology Research Facility located at The University of Tennessee, Knoxville, at various times throughout the year. Consecutive observations were made on each cadaver and photographs were taken to record the progression of decomposition. Each body was assigned a number to mark the progression into each of the four stages of decomposition: (1) fresh, (2) bloat, (3) advanced decomposition, (4) skeletonization. The fresh stage is marked by the absence of discoloration, except for lividity, and the absence of maggot activity. Early decomposition consists of discoloration, bloating, marbling, skin slippage and extensive maggot activity. Advanced decomposition is marked by the release of gases and the ensuing abdominal sagging, as well as extensive maggot activity. This period begins after maximum body bloating has been attained. The skeletonization stage is marked by the absence of any wet tissue and includes mummified or dry tissue. It is important to mention that patterns of decomposition are more marked in warmer months and may be ambiguous in cooler months. Extensive

freezing and lack of decay organisms in winter prevent observations of definitive decay patterns. Carnivores are also more aggressive in winter months, altering definitive stages of decomposition.

It is well known that temperature is the primary variable affecting the rate of decomposition. After Vass and coworkers (1992), accumulated degree-days were calculated for each subject in this study after the final stage had been reached. This is performed by adding the average temperature for each day to the previous day. Vass and colleagues found that it takes approximately 1285 +/- 150 accumulated degree-days (ADD) for a body to decompose. In order to make an assessment as to the effects of clothing, ADD's from this study were compared with ADD's from previous studies using nude cadavers. It was determined that clothing retards the process of decomposition. Therefore, the presence or absence of clothing must be noted and compensated for when making an estimate of time since death.

Time-Since-Death, Decomposition, Clothing

H45 The Effects of Lime on the Decomposition Rate of Buried Remains

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The goals of this research project are to present the results of an experimental study on the effects of lime on the decomposition rate of buried pig remains. This may aid investigators in more accurately determining a post mortem interval (PMI) in limed burials base on the preservation of the remains.

Of the many factors that affect buried remains, one that is particularly pertinent to forensic studies is the inclusion of lime in a burial. It would seem that assailants believe that lime accelerates the decomposition of soft tissues in buried remains. However, observations by forensic investigators suggest that lime actually tends to slow the decomposition of buried remains. Despite anecdotal information, the effect of lime on the decomposition of remains is not clearly understood. A systematic study of the role of lime in soft tissue preservation and how it interacts with other environmental variables is needed. The aim of this study was to determine the effects and interaction of three variables influential to the decomposition of buried remains: duration of burial, depth of remains below the surface, and the presence of lime.

Over the course of four years, six separate groups of pigs ranging from 50-70 pounds each were buried in six rectangular pits on a farm in northwestern Indiana. Pits 1 and 2 each contained five pigs, which were interred for approximately thirty months (Nov 1995 to June 1998) at a depth of 50-60cm. Pits 3 and 4 each contained three pigs interred for approximately six months (Oct 1998 – May 1999) at a depth of 10-20cm. Pits 5 and 6 each contained three pigs interred for approximately six months (Oct 1998 – May 1999) at a depth of 50-60 cm. Pits 1, 3 and 5 served as control groups. In Pits 2, 4 and 6 approximately 25 pounds of commercial lime covered each pig.

In order to run a statistical analysis of the rate and degree of decomposition, a visual assessment of the condition of the pigs was translated into a numerical score. A continuum of decomposition stages was constructed and a number of points were assigned to each decomposition stage. Upon excavation, each pig was given a score based on the degree of decomposition it exhibited. These scores served as the dependent variable in an analysis of variance (ANOVA), with the independent categorical variables being time elapsed, depth, and lime inclusion. The theoretical model that best explains the relationships between the variables in standard ANOVA format is: Decomposition = Depth + Time Interval + Presence of Lime + Error. The various interactions between the main effects (such as Depth Lime*Time Interval, etc.) were also examined. Extensive qualitative descriptions also proved essential to understanding the results.

The results show that lime does significantly slow the rate of decomposition of buried remains. The greatest difference in preservation between the limed and non-limed (control) burials occurred in the shallow, six-month pits (Pits 3 and 4). Although significant, the differences between the deep, six-month pits (Pits 5 and 6) and deep, thirty-month pits (Pits 1 and 2) were less impressive. Pits 3 and 4, being located near the surface, were potentially exposed to many more influential decompositional factors. The addition of lime to Pit 4 probably protected those remains from many of those same factors, while the unlimed Pit 3 remains quickly decomposed due to the near-surface exposure. The deeper burials in Pits 1, 2, 5, and 6 were better protected from temperature differences, insects, carnivores, moisture, and other factors by a thick layer of soil. The lime had little more protection to offer these deeply buried remains. Therefore, the decomposition scores between the paired pits (1 and 2, 5 and 6) were more alike, albeit still significantly lower for the limed remains.

In addition, due to the significance of the Lime*Time interaction, it appears that lime's preservation qualities may decrease with time. This is likely due to the burial's tendency to move towards equilibrium with the surrounding environment over time. It also appears that the preserving qualities of lime are not as influential at greater depths. This may occur because a thick layer of soil functions much like a layer of lime does in protecting against influential decompositional factors (such as insects). With this data, forensic investigators may be able to assess more accurately the postmortem interval for a limed burial.

Soft-Tissue Decomposition, Lime, Burial

H46 Evaluation of Odor as a Time-Since-Death Indicator

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The goals of this research project are to present a systematically method to collect and analyze decay odor and demonstrate its value as a time-since-death indicator.

Until recently decay odor has not been used as a forensic investigative tool beyond body discovery by cadaver dogs. The object of this study is to evaluate decay odor as a time since death indicator. Decomposition results from two internal processes, autolysis, the breakdown of the cells following circulatory stasis, and putrefaction, endogenous bacterial proliferation, as well as many external factors; i.e., bacteria, carnivores, insects. The byproducts of putrefaction contribute to the odor of decay and include cadaverine, putrescine, volatile fatty acids (VFAs), methane and hydrogen sulfide. As a corpse progresses through the stages of decay the composition and concentration of the decay odor is expected to change. This odor pattern variation is hypothesized to be consistent from individual to individual and correlated to temperature. To test this hypothesis, the odors of decaying corpses were collected and analyzed using electronic nose technology.

The greatest obstacle to successfully studying decay odor was the collection of a representative and replicable sample. A portable sampling device was designed to collect an appropriate sample. The device consisted of three glass pipettes filled with molecular sieve, connected to the inflow nozzle of an air pump. Molecular sieve, a universal dryant, captured the odor-causing agents under field conditions and released them under the analytical conditions of the electronic nose. The simultaneous collection of repeat samples, via the three pipettes, minimized the intersample error and reduced the sampling time.

Aroma samples were collected from eleven decaying individuals at regular intervals. The human remains were donated for scientific study with known time of death and cause of death. Each corpse was received during the fresh stage of decomposition and was unautopsied. Included in the study were eight males and three females; all individuals were white.

Age range was from 25 to 98 years. Cause of death was natural in all but three cases, two-suspected drug overdose and one suicide by hanging. Ten corpses were enclosed in a body bag during the decomposition process to concentrate and isolate the odor. One corpse was not placed in a body bag. A small hole was cut in each body bag through which the sample was taken. At each sampling event the temperature and humidity, as well as the intersample high and low temperature and humidity and rainfall, were recorded. The fluctuation and accumulated effects of temperature were summarized as accumulated degree days (ADD). Control samples were collected by sampling air contained within empty body bags. Four of the ten body bags were disturbed by carnivore activity during the decay process. The duration of the study was one year and at least one corpse was analyzed in every season.

The results of the study show that the aroma pattern as detected by the electronic nose did not change over time; however, the concentration of the odor did change. The intensity of the odor positively correlated to ADD when the body was isolated in an undisturbed body bag ($r=0.8$). Intensity of the odor did not correlate to ADD when the body bag was disturbed or the body was not placed in a body bag ($r = 0.3$). At this time, odor as a time-since-death indicator is only applicable to samples collected from bodies isolated in body bags. In order to expand the application of this method, the sensitivity of the sampling method must be improved. Furthermore, important odor pattern variation may become detectable with increased sensor sensitivity of the electronic nose. In sum, the concentration of odor positively correlated to ADD when specific conditions are met. However, aroma pattern change is undetectable.

Time Since Death, Decay Odor, Electronic Nose

H47 Determining Postmortem Interval: A Preliminary Examination of Postmortem Thorium, Actinium, and Radium Isotopes in Bone

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The goals of this research project are to present a potential new method for determining postmortem interval by examining Ra-228, Th-228, and Ra-228.

Determining postmortem interval (PMI) can aid in solving many police cases involving deaths. Authorities often look to the forensic anthropologist to determine PMI in skeletal material. Therefore, a method to determine PMI would be extremely beneficial to the anthropologist. The methods that are currently used in determining PMI include entomology, botany, pathology, and decomposition. Because the environment can affect these methods drastically, they can be inaccurate or not used at all. By determining a method based on the decay of radioactive isotopes, the environmental factor is eradicated. Environmental factors do not affect decay rates. Thus this method would have the benefit of being the only method not affected by any environmental factors or conditions. This research focuses on deriving a dating method similar to current radiometric methods such as C-14 and K/Ar. However, this study focuses on isotopes with a shorter decay rate: Ra-228, Ac-228, and Th-228.

Research has shown that the preceding isotopes have consistently been shown to be present in bone. These isotopes are part of the thorium series with Ra-228 decaying into Ac-228 and Ac-228 decaying into Th-228. The half-life of these isotopes ranges from 6.13 hours to 6.7 years, which will allow for a method that dates from the present to approximately 20 years ago. Research shows that during the lifecycle of a human the Ra-228 isotopes and its daughters exist in equilibrium. Once a person dies, bone no longer accumulates isotopes. The only activity seen is the

decay of the isotopes present in the bone at death. Looking at the ratio of remaining isotopes, a method to determine PMI can be derived.

The sternal end of a rib from 5 individuals was tested. The Montana State Medical Examiner harvested the samples and gathered age, sex, and time/date of death for each specimen. The samples were tested at the Pacific Northwest National Laboratory in Washington State on an ICP-MS and a coincidence system. The coincidence system has a high efficiency for capturing coincident gamma ray emissions. The decay rates of the isotopes were used to determine the integration constant, C. This research rested on the premise that C was constant for all samples. When C is constant, the only unknown in the following equation is the time since death.

$$C = (R_B(t) - \frac{R_A(t)\lambda_B}{\lambda_B - \lambda_A}) \left(\frac{1}{-\lambda_B e^{-\lambda_B t}} \right)$$

The preceding equation only takes into account the decay rates of Ra-228 and Th-228. Because this research was a preliminary study, Ac-228 was excluded from the equation. Ac-228 did not need to be included in this equation to determine whether or not this method would work. In further research, Ac-228 will be included for an accurate determination of the integration constant. If Ac-228 were to be included in this preliminary study, the equations would have become extremely cumbersome. By looking at Th-228 and Ra-228, determining whether or not this new method was viable became easier. The premise of this study was to decide whether or not this new method was viable and worth future research.

Postmortem Interval, Radioisotopes, Bones

H48 Differentiation of Bone and Tooth From Other Materials Using SEM/EDS Analysis

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Upon completion of this presentation, the attendee will understand how the identification of small particles as representing bone or tooth can be facilitated through scanning Electron Microscopy/Energy Dispersive X-ray spectroscopy (SEM/EDS) analysis.

With increasing frequency, materials thought to be of human origin submitted to the Federal Bureau of Investigation (FBI) Laboratory for identification are extremely fragmentary, incomplete, and often altered through taphonomic factors. Frequently such evidence is submitted with the intention that DNA analysis will clarify issues of identification. Prior to such analysis, it is desirable to determine if such evidence may be of bone or tooth origin or if it represents other materials commonly found in crime scenes which can be morphologically similar to bone or tooth. Determining if such evidence represents bone or tooth using standard morphological approaches can be problematic if such evidence is extremely small and/or has been altered taphonomically.

In such cases, interpretation can be enhanced by comparison of the results of SEM/EDS analysis to reference material data archived in an x-ray spectral database. This contribution reports on such an approach and the continuing project to build an appropriate database.

Analysis using SEM/EDS represents a well-known, commonly utilized tool to provide quantitative, qualitative, structural and/or comparative information to assist in the interpretation of materials of potential forensic significance. In 1994, the FBI initiated an effort to construct a database of x-ray spectra in support of laboratory analysis of forensic evidence (1). More recently, the concept of this database has been modified as a Windows-based application on a PC that functions with a

contemporary EDS system (1). The current system allows storage of standard spectra with display of qualitative composition, images and information about the sample. The system also permits comparison of spectral data from an individual sample against the database with expression of the appropriate probabilities of association.

To address the bone/tooth identification problem discussed above, the authors have augmented the pre-existing database with many known bone and tooth samples from a variety of contexts, as well as materials that are easily confused with bone and tooth. The bone and tooth samples consist of pristine examples as well as those representing the full range of altered conditions. Human as well as other vertebrates are presented.

Examination of this expanded database reveals the composition of bones and teeth, especially their proportions of calcium and phosphorus. These data will allow them to be successfully separated from most other materials in the database. Exceptions in the existing database that show potential for confusion with bone and tooth are ivory, mineral apatite, and perhaps samples from a group of corals. Research continues on new methods to differentiate fragments of these materials from bone and tooth.

References:

1. Ward, D.C., Use of an x-ray spectral database in forensic science. *Forensic Science Communications*, July, Vol. 2, No. 3, available on-line at www.fbi.gov.

Bone Identification, Elemental Analysis, Data Bases

H49 Factors That Affect mtDNA Recoverability From Osseous Remains

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Due to the unprecedented scale of efforts to identify unknown osseous remains by the U.S. Army Central Identification Laboratory and through extensive access to the resources of the Armed Forces DNA Identification Laboratory, over 2500 osseous samples have been submitted for mtDNA analysis. While previous reports of ancient DNA analysis success rates have been anecdotal, concerned sample sizes and explored a relatively narrow range of environmental variables, this paper reviews sufficient samples to statistically characterize relatively subtle effects that may throw light on the odds and even the mechanism of DNA recovery. Improvements in technology, element sampled, sample mass, and time-since-death are all reviewed. In addition, the huge range of preservational environments represented allows a more systematic investigation of the effects of climate on the recoverability of DNA from bone. We contend that placing this data in the public domain will assist in the planning and optimization of the use of ancient DNA analyses and that systematic study of our successes and failures will better inform the debate over the actual mechanisms of DNA preservation and recoverability.

CILHI, mtDNA, Preservation

H50 How Not to Stage a Burial: Lessons From North Korea

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This presentation conveys a range of factors that may be used to determine if a burial has been moved to its location recently with the design of deceiving investigators as to true burial age. This type of fakery can be detected most effectively at the time of excavation, since, in most cases, these remains have already undergone significant periods of burial

or intermediate storage in another location. Detection must therefore focus upon forensic archaeological techniques, with laboratory analysis as an additional important contributor. The discrepancies noted in the presented cases may also pertain to forensic investigations in other settings, where loss of primary burial context is suspected.

Through their recovery operations for the remains of soldiers missing in action from the Korean War (1950-53), the staff of the U.S. Army Central Identification Laboratory, Hawaii (USA-CILHI) has detected rampant staging of burial contexts in North Korea. This staging normally consists of the removal of skeletal remains and associated artifacts from a primary wartime burial or intermediate storage context and "planting" these items for recovery during joint operations with the Korean People's Army (KPA). Identification of these remains is therefore hindered through the loss of primary context, mixing of remains from multiple burials, the loss of elements, and the misassociation of U.S. military identifying artifacts (identification tags and cards, unit and rank insignia, specific issue uniform items, and labeled equipment) and personal effects with unrelated human remains. The reburial of these remains therefore is a major hindrance to their eventual identification and return to next of kin.

Multiple lines of field evidence have been used in the detection of staged burial contexts. Most obvious among these is the anatomical misalignment of skeletal remains laid out in approximate anatomical order. In some cases elements have been found reversed (right for left) in a burial otherwise appearing to have undergone no major disturbance. Other instances include vertebral columns with one reversed vertebra, single skeletal elements found at a significantly different depth than the remainder of a skeleton, thoracic elements found inside crania, or outright missing elements despite the excellent preservation of the surrounding bone.

Non-anatomical field evidence has also proven key in the detection of burial staging. In some cases, staged burial contexts have been reconstructed to appear as former entrenched positions with hasty wartime burials placed inside. These contexts often lacked any sort of battlefield trash in the form of expended ammunition or other items that are ubiquitous in these settings. The lack of any corrosive staining of sediments surrounding highly corroded metal artifacts also indicates the short interval in their discovered location. The taphonomic state of skeletal elements has indicated their recent reburial, such as undamaged but fragile crania in a shallow grave less than 25 cm beneath the surface of a plowed field, or recent breakage upon elements reported to have been buried for an extended period. Variable plant root invasion and damage to skeletal elements has also indicated their differential burial history from associated artifacts. Loose burial fill and loose sediments within crania also have indicated recent depositional status. Degradable objects, such as fresh plant stalks and leaves, have also been recovered deep within burial deposits. Geomorphology and soil analysis have also proven useful in the detection of recent reburials, as in the cases of still-visible low mounds over burials in areas of high erosion or soil in burial areas that do not correspond to nearby conditions.

Laboratory analysis has also aided in staged burial detection. Preliminary research in human taphonomy relative to soil pH has exposed multiple cases where the overall condition of the remains does not correspond to the relatively harsh or benign soil conditions where they had reportedly spent approximately 50 years. Gluing of elements and tool marks from previous excavation have also been found. Remains have also been identified as non-U.S. in origin, despite their association with U.S. artifacts. Laboratory analysis has also disclosed the modification of remains received through unilateral turnover from the North Korean government, including multiple mitochondrial DNA sequences from single sets of remains and other evidence of previous tampering during long term storage (gluing, drilling, and labeling).

The combination of the laboratory analyses and the field evidence described above provides a comprehensive list of factors which may be used to detect staged burial contexts in forensic investigations.

Staged Burial, North Korea, Forensic Archaeology

H51 The Pits: Recovery and Examination of Skeletonized Remains From a Concrete Filled-Fire Pit

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The goals of this research project are to demonstrate the problems encountered when removing human remains which have been covered in concrete, and the use of forensic anthropological techniques to determine probable cause of death and to establish positive identification.

Recovery of human remains is a scientific discipline within itself, requiring extensive study and implementation of specific methods and techniques. A multitude of recovery scenarios have been documented in the forensic literature for which the majority involve recovery of scattered surface remains. Aquatic recoveries such as from a pond, river or ocean also present many challenges. Similar challenges are encountered when attempting to recover remains from clandestine sites such as landfills, sewage tanks, and canals.

Some of the more complexing types of recoveries encountered by death investigators are those from beneath or within concrete. Locating remains hidden in concrete itself can be difficult, requiring the use of geophysical technology such as ground penetrating radar, gas probe detectors, and remote miniature video cameras. Fortunately, in many such cases, the postmortem decompositional process results in improper curing of the concrete. Postmortem gas production and release of decompositional fluids in many cases, infiltrates the concrete producing cracks and fissures. Breakdown of the epidermal tissues often acts to form a barrier to the adhesive properties of the concrete. Cracks or other rupturing of the concrete can allow access to the remains by carrion insects, and alert investigators to the presence of a decomposing body.

A case in point to be presented, involves the death of a twenty-nine year old Asian/American male whose decomposed and skeletonized remains were recovered from a concrete matrix. In October of 1999, a military platoon training in a partially-wooded area of US Army Post, Ft. Sill, Oklahoma, noted a strong odor emanating from an outdoor fire pit. The fire pit, which was rectangular in shape and constructed of large field stones and mortar, was utilized routinely by troops to cook meals while conducting field exercises. Upon inspection of the fire pit the soldiers noted the bottom to have been filled with concrete. A sizable young tree sapling along with a long aluminum pole was also noted strangely protruding from the concrete. Removal of the small fractured section of concrete, by one of the soldiers, revealed the presence of a large mass of maggots, and what appeared to be human bones.

Discovery of the remains was followed by recovery efforts conducted by representatives of the Armed Forces Medical Examiner's Office, US Army Criminal Investigation Command, and the Federal Bureau of Investigation. Examination of the fire pit revealed that the components of the concrete had been transported to the remote location, and mixed directly within the pit over and around the body of the deceased. The long aluminum pole, noted extruding from the fire pit, was determined to be the tool utilized to mix the concrete. Removal of the remains was conducted by carefully chipping away sections of the concrete with a masonry hammer and chisel. A small tarp was used to cover skeletal elements after they were exposed in order to protect them from flying debris. As a result of postmortem decomposition, the concrete had formed a type of hollow casing over the remains. The casing provided for easy separation with the exception of the right lower leg, which had been fully encased in the concrete.

Anthropological examination of the remains at the site revealed them to be consistent with an adult Mongoloid male between twenty-five and thirty-five years of age at death. Tactile examination of the cervical spine, which was covered in significant amounts of purified soft tissues, found extensive fragmentation of several of the vertebrae which was consistent

with a gunshot wound. Radiological examination of the skeletal remains and associated soft tissues led to the discovery of multiple lead shotgun pellets in the area of the neck. The death was ruled as a homicide resulting from a single shotgun wound to the neck. Positive identification of the homicide victim was not established until approximately three months later, when a missing persons lead provided for the recovery of antemortem dental radiographs of the deceased.

Decomposition, Physical Anthropology, Skeletal Recovery

H52 Of Posteriors, Typicality, and Individuality in Forensic Anthropology

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The goals of this research project are to present to the forensic anthropology community the basis for calculating probabilities and likelihood ratios for identification purposes.

With the increasing visibility of DNA evidence in the courts and the public press, forensic anthropologists are being called upon to present osteological information and/or evidence in probabilistic terms. This is an endeavor for which many forensic anthropologists are generally ill-prepared, as their training is likely to have included only a course or two in basic inferential statistics that rarely included more than a passing reference to probability theory in general, and Bayesian inference in particular. This paper gives a “gentle introduction” to probabilistic thinking in forensic anthropology, using examples drawn from the Forensic Anthropology Database maintained in the Department of Anthropology at the University of Tennessee, Knoxville.

The paper begins with a presentation of the ideas underlying “posterior probability” and “typicality,” two key concepts with which many forensic anthropologists are already familiar from their exposure to discriminant function analysis and/or FORDISC. In the discriminant setting, we want to find the posterior probability that a particular case “c” belongs to a particular group g_i of G groups. By Bayes’ Theorem, this conditional probability (i.e., posterior to the osteological information “x”) is:

$$P(c \in g_i | x) = \frac{P(x|c \in g_i)P(c \in g_i)}{\sum_{i=1}^G P(x|c \in g_i)P(c \in g_i)}$$

While the posterior probability of membership in a particular group may be high, the likelihood of getting the observed osteological information (which is proportional to) may be quite low. “Typicality” is designed to answer this particular concern, by finding the probability that the observed distance of the case to the particular group centroid, or any greater distance, could arise by chance. This paper uses a computer simulation approach to demonstrate the less intuitive concept of “typicality.”

Both “posterior probability” and “typicality” may be fairly comfortable concepts for forensic anthropologists, but the notion of “individuality” is a less familiar area. Forensic anthropologists are used to thinking in terms of “positive identifications,” and generally have less experience in calculating and presenting statistical evidence in an “identification case.” Neither “posterior probability” nor “typicality” are particularly relevant concepts in identification cases, because if the identification is correct there is no interest in a posterior probability calculation, and there is certainly no interest in the probability of finding any “more extreme” case (as in “typicality”). Instead, following Evett and Weir’s (1998) logic from their book *Interpreting DNA Evidence: Statistical Genetics for Forensic Scientists*, what is needed is a likelihood ratio that compares the probability of obtaining the observed osteological evidence if the putative identification is correct, versus the probability of obtaining the observed osteological evidence from the “population at

large.” The specificity of this likelihood ratio depends on the antemortem information that is available about the individual who is putatively identified. If the individual is only identified as to “being in group g_i ,” then the likelihood ratio is:

$$\frac{P(x|c \in g_i)}{\sum_{i=1}^G P(x|c \in g_i)P(c \in g_i)} = \frac{P(x|c \in g_i)}{P(x)}$$

Although this likelihood may be too diffuse to “make the positive I.D.,” when combined with other evidence it may provide a strong enough posterior odds ratio to satisfy the courts.

Osteology, Statistics, Evidence

H53 The Validity of Using Unique Biological Features as a Method of Identifying Victims of War Crimes in the Former Yugoslavia

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The goals of this research project are to present findings of a research study regarding the frequency of fractures, pathologies, surgery, and dental reconstruction in modern populations and the reliability of using these features as a means of personal identification.

The past decade has seen a dramatic increase in physical and forensic anthropologists participating in genocide and war crimes investigations in regions such as Rwanda, Argentina, and the Former Yugoslavia. Inherent in such rapid expansion is both the opportunity for research in previously unexplored areas and, unfortunately, the ad hoc use of untested methodologies.

Traditional methods of identifying individuals include visual recognition, fingerprinting, DNA, dental records and the comparison of antemortem and postmortem x-rays. However, in the Balkans the decayed state of the remains precludes visual assessment and fingerprinting; limited access to healthcare and inadequate documentation prohibit dental and x-ray comparisons and DNA testing on such a massive scale is too costly and requires laboratory resources not presently available. Yet the need to identify victims for prosecution and humanitarian purposes persists and demands innovative methods.

Current identification protocols in the Former Yugoslavia rely heavily on witness statements identification documents recovered family recognition of clothing and personal effects and the presence of unique biological identifiers such as artificial limbs, evidence of previous fractures or trauma, and extensive dental reconstructions. However, personal observation and experience in Bosnia in 1999 and Kosovo in 2000 indicated that it was not uncommon for a single mass grave to produce two or more individuals of similar age and sex who possessed identical fractures, surgical scars or dental work. Yet, identifications continue to be made on the basis of these features, under the assumption of their “uniqueness.”

This study seeks to identify those features which are sufficiently rare as to be deemed unique biological identifiers. While previous studies have examined the incidence of trauma and pathology in archaeological contexts or the frequency of specific fracture types within populations, no literature exists on the overall frequency in modern populations of dental modifications, fractures, surgical interventions and other biological characteristics that endure and are recognisable post-mortem. Nor is it currently known how such features vary among cohorts of different age, sex, socio-economic status or geographic location.

Data was collected on two modern skeletal populations which serve as control and comparative samples. The first population is housed at the Maxwell Museum of Anthropology at the University of New Mexico. This collection represents 463 individuals from documented donors as

* Presenting Author

well as recent medico-legal cases. This collection encompasses a wide demographic population ranging in age from new born to 101 years and with a representative distribution of males and females, ethnic affinities, and socio-economic classes. A second collection, housed at the University of Tennessee Forensic Anthropology Research Center, was also analysed. A total of 137 adult individuals were included from this collection, creating a total sample size of 600 individuals who died between 1984 and 2001. The need for such research to be conducted on very recent populations made the study of these collections preferable to the more traditional forensic research collections (such as the Terry collection at the Smithsonian), which were created pre-1950.

Features such as antemortem fractures, pathologies, dental repairs, and surgical interventions were recorded for each individual. Statistical analyses will provide the overall frequency of each feature within the population, as well as by sex and age cohorts, and will determine which features represent unique biological identifiers. Future publications will compare these findings to data collected in Bosnia.

The results of this research may be used to modify current identification methods and will provide the necessary scientific documentation to support or discredit the presumptive identifications of war crime victims should they be questioned in international and regional legal proceedings.

Forensic Anthropology, Identification, War Crimes

H54 Testing the Average Methodological Approach to Facial Approximation

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The goal of this presentation is to present research to forensic anthropologists, which, in the best-case scenario, indicates that standard facial approximation techniques will only permit about a 45% true positive recognition rate.

Facial approximation is the process of building faces on dry skulls for identification purposes. Currently the technique relies upon the prediction of facial feature dimensions and shapes from the skull. However, attempts are less than optimal since most predictions are based on general trends, or averages, that are not representative of all individuals. One example of this is the use of average soft tissue depths. Since at present, face surface color tones and texture cannot be predicted from the skull, they are usually left to the subjective interpretation of the practitioner. A more objective way to represent the surface color and texture of facial approximations is to use the same approach as that used for feature dimension and shape determination, i.e., averages. The ability of the “average” facial approximation approach to generate personal recognition is unknown. Given that facial surface textures and color tones are unlikely ever to be easily determined from skulls, this study examines the ability for personal recognition to be generated from faces displaying average color and texture information, but displaying exact individual face shapes. Since facial approximation techniques cannot yet reproduce exact face shapes, this experiment is expected to be a “best-case scenario” test of facial approximation methods. The faces used for recognition testing were constructed in two-dimensional frontal views, on computers, using average human faces, warped to the exact face shape/proportions of target individuals. From a face pool of six individuals, unfamiliar assessors were asked to attempt to identify the person to whom the warped average face represented. Assessors had the option of not making identification if they thought the target person was not present in the face pool. Familiar

assessors were also asked to examine the computer generated faces and indicate if they recognized any. Results indicate that average human faces, adjusted precisely to individual face shapes, allow identification in the majority of scenarios, however recognition rates are low (<45% on average). This suggests that average face color and texture can be used in conjunction with predictions of facial feature dimensions and shapes to generate personal identifications. However, current methods need to be significantly improved since they cannot replicate exact face shapes, because they are based on “averages,” and are therefore likely to have much lower recognition rates. This study also found that unfamiliar recognition responses follow similar trends to familiar recognition tests, indicating that unfamiliar identification trials are useful in assessing facial approximation accuracy.

Facial Approximation, Averages, Recognition

H55 Human Skeleton Found in a Chimney: A Misidentification Corrected and an Opportunity to Reevaluate Methods of Superimposition

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Upon completion of this presentation, the attendee will understand superimposition as a method of identification.

On January 19, 2001, repairs were being conducted on the Riverboat Gift Shop in Natchez, Mississippi. A local mason found bones of the lower extremities and a pair of cowboy boots resting on the damper of the fireplace. Later that afternoon, police chiseled into the chimney and found the remains of a human skeleton.

A leather wallet that was found in the remnants of a pair of “parachute” paints identified the remains as those of CW reported missing in 1984. Local law enforcement agencies were well familiar with the suspicious activities of this individual.

A set of skeletal remains found in 1987 had been tentatively identified as CW. This skeleton had the same parameters of age, sex, ancestry, and stature as CW. The cause of death in the “1987” skeleton was a gunshot wound to the face. The manner was determined to be homicide.

No dental records or antemortem radiographs of CW were available for comparison. A facial superimposition was done from photographs available from police files. An “acceptable” match was obtained. The report submitted to law enforcement stated “in all probability these are the remains of CW.”

As a comparison, a facial superimposition of the “2001” skeleton was conducted. This method used both tissue depth markers and Chang lines to enhance the analysis. In both cases, complete skulls and mandibles were available.

The critical variables of position and size were considered minimal. Superimpositions on both the 1987 and 2001 skull were done using “mug shots” provided by the local police. Each technique used the “sweeping” and “blending and fading” methods. The “box sweep” was used on the 2001 skull, providing a better assessment of oral and nasal structures.

Researchers have debated the reliability of this technique as a method of positive identification. The two superimpositions were compared for points of nonconformability as well as points of commonality. The presenters strongly support the use of this technique in reaching a decision to include or exclude an individual for further consideration. Continued research in this area would serve to enhance the use of this procedure in establishing a positive identification.

Forensic Anthropology, Superimposition, Human Identification

H56 Comparative Radiography of the Lateral Hyoid: A New Method for Human Identification

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Attendees will learn that radiographic images of the human hyoid can be utilized for purposes of positive human identification.

This paper has three objectives: First, the gross radiographic shape of the hyoid, in which differences in the radiographic pattern of the body and horns and cross-sectional architecture of the body are demonstrated to be variable and individualizing. Second, an easy, replicable method for the approximation of postmortem to antemortem lateral cervical radiographs will be described. Finally, the results of a validation study that tested identification by comparative radiography of the hyoid will be discussed.

In human remains cases where identity is unknown or needs to be verified, antemortem/postmortem x-ray comparison is often the most effective and powerful means of positive identification. It is imperative in such cases that practitioners understand medical radiographic techniques and standards and know which dental and skeletal elements have been shown to be useful and acceptable in our legal system. Unfortunately, few validation studies have been published that contribute to our understanding of the uniqueness and the power of discrimination of various skeletal elements. In this study, a noninvasive protocol for approximating medical lateral cervical radiographs in the lab will be described, as well as the results of a validation procedure.

From a sample of 200 medical examiner cases, ranging in age from birth to 92 years, 86 of the specimens exhibited unilateral or complete fusion. After eliminating specimens that had fused lesser horns and greater horns that could not be easily re-articulated, the sample consisted of 50 hyoids. The greater horns of unilaterally-fused hyoids were glued to the body and no attempt was made to re-articulate the lesser horns on any hyoid.

Each of the 50 hyoids was individually x-rayed in a left lateral position using a General Electric Amx2 portable x-ray unit. The left horn of the hyoid was inserted into a floral foam block with the middle of the body oriented 7 inches from the cassette. Lateral approximation was accomplished by using a metal ruler to control for lateral and anterior/posterior tilt. The distance from the x-ray beam source and cassette was set at 40 inches. A review of several medical antemortem lateral cervical x-rays required that the x-ray unit settings for this study were maintained at 70 kVp and 8 mAs. Ten hyoids were then randomly selected from the 50 hyoids and x-rayed again using the same positioning technique and x-ray unit settings. Finally, the tenhyoids that were x-rayed twice were compared to insure that there were no serious deviations from the first set of x-rays. Three of the hyoids were x-rayed again due to differences in orientation and exposure problems between the first and second x-ray series.

The data were submitted to two forensic pathologists, two forensic anthropologists, and two forensic anthropology graduate students for comparison and matching of the 10 simulated unknown individuals. Each of the participants performed their analysis independently at different times and places. Participants were asked to compare each of the 10 lateral radiographs to the entire population of 50 hyoids to examine the possibility that more than one hyoid could match one from the test group. Part of the analysis involved asking the participant to report the specific anatomical criteria for justifying the identification.

Based on this sample, the variability of the hyoid bone allows individuals to be discriminated radiographically. None of the participants mismatched or included any other hyoids as a possible match. The most useful attributes for identification were reported by the participants to be the shape and cross-sectional architecture of the hyoid body, and the shape

of the greater horns. Other important distinguishing characteristics included trabecular patterns of the hyoid body and greater horns, the shape of the terminal greater horns, the angle of the body to the greater horns, and radiopacity or radiolucency of the greater horn/body junction.

The results of this study demonstrate that the radiographic configuration of the hyoid represents an individualizing skeletal element that can be used for purposes of human identification. Forensic anthropologists and forensic pathologists will benefit from the replicable technique employed in this study. The positioning and x-ray unit settings were selected based on a review of antemortem lateral cervical radiographs. The application of this technique does not require the removal of the hyoid for approximation and interpretation.

Human Identification, Hyoid, Comparative Radiography

H57 Musculoskeletal Stress Markers: An Exploration of Forensic Applicability

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The goal of this research project is to report a method of evaluating musculoskeletal stress markers for use in human identification.

Musculoskeletal stress markers (MSM) are sometimes used by physical anthropologists to evaluate activity patterns in skeletons from historic and prehistoric populations. Forensic anthropologists, as well, have long been interested in the potential to use MSM when reporting on unidentified human skeletons, but are often hindered in their efforts by the paucity of modern references and the lack of standards for MSM evaluation.

MSM consist of remodeled regions of muscle attachment (i.e., the enthesis) which are attributable to musculoskeletal stress along with potential genetic, hormonal and dietary components. Examples of MSM include robust or enlarged markers of the adductor magnus insertion which can be the sign of a horseback rider and stress lesions or a depression of the costoclavicular ligament which can be found on males of populations known to paddle kayaks.

The normal variation of MSM in modern populations is virtually unknown. MSM evidence from past populations is documented in the literature often used by forensic anthropologists, but modern examples remain largely anecdotal. Modern individuals are not generally engaged in the specialized forms of labor as members of past populations often were. Thus, modern MSM must be evaluated statistically and not in pursuit of occupational titles which may confound investigations.

Some physical anthropologists believe that attempts to deduce specific activities from skeletal material lead to speculative conclusions. One alternative to this practice is to examine the organization of activity suggested by MSM throughout the entire skeleton. In this study, MSM research on a modern population (n=30) focused on the interpretation of data with respect to sex, weight, bilateral distribution of MSM scores and age. The range and variability of MSM expression in this population provide a generalized profile for evaluating individual skeletal remains.

In order to evaluate a contemporary population, a descriptive, ranked method was used to determine the distribution of MSM in 39 post-cranial attachment areas, or entheses, using a post-1970s sample. Thirty skeletons from the Maxwell Museum of Anthropology and the Forensic Anthropology and Computer Enhancement Services Laboratory (FACES) were used. All skeletons were visually screened for bone modifying processes associated with known rheumatic and metabolic disorders. Twelve of the 30 skeletons had some documentation as to the individual's occupation at time of death. Magnitudes of both robust markers and stress lesions were evaluated. MSM attributed to injury (myositis ossificans) were disregarded since they often relate to isolated traumatic events and not prolonged periods of stress.

Wilcoxon signed ranks tests revealed significant bilateral distribution differences in MSM scores peculiar to both males and females. Additionally, scores in males show greater correlation with age using Spearman's coefficients than females. Overall, age appears to have a limited effect on MSM scores for individuals between the ages of 20-59 using chi-square. Males show greater correlation of upper body muscle pairs. In both sexes, the lower body shows increased correlation of pairs when compared to the upper body. Weight was shown to correlate with a variety of MSM sites in both sexes.

Individual skeletons with anomalies can be easily visualized using boxplot graphs. Comparisons of individuals against the population can reveal regional differences involving musculature which often work together in groups. Anomalies in individuals may be compared with distribution statistics for the appropriate sex to ascertain regional differences that are inconsistent with the population as a whole.

The elucidation of musculoskeletal anomalies may be useful in human identification since individuals with extraordinary MSM may reveal patterns of biased recruitment of muscle groups used in habitual activities or in tandem with variations in morphological characteristics of individual skeletons. MSM are not only important markers of osteoindividuality, but are potentially useful when comparing medical records, radiographs or biographical profiles of unidentified persons.

Musculoskeletal Stress Markers, Osteoindividuality, Human Identification

H58 Be Tenacious in Your Searches for Clandestine Burials: A Lesson From the Field

Ann W. Bunch, PhD, and Calvin Y. Shiroma, DMD, U.S. CILHI, 310 Worcester Avenue, Hickam Air Force Base, Honolulu, HI*

The attendee can expect to learn how to use all possible information and methods available to him/her in order to discover clandestine burials/remains.

In August 1971, a U.S.-manned armored patrol car (APC) moving to a night defensive position near Hoi An City, South Vietnam, was hit by enemy rocket-propelled grenade fire. This offensive action resulted in the deaths of all six soldiers aboard the vehicle. One of their bodies was not recovered. After-action reports from American eyewitnesses stated that the APC had exploded violently, as it was carrying various types of ammunition. These U.S. witnesses suggested that the lost soldier's remains would likely never be found, as they were completely disintegrated in the explosions.

Joint investigative teams followed up on this incident in the 1990s, interviewing Vietnamese witnesses who claimed to have buried the remains of an American in a nearby rice field after the U.S. troops had evacuated the area after the incident. One witness claimed to have disturbed the buried remains in the 1980s, however, with additional investigation, analysts deemed this individual "unreliable."

In May 2000, a joint recovery team from the U.S. Army Central Identification Laboratory, Hawaii (CILHI) and the Joint Task Force-Full Accounting (JTF-FA) was sent to this incident location, admittedly with low expectations of success. Five witnesses were initially interviewed and excavation began in earnest. A combination of excavation techniques (e.g., trenching, shovel-skimming, test pits), screening (dry and wet), and witness interviews were utilized in order to recover any remains. A key sixth witness eventually "cracked the case" for the team. The result was the recovery of dental remains, a dental prosthesis, and supporting material evidence. The seventeen teeth and partial denture were positively identified as the missing soldier from the August 1971 incident.

Forensic Recovery, Clandestine Burial, Witness Interviews

H59 The Importance of Recovered Life-Support Equipment In the Resolution of MIA Cases

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The attendee will learn that search and recovery of life-support equipment from military aircraft crashes can provide circumstantial information that can lead to resolution of MIA cases.

The United States Army Central Identification Laboratory, Hawaii (CILHI) is responsible for the recovery and identification of U.S. service members killed and missing during World War II the Korean War, and the Cold War era. For the past five years, the CILHI mission has emphasized the search and recovery and identification of the U.S. service members killed and missing during the Vietnam War. The CILHI deploys search and recovery teams to Vietnam, Laos, and Cambodia to conduct archaeological excavations of aircraft crash sites and isolated burials. The greatest percentage of cases involving unaccounted-for U.S. service members involves aircraft crash sites of jets, helicopters, and propeller-driven airplanes. Inside these aircraft are life-support systems and life-support equipment that enable the aircrew to survive the stresses of flight while in the aircraft and in the event of an impending crash, to survive in a hostile/enemy environment should they survive the crash or successfully egress from the aircraft before crashing.

When a search and recovery team excavates an aircraft crash site, the team may recover human remains, personal effects, life-support equipment (flight suit, anti-gravity suit [G-suit], helmet, oxygen mask, parachute, survival vest, and survival kit) and aircraft wreckage that may identify the type of aircraft (data plates and part identification numbers). The human remains and personal effects are repatriated to the CILHI where forensic anthropologists and odontologists attempt to establish positive biological identification, either through the traditional use of forensic anthropology and odontology or through the use of mitochondrial DNA analysis. Additionally, if the team recovers life-support equipment and significant pieces of aircraft wreckage such as data plates and aircraft identification numbers, this evidence is sent to the Headquarters of the Joint Task Force-Full Accounting (JTF-FA) where it is analyzed by life-support technicians (LST). In cases where further and extensive analysis is needed the evidence may be sent to the Life Sciences Equipment Laboratory (LSEL) at Kelly Air Force Base, San Antonio, Texas, where a team of scientists skilled in aeronautical engineering analyzes it, aircraft crash analysis, and life-support equipment analysis. The information provided by the LST and the LSEL is critical in instances when the human remains recovered at the crash site cannot be biologically associated to the unaccounted-for individual or when human remains are not recovered. This information may provide compelling and circumstantial evidence on the fate of the unaccounted-for individual, i.e., the individual(s) who perished in the aircraft crash or successfully ejected.

This paper will provide two recovery scenarios: 1) an excavated aircraft crash site where the recovery of human remains and life-support equipment provided information to make an identification and provide information on the fate of the crewmember, and 2) an excavated aircraft crash site where the recovery of possible human remains (it is yet to be determined whether the remains are human or not human) and life-support equipment, circumstantially indicate that the unaccounted-for individual was in the aircraft at the time of impact.

The recovery of life-support equipment, in addition to human remains (if they are recoverable and whether they may be biologically associable or not), personal effects, and significant aircraft wreckage, may provide significant information to answer the proverbial questions of who, what, when, where, why, and how and to provide information that can assist in determining the fate of the unaccounted-for individual.

In summation, the two cases presented here illustrate the importance of the recovery of life-support equipment, what one can determine from it,

and how the use of this information can provide circumstantial evidence in the resolution of MIA cases.

Human Remains, Life-Support Equipment, Search and Recovery

H60 Recovery and Identification Challenges in a Case of Suicidal Self-Cremation

Emily A. Craig, PhD, Medical Examiner's Office, 100 Sower Boulevard, Suite 202, Frankfort, KY; and Corky Deaton, DMD, Consulting Forensic Odontologist, 359-C South Fourth Street, Danville, KY*

This research project will present to the forensic community a case report that demonstrates improvised scene recovery techniques which led to positive identification in a unique case of suicidal self-cremation.

This presentation outlines how a multidisciplinary group of investigators recovered and identified an individual who had burned for four days inside a huge truck tire. Rescue and recovery personnel were faced with a unique crime scene that was complicated by extreme climatic conditions.

On November 28, 2000, in Adair County Kentucky, a man left a suicide note on his kitchen table. His wife was out of town and did not read the note until three days later. Upon her return, she contacted an emergency 911 center in Adair County, and a search team responded. On the night of December 1, a huge smoldering TS24 vehicle tire (88.6 inches in diameter) was discovered in a remote section of the decedent's property. Although the tire was still burning, first responders could see what appeared to be calcined bone fragments, remnants of a homemade shotgun, and a propane tank within the circumference of the tire. The tire had apparently been rolled to this remote site, laid on its side, and bolstered with firewood. The position of the skeletal remains indicated that the victim had been sitting in the tire with his head and shoulders against one side, and his buttocks on the bare ground. The presence of the propane tank and the shotgun near the feet of the victim corroborated evidence of suicide. Also the victim had apparently previously plowed three tractor-width furrows around the tire to create a buffer which prevented any spread of the fire. At the coroner's direction, the scene was secured and left undisturbed until daylight the following day. This action was a critical component in the successful outcome of the investigation.

On December 2, the scene was processed. By improvising and elaborating upon usual and customary methods of fire suppression, the fire fighters were able to insure the safety of the recovery team while preserving the physical integrity of the evidence. Severe winter weather, which included heavy sleet and freezing rain, complicated the recovery of the remains. As this precipitation fell onto the remaining fragments of teeth and bone, these materials would shatter. Any cover placed over the still-smoldering tire would have presented a safety hazard and a predicted heavy snowfall prevented a simple wait-and see protocol. A delicate balance between fire suppression and skeletal material recovery ensued and this took approximately three hours to complete.

Once skull fragments were located this area was carefully processed. As visible skeletal and dental materials were recovered they were immediately transferred to the heated cab of a truck where they were laid on sheets of aluminum foil and allowed to cool slowly. The remaining ash and debris from this area were swept into a dustpan and transferred in small amounts to individual paper sacks lined with aluminum foil. Remnants of teeth, bones and numerous shotgun pellets were thus recovered from the same immediate area as the skull fragments. The post-cranial elements were recovered and placed in a number of small plastic boxes, each labeled according to the corresponding anatomical area. The recovered bone was extremely fragile and approximated that seen in commercial cremations at the end of the firing stage, with a total residual weight of 2.17 kg.

The coroner was able to retrieve several antemortem cranial and postcranial radiographs, but almost total thermal destruction of bones precluded positive identification from skeletal radiographic comparison.

Nevertheless, the careful and thorough recovery of ash and debris at the scene produced dental materials that could be used for antemortem/post-mortem comparison. As each bag of ash was x-rayed, the radiographs revealed the presence of shotgun pellets as well as other radiopaque objects. This ash was then screened and washed to reveal porcelain-fused-to-metal crowns, which had remained remarkably intact even after prolonged exposure to extreme heat and the subsequent exposure to freezing rain. These were sufficient for positive identification.

Forensic Anthropology, Forensic Odontology, Crime Scene

H61 Accident, Suicide, or Homicide: A Case Study Involving the Investigation of Skeletonized and Bear-Scavenged Remains

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The presentation will demonstrate the perplexity of investigations involving human remains which have been scavenged by animals. A selected case study will present evidence of postmortem bear scavenging in which the interpretation of gnawing patterns along with scene evidence provided crucial answers to a perplexing death.

Human remains scavenged by animals can present a number of difficulties to investigators. Damage to soft tissues and/or skeletal elements may be misinterpreted as an antemortem injury resulting from human interaction. Recognition of animal gnawing, specifically identifying tooth marks and scavenging patterns are essential in providing important evidence in many cases of questionable death. Over the years, bears in wilderness areas of the U.S. have attacked a number of humans. Many of these bear attacks have resulted in serious injuries, some of which have resulted in death. Investigation of a death involving human remains recovered from a wilderness area that is populated by bears can be especially problematic. In such cases, questions arise as to whether death resulted from a bear attack, or by other means.

One such case involved the death of a nineteen-year-old soldier whose badly decomposed remains were discovered in a remote wilderness area near Mt. Home Air Force Base, Idaho. Two hunters discovered the remains of the young soldier in late October of 1999. According to investigative reports, the deceased was reported to have been last seen on September 5, 1999 when he left his residence during the early morning hours in order to go scouting for wild game. The remains of the young soldier were initially transported to Mt. Home Air Force Base, ID, where dental comparisons were conducted, to establish positive identification. Later the remains were transported to the morgue and laboratory facilities of the Armed Forces Medical Examiner in Washington, DC. Detailed fluoroscopic examination of the remains including the clothing that remained on the body revealed no foreign objects or metallic fragments.

Gross examination of the body revealed it to be in a highly decomposed state with partial mummification and skeletonization. No internal organs were present with the exception of a small amount of decomposed brain matter located within the skull. The body was noted to be in a contorted position as the result of postmortem animal movement and mummification. Most of the tissues of the head and face were present and in a mummified state with the exception of the right side of the head where the skull was exposed as the result of a large open defect over the right frontal, sphenoid, parietal and temporal bone area. Multiple sites of animal gnawing were noted on the remains as well as the clothing. The most prominent area of animal gnawing was an area along the upper left chest where the clothing was torn through and through, with significant damage to the underlying musculature of the chest.

Three personal items of particular note which were examined included a gold wedding band, a camouflaged baseball style cap, a nylon back pack, a 35 mm camera, and a .30-06 caliber rifle. The back pack

which was still attached to the deceased did not exhibit evidence of tearing or tooth marks, the ring was noted as being somewhat deformed, and the right half of the brim of the baseball cap was found to be missing with ragged borders. Examination of the animal tooth marks and gnawing patterns on the remains found them consistent with a large carnivore, specifically a bear. All of the tooth marks were determined most likely to have occurred postmortem as scavenging activity. Examination of the skull, including additional fragments and dentition, which were located during a secondary recovery effort, were negative for animal tooth marks or gnawing patterns. The extensive fracturing of the skull was found to be most consistent with that of a grazing gunshot wound to the right side of the head.

Film developed from the recovered camera included photographs depicting the deceased smiling while posing with a recently killed coyote. Also noted in the photographs was the location of the deceased standing just a short distance below the rocky ridge where his remains were recovered. Examination of the recovered rifle revealed that a single round had been fired and that the spent cartridge remained within the rifle chamber. Testing of the rifle by ballistic experts noted that the rifle's sear had been modified to produce a "hair trigger." The hair trigger, which was gauged at one pound and six ounces, resulted in the rifle being extremely unsafe, discharging if dropped from a height of two inches, or by tapping on the rifle's stock. Death of the subject which was initially thought possibly to be the result of a bear attack was ruled as resulting from a single gunshot wound to the head. It is believed that the subject slipped during his ascent of the rocky ridge, thus accidentally, discharging his rifle.

Postmortem Changes, Tooth Marks, Skeleton

H62 From Caffey (1946) to Kempe (1962): Historical Perspectives of the Recognition of Child Abuse

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This paper attempts to critically examine physicians' treatment of trauma in children in the earlier part of the last century.

This historical review of the medical literature examines the recognition of child abuse from the perspective of the physicians in the first half of the 20th century. The literature reveals an interesting mix of obsessions with accurate diagnosis of bone fracture and hesitance to associate severe trauma in children with caretaker abuse. As Silverman so aptly states: *Perhaps no body system of infants has been studied more intensively by the roentgen technique than the skeletal system. It is surprising, therefore, that physical trauma, probably the most common bone "disease" of infancy, should have certain roentgen manifestations which perplex physicians when discovered accidentally (Silverman 1953).*

When Kempe introduced his brazen phrase "Battered Child Syndrome" in 1962, he accomplished his intended purpose: to inflame the public into an awareness of child abuse. Although seldom used today, Kempe's terminology also struck a cord in the medical community, producing a heightened awareness of abuses to children that still exists today.

Kempe was not the first to discover child abuse. Beginning in the 1940s, Caffey encouraged the medical profession to be suspicious of trauma in children. The culmination of his 20 years of experience and research prompted him to suggest that a correlation **may** exist between subdural hematoma, bone fractures, and caregiver abuse (Caffey 1946).

So how does the early 20th century fare in the recognition of child abuse? One typical published case is illustrated below in table 1:

Table 1. Case Study: This is a child born prematurely into a healthy family of 2 children. Clinical findings and comments are given below (all from Astley 1953).

Age of Victim	Complaint	History of Injury	Radiographic Healing Trauma or Other Injury
6 months <i>Comments</i> —"bones normal in all other respects . . ." " . . .no osteoporosis"	Lt Arm and Shoulder	None	Andy Proximal Lt Humerus, 15 Posterior Healing Ribs, Distal Rt radius, Distal Lt Ulna, Distal Rt & Lt Femur, Proximal Lt Tibia, Distal Rt and Lt Tibia, Distal Rt Fibula
12 months	Rt Elbow	None	Distal Rt and Lt Humerus, Distal Lt Tibia Proximal Rt & Lt Tibia, Distal Rt & Lt Femora
17 months <i>Comments</i> —"united normally . . . appeared firm 2 months later"	Rt Leg	Fell out of a pram	Acute Rt Femur Shaft Fx
23 months <i>Comments</i> —"united in a month"	Rt Leg	Relearning to walk	Acute Rt Femur Shaft Fx
32 months <i>Comments</i> —"still very well" e:		None	Rib Fx and Acute Lumbar 2 Body Fx Curvature or irregular outline of the Proximal Lt Humerus, Rt and Lt Elbows, Lt Tibia
39 Months <i>Comments</i> —" . . .healthy looking girl"		None	Lt Retinal Detachment Lt Humerus, Deformity of Lt Tibia

Final Comments— . . . most of these [fractures] produced little disturbance and many were chance findings on X-ray exam. It is difficult to believe that a normal child could have such extensive lesions without a very definite story of trauma and without considerable pain. Thus while trauma is probably a factor in this condition, it seems likely that there is some additional underlying structural abnormality . . . **the title of Metaphyseal Fragility of Bone is suggested as a provisional label for the syndrome (Astley 1953).**

In this blatant child abuse case, you can see physician attempts to explain these pathologies medically while ignoring indicators of abuse, thus the diagnosis of "Metaphyseal Fragility of Bone." This represents just one of many child diagnoses seen in the literature that appears glaringly obvious today, but at the time were either misunderstood or mischaracterized. Physician denial of child abuse was commonplace in this time period, especially considering that physicians often knew their patients and were unaccustomed to the role of the accuser. Physicians solve medical, not social problems. Before public and legal consciousness was stimulated in the 1960s, children were often left to their own destiny. This historical review allows medical professionals a critical inspection of the past, while demonstrating that patterns of abuse remain the same; only the recognition has changed.

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Child Abuse, Bone Fracture, Battered Child Syndrome

H63 Fracture Patterns in Abused Children: A Study of Skeletal Trauma Among Battered Children in a Clinical Cohort From the Leeds (UK) Metropolitan Area

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This presentation concerns the physical abuse of children, specifically the characteristics and patterns of non-accidental skeletal fractures for patients admitted to two hospitals in the area of Leeds, United Kingdom. The analysis of patterns of non-accidental fractures sustained by maltreated children can be used as a guide by the medical-legal community to determine if antemortem, perimortem, and/or postmortem fractures in children are the result of abuse.

In this study, data concerning non-accidental fractures has been obtained from a study of the medical records of abused children with fractures. This data will create an added reference for fractures in abused children, specifically for the Leeds area. The discussion will place the new data in perspective with previous fracture pattern studies and accepted knowledge in order to establish validity and highlight the characteristics of abusive injury to children residing in inner urban areas of northern England.

The occurrence of child maltreatment or abuse is more common than society may realize. In the broader definition of child abuse (including neglect, physical abuse, sexual abuse, and emotional abuse) at least one million children are abused each year in the United Kingdom. Medical professionals, including those from the forensic community, often have primary responsibility for diagnosing and acknowledging child abuse. The recognition of non-accidental injury is one of the most important diagnoses a medical professional can make. An accurate diagnosis can save a child's life or result in important information for the medical-legal authorities if the recognition is postmortem (Meadow 1997). According to Hobbs (1992) it is by physical abuse, or non-accidental injury, that the medical community often has its first concerns about a child suffering abuse. During the 1980s, approximately 1.5-2% of all children in Britain had been physically abused by the age of 17 years, and of the more severe cases of non-accidental injury between 200 and 230 deaths occurred annually. Hobbs et al. (1993) classifies non-accidental injury into superficial or dermatological injuries; deeper lesions; fractures, dislocations, wrenched limbs, and periosteal injury; thoraco-lumbar internal injury; intracranial and spinal injury; asphyxia, drowning, and poisoning; and fabricated disorders (Munchausen by proxy).

The association of long bone fractures and subdural haematoma by Caffey (1946) began the recognition of child abuse as a medical condition. Since then, physicians have used skeletal fractures as a central part of the understanding and documentation of child maltreatment. Skeletal fractures have a high specificity for abuse and warrant extensive investigation in children who sustain them (Kleinman 1998). Analyses of child maltreatment cases have revealed a number of informative characteristics of fractures in abused children such as average age, sex,

socio-economic status, most commonly fractured bone, and the most common fracture type.

In the current study medical records were examined from 180 children under the age of three years, admitted for non-accidental skeletal fractures to St James' University Hospital and Leeds General Infirmary in Leeds, West Yorkshire, U.K., during the period of 1990 to 1999. Results from the study revealed a skeletal fracture pattern for non-accidental abuse. The average age of the 180 children in the study was one year, more boys (58%) than girls were injured, and the majority of the children came from socially deprived areas (established from home postal codes). The bone most often fractured was the parietal bone (25%), and the most common fracture types were the single linear and rib fracture. Significance tests (chi-squared) revealed that abused children one-year of age and younger are at a significantly greater risk of skull fractures than older children in the group ($\chi^2 = 4.803$; $p < 0.05$). Children of this same age were also found to be more at risk of sustaining multiple fractures than older children ($\chi^2 = 4.540$; $p < 0.05$). Children who have sustained rib fractures are less likely to also have skull fractures ($\chi^2 = 8.207$; $p < 0.01$), while those with skull fractures are significantly less likely to have also sustained a long bone fracture ($\chi^2 = 102.109$; $p < 0.001$). In addition, a child who has sustained multiple fractures is more likely to have broken bones other than the ribs ($\chi^2 = 35.701$; $p < 0.001$).

The skeletal fracture patterns and other results of this study are in general agreement with the previously established signs of abusive fractures as well as many of the findings of similar studies for age, sex, socio-economic status, bones fractured, and fracture types. The average age agrees with earlier studies revealing that fractures due to abuse occur more often in the first year of a child's life and more male than female children suffering non-accidental skeletal trauma tend to be victims of abuse (e.g., Kogutt et al. 1974). The majority of children in the study lived in sections of the Leeds Inner Area (LIA), part of the 10% most deprived areas nationally, which conforms with associations between poverty and child abuse established by Hobbs et al. (1993). The most commonly broken bone in this study corresponds with that of Hobbs (1984), who stated that the parietal bone was the most frequently fractured skull bone in cases of abuse and accidents. However, the finding in the present study of a high prevalence of single linear fractures to the skull in child abuse cases is juxtaposed to previous studies showing that this type of fracture is more typically caused by accident (Hobbs 1984). The prevalence of rib fractures in the Leeds cohort is similar to that found in other studies of child abuse.

This study has identified fracture patterns in the cohort of abused children that correspond, for the most part, to the established characteristics of abused children with non-accidental fractures. Other more unusual fracture patterns and associations with various patient factors have been highlighted. It is difficult to compare these findings to other fracture pattern studies since no similar comparisons were made. Overall, the findings of this study may be useful as an added reference for medical-legal professionals in Leeds and elsewhere in other inner urban areas for non-accidental fractures in children, and as such, may aid in the detection of child abuse.

Fracture Patterns, Child Abuse, Skeletal Trauma

H64 Diagnostic Imaging of Child Abuse: A Comparison of Radiographic Views to Detect Rib Fracture

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This paper is informative of the positive predictive value of oblique chest x-rays in the detection of rib fractures in the child.

While some 2000 children die each year as a result of abuse or neglect by parents or caregivers, it is estimated that 10 times as many children survive abuse as die from it (Report of the U.S. Advisory Board on Child Abuse and Neglect, A Nation's Shame 1995). Diagnostic imaging studies are often critical in assessment of infants and young children with evidence of physical injury, and the recognition of child abuse (AAP Section on Radiology, 2000). The Regional Forensic Center in Memphis, TN conducted research on the effectiveness of different radiographic views used to detect rib fractures in children. Skeletal injuries such as rib fractures, rarely pose a threat to the life of an abused child, yet, certain patterns of injury suggest the possible diagnosis of inflicted injury (Bulloch, et al, 2000; Shouldice & Huyer, 2000).

Historically, rib fractures have been difficult to detect radiographically. To produce the highest diagnostic yield, imaging surveys must be performed at a high level of technical excellence but still remain at an acceptable cost. Based in part on the Kleinman (1996) study of 31 infants, the American Academy of Pediatrics Radiology Section (2000) has suggested that oblique views of the thorax may produce a higher yield than the recommended anterior/posterior (AP) and lateral views. However, few researchers have addressed or tested the predictive value of the oblique view in detection of rib fracture of an abused child.

In the study presented, children from birth to eighteen years of age were examined externally, radiographically, during autopsy, and histologically to identify thoracic fractures. The attending pathologist, forensic anthropologist, and nurse researcher reviewed all radiographs. AP and lateral radiographs of the thorax were inspected, and a determination was made concerning the presence or absence of rib fractures. Oblique films were then examined, to test for improved visibility of fractures noted in the right and left posterior, and right and left anterior oblique views. Any radiograph accompanying a referred child was included in the study and viewed in the same manner. Ribs were also inspected at autopsy and palpated for abnormalities. For further examination, the attending pathologist or anthropologist excised ribs either suspected of fracture or lying adjacent existing fractures; the excised ribs were processed, photographed, and sectioned for histology. Histologic slides were reviewed by the attending pathologist both to confirm rib fracture and assist in determining the age of the fracture.

Findings, gathered in the first twelve months of the study, indicate that for rib fractures not seen in the AP and lateral views, no significant positive predictive value was found by oblique view of the thorax. Initial findings suggest that the addition of oblique radiographs have yielded no significant additional diagnostic results, but limitations of the study may be contributory. While small sample size may likely be a valid limitation to the study, radiographic technique, angle, and lack of a radiologist assessment may be additional inhibiting variables. However, it must be emphasized that the purpose of this study was to facilitate medical examiners and other clinicians commonly lacking radiographic technologists, much less radiologists. In this regard, adopting guidelines promoted by the American Academy of Pediatric Radiologic Section can benefit forensic pathologists.

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Child Abuse, Rib Fracture, Radiography

H65 Recognizing Child Abuse in the Thoracic Region Through a Multidisciplinary Approach

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The goal of this presentation is to describe child abuse trauma to the thoracic region, which may be difficult to recognize or incompletely understood without a forensic osteological analysis.

The recognition and subsequent presentation of persuasive evidence of child abuse is a difficult task often requiring evidence of: 1) specific definitive trauma patterns, and 2) evidence of multiple or repetitive traumatic episodes (temporally distinct). The forensic pathology literature on soft tissue characteristics of child abuse is abundant, however, descriptions of osteological markers and patterns of chronic trauma in many areas of the skeleton are limited.

Skeletal trauma in child abuse can be found in many regions of the body. Cranial trauma is highly visible and represents the most commonly-detected fatal traumatic site. Fractures of metaphyseal/epiphyseal junctions of the appendicular skeleton are rare in non-abuse cases and are radiographically distinct and easily found. Even though trauma in the thoracic region has a strong correlation to child abuse, this area remains one of the more difficult to detect fractures during external examinations and even following radiographic surveys of the body and may thus be under-represented. Gross osteological analyses are often required to more definitively characterize traumatic defects associated with child abuse.

It will be argued here that the unequivocal documentation of trauma in terms of specific defect location, morphology, severity and degree of healing requires a multidisciplinary effort of law enforcement and forensic specialists that necessarily includes a comprehensive osteological analysis of the remains completed by a accredited forensic anthropologist. The benefits of this approach to the identification and prosecution of child abuse cases will be illustrated through three cases. Focus is upon the thoracic region.

Case 1: The first case involves a 3 ½ month-old white male who was transported to a hospital emergency room in full cardiac arrest. The mother reported that another young child allegedly fell and landed on the infant's head. Early the next morning the child was found to be unresponsive. Multiple traumatic injuries were identified on the head back, legs and genitals. Radiologic studies revealed a posterior right parietal skull fracture and probable healing fractures to the sternal 1/3rd of left ribs 2-7 and left posterior 8th rib. Criteria for brain death were subsequently fulfilled, and life support measures were withdrawn. At the autopsy, the calvarium showed a simple non-displaced skull fracture to the posterior right parietal bone with multifocal overlying subgaleal hemorrhage. The cause of death was determined to be due to blunt force trauma to the head. In keeping with a previously established practice of multidisciplinary forensic cooperation, anthropologic consultation was undertaken in an effort to further evaluate and characterize the traumatic skeletal injuries.

Following removal of all overlying soft tissue, the skull exhibited an incomplete linear fracture in the right parietal bone resulting from lateral bending forces on the bone and not direct blunt force trauma. Each of the six damaged left ribs exhibited a similarly-sized bony callus arranged in the linear "string of beads" pattern suggesting one specific episode of trauma. In addition, bony calluses were noted at the vertebral ends of left ribs 5 and 8. The size and configuration of the calluses (grossly and radiographically) indicated different degrees of healing relative to one another and relative to the sternal fractures. The comprehensive osteologic evaluation was vital in this instance in that

three separate incidents of non-accidental trauma were identified which allowed the prosecution to establish of a "course of conduct" on the part of the defendant and resulted in a conviction.

Case 2: Emergency medical personnel responded to a residence where a five month-old white male was in cardiac arrest. According to the primary care givers efforts to revive the child included CPR. A brief evaluation of the infant showed fixed and dilated pupils, no audible heart tones and slightly increased heart size. The initial diagnostic impression was severe hypoxic ischemic encephalopathy secondary to cardiopulmonary arrest, possibly due to sudden infant death syndrome or non-accidental trauma. A CT scan of the head did not reveal any hemorrhage or signs of trauma. A radiograph of the chest and subsequent bone scan revealed a possible healing fracture of the left 6th rib. The child's neurologic condition continued to deteriorate and a decision was made to withdraw supportive ventilation.

An autopsy revealed a cardiac laceration to the base of the right atrial appendage and a gastric contusion affecting the cardia of the stomach. In addition, an incomplete sternal fracture affecting the manubrial-sternal joint was identified. Potential fractures of a number of ribs were also noted though specific diagnosis of morphology, biomechanical etiology, and state of healing was not possible. The cause of death was determined to be hypoxic ischemic encephalopathy which developed as a consequence of blunt force trauma to the trunk.

A subsequent forensic osteological analysis of the ribs indicated antemortem damage to the sternal portions of left ribs 2-7 and right ribs 2-6. The evidence consisted of previous linear fractures with minimal and large callus formation, and remodeled costochondral rib ends. The perimortem evidence included new fracture lines through healing defect sites on the ribs and a linear fracture through the mesosternal cartilage. Two and likely three separate and distinct trauma episodes were indicated and the caregiver arrested, thus negating the suggestion that CPR efforts alone led to the broken ribs.

Case 3: The third case involves a 3-year-old boy rushed to a hospital in 1994 following a seizure, collapse and death. Although caretakers reported that the child had a history of seizures and was on medication for the condition, emergency room personnel contacted law enforcement authorities to report discrepancies between the reported history and the apparent traumatic condition of the child.

External examinations at autopsy revealed minimal findings with the exception of numerous linear marks associated with bruising evidence on the back of the child. When the case occurred, it was still customary for the autopsy to proceed before full body radiographs were taken, thus allowing the medical findings to dictate whether radiographs were necessary. Soft tissue damage included lacerations of the heart, liver and lungs. Numerous rib fractures were also identified and radiographs requested.

Even though radiographs revealed little skeletal abnormality, the detailed osteological analysis revealed that all right ribs except 2 were fractured acutely. Of these, five were in the process of healing. Three of the seven fractured ribs were in repair. All healing appeared to be in the reparative stage suggesting similarly-aged previous trauma. The healing and re-fracturing of half of the broken ribs strongly indicates a repetitive pattern of abuse. While radiology was confusing in this case, invasive techniques by pathologists and anthropologists provide clear evidence for a court of law.

Summary: Detailed evidentiary documentation of fracture locations, number of elements involved, and temporal variation of traumatic events all play a key role in the identification of child abuse and eventual successful prosecution. In all three cases described above, osteologic analysis was critical in establishing the repetitive nature of the non-accidental abuse and trauma and in a number of cases can successfully refute a potential "CPR defense" as an explanation for the injuries sustained during this child's terminal event.

Child Abuse, Thoracic Region Trauma, Forensic Osteological Analysis

H66 A Multidisciplinary Approach to Evaluate Chronic Malnutrition During Childhood in a Case of Suspected Fatal Child Abuse

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The goals of this presentation is to detail and promote a multidisciplinary approach to the identification and documentation of severe chronic malnutrition in children during autopsy.

It has long been recognized that deaths due to child abuse and neglect are often misidentified as accidental or missed entirely and classified as natural. With this in mind, there has been a call for more aggressive autopsy techniques, utilizing a multidisciplinary team approach and focusing on a broader range of evidence, i.e., radiological, skeletal, dental, pathological, toxicological. Application of such an autopsy strategy has resulted in the identification of cases of abuse and neglect that may not have been identified previously. Conversely, such an aggressive autopsy approach may prevent an erroneous identification of manner of death as homicide and thereby reduce the risk of wrongful conviction.

At 5:00 pm on June 8, 1992, a seven-year-old girl was pronounced dead in the Emergency Department of University Medical Center, Lubbock, Texas. At 7:30 pm that same evening an autopsy was performed; cause and mechanism of death were listed as "... a severe and chronic malnutrition which led to extensive emaciation resulting in metabolic acidosis and subsequent cardiac damage with cardiac arrhythmia and myocardial arrest." Following an investigation, both parents were arrested and tried for the death of their daughter. Each was convicted of contributing to their daughter's death. The father received a 10-year prison sentence, the mother, as primary care-giver, received a more severe sentence of 50 years.

Following the mother's conviction, Dr. Susan Roe was contacted by a colleague regarding the case and agreed to review relevant court, law enforcement, and medical records. After examining the autopsy report, autopsy photographs, medical records, microscopic slides, court documents and related reports, as well as consulting a second pathologist, a pediatric pathologist, and a forensic and cardiac pathologist, Dr. Roe concluded that the original autopsy findings were in error. Specifically, the materials reviewed could not support diagnoses of chronic malnutrition and cardiac damage from malnutrition. Following her review, Dr. Roe stated that the exhumation of the child's body would aid in resolving the issues about this case and agreed to conduct a second autopsy. In 1996, as part of the mother's application for writ of Habeas Corpus, the child's body was exhumed and transported to St. Paul, Minnesota for the second autopsy. The condition of the remains warranted consultation of additional experts including forensic anthropologists, a forensic odontologist, and a pediatric pathologist to fully assess the original cause and manner of death.

The anthropological and odontological examination centered on skeletal indicators of nutritional deficiency. Dietary sufficiency may be evaluated by measuring the concurrence of skeletal and dental development with known chronological age of the decedent. Additionally, skeletal and dental evidence of growth interruption and recovery may be observed on both skeletal and dental tissues. Dental development, long bone length, enamel hypoplasias, and Harris lines were evaluated. The stage of dental development observed is consistent with a 6.5 - 8.0 year old child. The maximum lengths of the femora, tibiae, and fibulae are consistent with a 6.0 - 9.0 year old child. No enamel hypoplasias were observed on the deciduous and permanent teeth present. Incomplete and

faint Harris lines were observed on the distal end of the femora. Previous research has identified a relationship between Harris lines and enamel hypoplasias and various nutritional inadequacies. Enamel hypoplasias, however, are generally accepted as the more reliable and sensitive indicator of nutritional deficiency.

The pathology examination and a review of the records contradicts the original autopsy findings. The original pathologist opined that the heart showed changes from malnutrition. The heart, however, is within normal limits for a 7-8 year old child. The organ weights are also within normal limits for the child's age and the body fat visible in the autopsy photographs is within normal limits for this age child. Another factor used to support the original diagnosis of malnutrition was a fatty liver, the review of the records indicates that in fact the liver section was within normal limits for a child this age. Additionally, numerous vital studies, including postmortem vitreous electrolytes, postmortem culture results, and a bone marrow sample were not performed. In summary, the decedent was a 7-year-10-month-old female with normal body fat, normal organ weights, normal bone growth, and normal dental growth. Because many vital studies were not performed at autopsy, it is not possible to determine the manner or specific cause of death in this child. It is, however, clear that there is no evidence to support a diagnosis of chronic or acute malnutrition and, consequently, the reported manner of death as homicide.

The multidisciplinary approach applied in this case highlights the contributions of a wide array of experts and the broad range of evidence that may be evaluated when investigating cases of suspected fatal child abuse. Although, the multidisciplinary team was originally assembled due to the advanced state of decomposition of the body, we advocate such a protocol for any case of suspected fatal child abuse to determine more accurately and to document more thoroughly the cause and manner of death

Child Abuse, Multidisciplinary, Malnutrition

H67 The Hidden Truth: Mandibular Condyle Fractures in Child Abuse

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Attendees will learn that mandibular fractures in infants may be more common as an indicator of child abuse than what the literature indicates.

A high percentage of trauma in abused children occurs in the facial region. It has been stated that abusers often attack the face of a child because it "represents" the individual child (O'Neill et al. 1973). The most common areas of skull fractures in children, resulting from both accidents and abuse, are the parietals and post-parietal regions. Fractures that occur in other locations (such as the mandible) are also highly indicative of abuse (Hobbs 1984) but not as commonly identified. Identification of acute and healing fractures in the cranium and splanchnocranium are crucial to trauma analysis and establishing patterns of abuse.

Mandible fractures are common in adults but have seldom been referenced in association with children, especially in cases of suspected abuse. This is a glaring contradiction to the reported high frequency of facial trauma in child abuse. This research suggests that facial fractures may be more common in child abuse, but often remain undetected.

In a review of the 1998 child abuse cases from the Regional Forensic Center in Memphis, TN, two abuse cases illustrated mandibular condyle fractures. In the first case, a 10-month-old male was taken to the day care at 7:30 AM. That afternoon, the day care center alerted the parents that the child had a seizure, fell, and required emergency medical service. The child was admitted to the local children's hospital in full arrest. CT scans

revealed skull fractures. Local law enforcement and the medical examiners office were contacted because the history did not correspond to the severity of the injuries. The child was transported to the medical examiners office for examination.

External exam illustrated that all of the injuries impacted the face and head. These included numerous acute contusions and abrasions. The forensic pathologist noted massive injuries to the posterior head including subgaleal hemorrhage, brain swelling, and fractures to the occipital, parietal, and internal border of the left eye orbit. After autopsy, several cranial bones were retained by the medical examiner for skeletal analysis by a forensic anthropologist. Skeletal analysis revealed radiating fractures from the basilar skull to the anterior frontal bone, and a fracture in the neck of the left mandibular condyle.

The second case involved an 18-month-old female who was admitted to the local children's hospital in full arrest. The child's mother claimed that the child fell in the bath while being cared for by her current boyfriend. Local law enforcement and the medical examiners office were notified because the history did not correspond to the severity of the injury, which included an occipital bone fracture. The child was eventually transported to the medical examiners office for examination.

The external exam revealed numerous acute contusions, abrasions, and lacerations, particularly to the face and head. The autopsy revealed subgaleal contusions on the occipital, bilateral occipital subdural hemorrhage, and occipital bone fracture. Several skeletal elements were retained for skeletal analysis, which revealed a healed mandibular condyle fracture, in addition to the occipital fracture. The healed condylar fracture is indicative of a pattern of abuse.

Two questions arose from these cases. Do infant mandibles fracture differently from those of adults, and why are so few reported in cases of abuse? The infant mandible undergoes many rapid biomechanical changes during the first few years of life. Tremendous growth occurs in each mandibular ramus. Furthermore, the introduction of new foods changes the biomechanical demands placed on the condyles, generating a period of rapid bone reorganization. During this period, it is probable that an immature vs. mature mandible responds to external forces differently. Different biomechanical responses may be a contributing factor to the difficult identification on radiographic films, in external exams, and in autopsy. To correct this problem and visually identify fractures of the mandibular condyle, aggressive autopsy techniques are required by the forensic pathologist, with a complete anthropological examination to follow.

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Child Abuse, Fracture, Mandible

H68 Child Abuse Case: Multiple Forensic Issues

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The goal of this presentation is to expose forensic investigators to many facets and intricacies associated with cases of child abuse.

Introduction: On the evening of 16 October, 2000, the medical examiner's office was notified of a four-month-old white male who had presented to a local emergency department in cardiac arrest. The baby's past medical history was notable for a premature birth at 24 weeks gestation, followed by a lengthy (approximately 3 months) hospitalization in the neonatal intensive care unit. The baby survived many of the expected sequelae associated with prematurity, including respiratory distress syndrome and infections, only to be discharged home where he

ultimately succumbed approximately one month later, to the violent and inexplicable act of child abuse.

Clinical History: Premature male infant, born 11 June, 2000, by spontaneous vaginal delivery at 24 weeks gestation to a 17-year-old female. After spending approximately three months in the neonatal intensive care unit (NICU) before being discharged home with his parents on 2 September, 2000. While in the NICU, his parents would frequently disappear for several days at a time, despite agreeing to regularly scheduled visitations to become more proactive in his care. Hospital social workers became concerned over the repeated abandonment and two attempts to get DCS involved were unsuccessful. At the time of his discharge, arrangements were made such that the baby and his parents would be living with one of the baby's grandparents in order to have greater access to medical care. On 6 October, 2000, he presented to the local children's hospital for a respiratory illness, for which he was treated with nebulizers. At that time, he was noted to have unusual bruises over parts of his body and a forensic consult was sought. Skeletal radiographs showed buckle fractures involving the proximal left tibia and distal left radius. DCS was again contacted to investigate. However, it was felt that the fractures could be secondary to his prematurity and he was discharged home with his parents on 10 October, 2000. Per his parents and his paternal grandmother, on 13 October, 2000, he developed congestion requiring "breathing treatments." Two days later, he had an apneic spell, "turned blue," and required suctioning. He did better initially, but later that evening, he was noted to be lethargic and another "breathing treatment" was administered. In the early hours of 16 October, 2000, he was noted to be apneic, his father began administering CPR and called 911. He was essentially comatose at presentation to the Children's Emergency Room and died several hours later. Child abuse was suspected after ophthalmologic examination revealed bilateral retinal hemorrhages and a chest x-ray revealed several rib fractures. Postmortem examination was ordered by law enforcement agents at the request of the medical examiner.

Autopsy findings revealed multiple blunt force injuries caused by blows to the abdomen and chest causing multiple bilateral rib fractures, acute and remote, lung contusions, extensive liver and spleen lacerations and internal bleeding. Additionally, findings attributable to shaken infant Syndrome were also present, including but not limited to, bilateral retinal hemorrhages, acute subdural hematoma and cerebral edema. Abrasions and contusions were present around the anal canal, with mucosal hemorrhage of the distal rectum. Contusions were also noted on both lower extremities. Cause of death was attributed to multiple blunt force injuries and shaken infant syndrome.

Anthropological analysis was performed on the entire rib cage to further understand the extensive fractures present. Not just acute bilateral fractures but healed rib fractures indicative of trauma two to three weeks prior were revealed. Histological analyses demonstrated a moderate degree of osteoblastic activity within the callus formation in the two to three week window when the antemortem fractures were sustained.

A heated and emotional trial ensued against the father, resulting in a guilty verdict and sentencing to life in prison without the possibility of parole. No charges were ever filed against the mother. Testimonies by both the forensic pathologist and forensic anthropologist involved in the case were heard. However, part of the anthropological evidence was deemed inadmissible, adding a whole new dimension to the case.

Most cases of child abuse are not isolated events. Not uncommonly, there are episodic bouts of trauma, that culminate in a final, fatal event. Unfortunately, it is the opinion of our justice system that evidence of prior trauma is inadmissible in these instances, taking away proof of prior suffering the infant experienced during life, thereby possibly reducing the level of punishment imposed. Finally, the greater crime may be imposed by an inept child and family services programs who on numerous occasions dropped the ball on not only recovering the child from the home during his brief life, but for placing the infant in that environment in the first place.

Child Abuse, Rib Fracture, Recognition

H69 Child Abuse: It's All in the Recognition

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The goals of this research project are to demonstrate how using a multidisciplinary approach for cases of sudden infant death lends the added expertise to allow the most accurate determinations of cause and manner of death.

Historically, the ruling of manner and cause of sudden infant deaths has been challenging. This is due to a lack of eyewitness accounts and accurate historical records, not to mention the emotional involvement of the caregiver, law enforcement, and medical professionals. This problem has prompted the professionals at the Regional Forensic Center in Memphis to combine fields of expertise in the examination of sudden infant deaths. This multidisciplinary approach allows a more accurate and complete assessment of child mortality. While the forensic pathologist makes the final ruling, the enlistment of anthropology, nursing, bloodstain pattern analysis, and radiology can all contribute to a more complete investigation of children's untimely death.

Three case studies will demonstrate this multidisciplinary approach.

Case 1: This 22-month-old male was found at home in full arrest by the mother's boyfriend. Paramedics were called, but extensive resuscitation at the scene and in the emergency room could not save the child. When law enforcement interviewed the mother about her son's death, she stated that he had been fine when she had left him in the custody of her boyfriend. The mother stated that her boyfriend had been rough to the child in the past.

After pronouncement of death, the incident was reported to law enforcement and the body was transported to the medical examiner's office. An examination into the child's past medical history by the forensic nurse raised suspicion of past abuse. Seven months prior to the child's death, caretakers claimed the child burned himself when a hot iron fell on him. There was also a report of a left humeral injury 6 weeks prior to death where victim "fell off a bed." DHS was not notified in either case. External examination of the child revealed the burn scar on the calf of the right leg and multiple contusions and scars over the trunk and extremities. Radiographic findings included the healed periosteal elevation on the distal left humerus and a single acute fracture of right rib 7 that was suggested to be resuscitation related.

Autopsy findings were unmistakable. Most noticeable were contusions of the intestine and a lacerated liver, suggestive of severe blows to the abdomen. The cause of death was ruled blunt force injuries to the chest and abdomen producing injury to vital organs, bleeding, and death. The anthropologist confirmed the existing fractures and examined each rib for acute or healing trauma. Even though nothing definitive was detected by examination of radiographic film or by palpation, ribs 6 through 8 were removed along with fractured rib 9, as well as the healing humerus.

Examination of the ribs in a dry state produced more unexpected results. Each rib exhibited a healing fracture on the internal surface. While these rib defects were not visible radiographically, to the naked eye, or by palpation, their subtle presence provided unmistakable evidence for a pattern of abuse that existed long before the day the child died.

Case 2: This case begins in the back of a garbage truck. As the attendant was compacting garbage into the truck, he noticed what appeared to be a human baby protruding out of a trash bag. Law enforcement officers and the medical examiner's office were notified. The newborn was recovered from the truck, and found to be in the beginning stages of decomposition. The medical examiner decided to delay the autopsy until more information about the circumstances surrounding the discovery were obtained. The following day the medical examiner's

office was notified of a crime scene less than a block from where the newborn was discovered. At the crime scene, a female was found hanging in a closet by a ligature around her neck. Law enforcement suspected that the victim was the mother of the deceased infant.

The crime scene was thoroughly examined, with the assistance of law enforcement, a bloodstain expert, pathologists, anthropologists, and a nursing practitioner. It was determined that the victim was the mother of the new born. There was evidence for a home birth that resulted in the natural death of the new born. Possibly distressed by the death, the mother resorted to suicide by cutting her wrist and neck before eventually hanging herself. Her death was ruled a suicide. The autopsy of the child produced suspicious results. There appeared to be subgaleal hemorrhage to the back of the head, and directly under the hemorrhage, were fissures in the occipital and parietal that appeared to be fractures. Was this child beaten?

Anthropology was called in to confirm fractures, and within minutes, the lightly processed bones examined under magnification revealed that these were expected lateral fissures related to normal growing fetal skull bone.

Case 3: An 18-month-old male was found choking in the home. The father started CPR and the mother called paramedics from a neighbor's phone. Following extensive resuscitation attempts at the scene, the child was hospitalized for 48 hours and was pronounced dead in the intensive care unit. Interviews with the mother indicated that the child was in good health with the recent exception of vomiting and diarrhea associated with a common cold.

Law enforcement was contacted immediately due to the unruly and uncooperative nature of the mother in the emergency room. At this time it was noted that the parents reported three different accounts of incidents

leading up to the discovery of the choking child. The "best" story appeared to be that the child was being fed his bottle by an older sibling when he choked. The medical examiner's office was contacted and the baby was transported to the Regional Forensic Center for examination.

The forensic nurse examined the family and medical history of the infant, finding that an older daughter of the family had been placed into foster care for complicated medical problems since her parent's home was identified as "unsuitable" to her care. Also, an older sibling of the deceased died at the age of four months, diagnosed with SIDS. The deceased appeared to have no prior medical history.

This case obviously has numerous historical indicators of child abuse, including a suspect family history, injuries inconsistent with the child's developmental age, history of injury changes, and caregivers unwilling to cooperate with authorities. There was no history or external evidence of previous injury and the child was well developed for his age.

Autopsy findings produced no indicators of trauma. Besides the stigmata of medical intervention, there were no signs of abuse or neglect. However, dissection of the lung did reveal a foreign object. Imbedded deeply in the bronchus was a bead from a necklace. Upon reinterview with the parents, they confirmed that the child had been playing with a necklace shortly before eating. Cause of death was ruled aspiration of foreign body with occlusion of right bronchus.

These cases illustrate how immature investigations or immediate medical findings can be deceptive and even misleading, especially in child abuse cases. But as medical examiners begin to depend more on a multi-disciplinary team investigation, more information is utilized to influence decisions of cause and manner of death.

Child Abuse, Bone Fracture, Trauma

11 A Theory of Mind Model in Delusional Misidentification Associated With Aggression

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After attending this presentation, the participant will understand the basics of delusional misidentification and the potential use of the theory of mind concept in analyzing dangerous delusional misidentification.

This paper has two objectives: 1) to learn the different types and basic biology of delusional misidentification, and 2) to gain some understanding of the theory of mind concept with application to delusional misidentification associated with aggression.

The delusional misidentification syndromes are characterized by a delusion of misidentification of the physical and/or psychological identity of the self or others. Less frequently, animals or inanimate objects are delusionally misidentified. Capgras syndrome is the best known of the delusional misidentification syndromes. In Capgras syndrome, the affected individual delusionally believes in the existence of physically identical replicas of a person. The replica, however, has a different psychological make-up from that of the objective identity. Since the first published case of delusional misidentification syndromes by Capgras and Reboul-Lachaux in 1923, several other types of delusional misidentification have been reported in the psychiatric literature.

The delusional misidentification syndromes have been associated with verbal and physical aggression. Individuals who suffer from delusional misidentification syndromes may attack misidentified objects because they conceptualize the objects as malicious and/or threatening to the delusional individual. The misidentified objects are usually well known by the affected person. Delusional misidentification may unleash aggression toward a loved one that would be unacceptable to the affected person if the victim had been accurately recognized.

The delusional misidentification syndromes have been studied from phenomenological, nosological, epidemiological, neuropsychiatric and cognitive-psychological perspectives. In spite of these advances, a comprehensive model that integrates mental and behavioral phenomena with neurobiological factors in delusional misidentification has yet to emerge. This state of affairs is expected given the complexity of any such integrative model. Nonetheless, delusional misidentification has emerged as a potential candidate for a biopsychosocial model of psychopathology because its mental and behavioral categories are potentially codable and therefore can be linked to neurobiological substrates. In this presentation, we propose a comprehensive model of delusional misidentification. We also develop this model from the perspectives of a conceptual construct called theory of mind (TOM) and relate it to aggression.

The theory of mind concept was initially proposed as a way to facilitate inquiry as to how chimpanzees were able to assess the mental states of their conspecifics. These considerations were then adopted by investigators of autism as a useful paradigm to aid in the study of the mental life of autistic children. The essence of their findings suggests that autistic individuals have serious defects in estimating the mental states of others. Other investigators have shown that TOM abilities are well developed in young normal children. More recently, the TOM model has been applied to psychotic conditions. Preliminary data suggest that compared to non-psychotic controls, adult schizophrenics tend to perform more poorly in some theory of mind tests. At the neurobiological level, other studies suggest that conditions such as autism and schizophrenia may present with

abnormalities in the frontal and temporal cerebral areas. This suggests that when these areas are functioning normally, they may be implicated in the normal development of TOM abilities.

In this presentation, we propose that the delusional misidentification syndromes may be associated with deficits in theory of mind abilities. An important reason for this is inherent in the very nature of delusional misidentification, because most cases of delusional misidentification involve misidentification of the psychological makeup of others. In fact, these deficits are so profound that individuals with delusional misidentification have not only inaccurate interpretations about the mental states of others, but false beliefs regarding the whole mental identity of others.

This presentation also reviews the association of delusional misidentification with aggression. Dangerous delusional misidentification is explored as a function of several important substrates, including biological factors, delusional misidentification, and theory of mind abilities. The proposed model consists of two main levels of organization, the neurobiological and the psychological. We conclude this presentation with a brief overview of areas in need of further inquiry. First, further refinement is needed in the diagnostic reliability and validity of classification of delusional misidentification syndromes. In addition, comprehensive psychometric, especially neuropsychometric, instruments are needed for more accurate measurement of the cognitive, affective, and perceptual factors involved in dangerous delusional misidentification. And when current instruments are unable to do this, the development of appropriate instruments would be a necessary step. Finally, we are at a stage where systematic neurobiological studies of delusional misidentification as they relate to aggression and TOM concepts can be initiated. In particular, neuroimaging studies will be essential for the development of a functional neuroanatomy of theory of mind in the context of delusional misidentification.

Delusional Misidentification, Theory of Mind, Aggression

12 A Classification of Dissociative Phenomena Involved in Violent Behavior in Posttraumatic Stress Disorder

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After attending this presentation, the participant will understand the current status of knowledge about the interface of dissociation, aggression, and PTSD in a psychiatric-legal context.

This paper has two objectives: 1) to discuss the role of dissociation from a forensic psychiatric perspective, and 2) to propose a classification for the various types of dissociative experiences associated with aggression in the context of PTSD.

Since its formal introduction into the psychiatric nomenclature in 1980, posttraumatic stress disorder (PTSD) has frequently appeared in both criminal and civil litigation. In particular, the dissociative phenomena arising out of an individual's PTSD may have particular relevance in the formulation of opinions by the forensic psychiatric expert. PTSD-associated dissociation can be conceptualized as a spectrum condition that encompasses several degrees of severity. We apply this conceptualization in a proposed typology of dissociation secondary to combat-induced PTSD. Three types of dissociative experience are

identified. Case examples illustrate the cogent features of each type. All three types contain a strong affective component often associated with intense emotions (i.e., fear, anxiety, hostility, and/or depression).

The first type of dissociative experience combines strong cognitive and perceptual components in addition to the affective disturbances. This type of dissociation is arguably the most dramatic type of dissociation encountered in the context of PTSD. The most vivid example is the classic PTSD flashback. This dissociative episode is characterized by intense perceptual abnormalities in which the affected person usually re-experiences the environment where the traumatic event took place in a visual, cinema-like manner. Other perceptual abnormalities may also occur including auditory hallucinations as well as olfactory, gustatory, and somatosensory abnormalities. The affected persons also have impaired reality testing in that they re-experience the original trauma as though it is actually occurring. Although this presentation shares many features with a delusional state, the psychopathology involves intense dissociative phenomena.

In the second type of PTSD-associated dissociative experience, the affected person suffers from perceptual and affective abnormalities, but with preservation of reality testing. These individuals are aware that their unusual perceptual and affective experiences are not consistent with objective reality. They tend to become verbally and/or physically aggressive as a result of reduced frustration tolerance and of poor impulse control associated with their dissociative pathology.

In the third type of dissociative experience associated with aggression, the affected individuals still experience intense, affective responses during which they feel as if the trauma is being re-experienced. However, abnormal perceptual experiences and cognitive abnormalities associated with impaired reality testing are absent or minimal.

Dissociative phenomena that appear to be linked to aggression in the context of PTSD may be also mediated by other psychiatric factors such as impulsivity and general level of anxiety. The role that these factors might have in the genesis of aggression and violence is also discussed.

The classic PTSD flashback can arguably be conceptualized as the most severe form of dissociative phenomena in PTSD. In some cases, this is the reason the classic PTSD flashback has been linked to the legal issue of insanity. However, all dissociative states associated with violence in PTSD can, from a psychiatric-legal standpoint, be conceptualized as being composed of various degrees of mental responsibility. Therefore, the detailed phenomenological characteristics of those mental states, in the context of combat associated PTSD-induced violence, may help clarify not only the causes of violence due in part to dissociative phenomena in the context of PTSD, but also the related issue of criminal responsibility. However, the proposed typology of dissociative experiences should not be only viewed as a classification of dissociation associated with aggression in PTSD. Rather, other important aspects of dissociative phenomena, as well as other structural psychological factors, are essential in understanding violence in PTSD. Furthermore, the specific way in which PTSD-induced dissociation affects criminal responsibility may require a different classification scheme than that solely related to psychopathology. Suggestions for further investigation of the combination of PTSD, dissociation, and aggression are offered.

Dissociation, Posttraumatic Stress Disorder, Violence

I3 Shared Psychotic Disorder - Folie a' Deux: A Case Report

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One of our cases diagnosed to have shared psychotic disorder (folie a' deux) has been presented because of his rare and masculine nature and criminal deliriums, which may be considered to be interesting.

Shared psychotic disorder, perhaps better known as "folie a' deux", is rare. A patient is classified as having shared psychotic disorder when the

patient's psychotic symptoms developed during a long term relationships with another person who had a similar psychotic syndrome before the onset of symptoms in the patient with shared psychotic disorder. This disorder is called 'shared psychotic disorder' in DSM-IV, and most commonly involves two people, a dominant and a submissive one, the patient with shared psychotic disorder. Cases involving more than two individuals used to be called 'folie a trois', 'folie a quatre', 'folie a cinq' and so on. More than 95 percent of all cases of shared psychotic disorder involve two members of the same family and may be more common in lower than in higher socio-economic groups as well as in women than in man.

Although the primary theory about disorder is psychosocial, because more than 95 percent of cases involve people in the same family, a significant genetic component to the disorder has been suggested. A modest amount of data indicates that affected people often have a family history of schizophrenia.

The dominant member of the dyad has a preexisting psychotic disorder, almost always schizophrenia or a related psychotic disorder, and rarely an affective or dementia-related psychosis. The dominant person is usually older, more intelligent and better educated and has stronger personality traits than the submissive one who is usually dependent on the dominant person. The two (or more) people inevitably live together or have an extremely close personal relationship, associated with shared life experiences, common needs and hopes and often a deep emotional rapport with each other. The relationship between the people involved is usually somewhat or completely isolated from external societal and cultural inputs.

The submissive person may be predisposed to a mental disorder and may have a history of a personality disorder with dependent or suggestible qualities as well as a history of depression, suspiciousness and social isolation. The relationship between the two, although one of dependence, may also be characterized by ambivalence, with deeply held feelings of both love and hate. The dominant person may be moved to induce the delusional system in the submissive person as a mechanism for maintaining contact with another, despite the dominant person's psychosis. The dominant person's psychotic symptoms may develop in the submissive person through the process of identification. By adopting the psychotic symptoms of the dominant person, the submissive person gains acceptance by the other. The submissive person's admiration for the dominant person, however, may evolve into hatred, which the submissive person considers unacceptable; when the hatred is directed inward, depression and sometimes suicide can result.

The cases to be presented are a 72-year-old male, and a 41-year-old male, for whom the Council of Forensic Medicine, 4th Specialization Board (Forensic Psychiatry Dept.) was consulted by the court if they had any mental disease to affect their criminal liability with the crime of "making juridical authorities busy".

The histories of the cases suggested that they met each other 5 years ago and made good friends, and they suspected a person who had been dwelling with S.S. in the same region for the recent 3 years to be a "drug pusher and a gunrunner" and attempted to make him arrested, due to their deep patriotism, by chasing him. SS expressed that he had already been retired and permanently watching the house of the suspected from his house by his own binoculars, and his friend, S.A. was a shift worker and participated mostly in this watch after working hours, and that they regularly recorded his coming and going hours, car plate numbers in case he and his companions use a car, their identities and jobs, and appealed to police, juridical authorities, Ministry of the Interior, Ministry of Justice and Turkish Parliament.

During the examination of the files of the said individuals, it was found out that police searched the house and person several times upon their complaints and separately asked him and his companions recorded to give expression to. The reclaimants were sent to our department for examination upon the clarification of their false claims and separately, their insistence upon the so-called collaborationism of the police and juridical authorities with the criminals. After their examinations and

psychological tests, paranoid syndrome was determined in 72-year-old case, and the other case, 41 years old, was ascertained that he shared the deliriums of his close friend.

Shared Psychotic Disorder, Folie a' Deux, Paranoid Syndrome

14 Guidelines for Good Forensic Practice

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The goals of this research project are to become familiar with guidelines for good forensic practice and facilitate audience input into their development.

The AAFS Good Forensic Practice Committee is developing guidelines for good forensic practice. Unlike ethics requirements that represent minimum requirements, violation of which can result in sanctions by AAFs, the Good Forensic Practice Guidelines are intended to represent aspirational guidelines. Aspirational goals might not always be possible to achieve and might be such that they never could be enforced, but they are such that a good forensic science practitioner should make every reasonable effort to achieve them. Violation of these guidelines would not result in sanctions by AAFS and should not result in sanctions by anybody else, but hopefully, they would help raise the level of forensic science practice. They would be consistent with the ways good forensic science practitioners currently practice.

Members of the Good Forensic Practice Committee of AAFS will participate in this presentation. Each of the proposed AAFS Forensic Practice Guidelines will be presented. The audience will be given time to give feedback about them and give suggestions for possible revision.

Ethics, Forensic, Guidelines

15 Standards of Practice in Forensic Consultation to Military, National Security, and Law Enforcement Agencies

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The goals of this research project are to examine involving standards of practice in forensic psychological and psychiatric consultation in sensitive military, national security, and law enforcement cases.

Today, psychologists and psychiatrists are increasingly being asked to consult on cases in which the client is either a military, government intelligence or law enforcement agency. In many such consultations, these forensic professionals are asked in highly sensitive situations to render opinions regarding third parties. For example, military and intelligence officials may seek professional input on personnel, security, safety, and counterintelligence issues. Law enforcement agencies may ask for assistance in targeting, searching, apprehending, and interrogating suspects, or in managing crises such as hostage situations.

In providing such consultation, forensic mental health professionals sometimes never meet the individual about whom consultation is sought. In other instances, the professional not only meets but evaluates the individual in question. In either event, however, in these cases there is no traditional "doctor-patient" relationship, and the "client" is not the individual assessed but the entity or agency seeking the consultation.

While all psychologists and psychiatrists must adhere to well established ethical and practice standards, most of these principles contemplate traditional clinical situations in which the professional is presumed to be acting in the best interest of the individual being assessed and has direct or at least shared responsibility for case management. When

serving as consultants to the military, an intelligence agency or law enforcement, however, mental health professionals generally are not functioning in a traditional clinical role, do not have ultimate authority and responsibility for case management, and are not acting in the best interest of the individual being assessed. Indeed, in some instances, the professional may act with the knowledge that his or her input is likely to have negative repercussions for the individual in question.

To date, the ethical principles and standards of practice pertaining to this growing area of forensic practice have received little formal discussion. As a result, many psychologists and psychiatrists who consult with military, intelligence, and law enforcement agencies find themselves in uncharted waters.

This paper explores some of the ethical and practice concerns peculiar to psychological and psychiatric consultation where the client is not the individual about whom advice is being sought but rather the military, government intelligence, or law enforcement, and the consultant must act within parameters set by the law and/or dictated by concerns for public safety or national security.

Among the issues considered are ethical and professional concerns that arise in the following circumstances.

1. The consultant's input may have serious consequences for the individual in question but, for legal and/or public safety/national security reasons, the consultant has no direct access to the individual. Examples discussed include consultations related to hostage negotiations, interrogation, security clearance, and counter-intelligence.
2. The consultant does have professional contact with the individual in question but law, national security and/or public safety concerns dictate that the true purpose of the contact be withheld from the subject(s) of the investigation. Examples discussed include face-to-face encounters in which the subject(s) may not be aware (or fully aware) of the consultant's function.
3. Certain aspects of the consultant's role are dictated in part by legal parameters outside the consultant's control. Examples discussed include situations in which an interview is covertly audiotaped, videotaped or otherwise recorded pursuant to legal authorization or requirement.
4. The consultant knows that his or her input may result in tactical decisions that could result in injury or loss of life to the subject(s) and/or others. Examples discussed include consultations regarding military operations, counter-intelligence, hostage negotiations, and the execution of arrest and search warrants.

Consultation, Military, National Security

16 Problematic Aspects of Sexually Violent Predators Assessment

Gene G. Abel, MD, Behavioral Medicine Institute of Atlanta, 1401 Peachtree Street, NE, Atlanta, GA*

Upon completion of this presentation, participants will be able to outline problematic aspects of assessing possible sexually violent predators and predicting their recidivism.

An important aspect of the assessment of possibly sexually violent predators is to obtain objective evidence of paraphilic interest that makes the predator more vulnerable to recidivism. The methodologies involved in (the use of plethysmography, visual reaction time and polygraphs are reviewed with the advantages and disadvantages of each in identifying paraphilic interest. Determining the risk for recidivism has been problematic as has developing risk appraisal instruments. The VRAG, SORAG, RRASOR, and Static-99 are described with the advantages and limitations of these actuarial instruments.

Sexual Predator, Predator Assessment, Recidivism

17 Monitored Antiandrogens: The Cornerstone for Recidivism Prevention-Review of Literature and Our Experience

Jay W. Seastrunk II, MD, and Mary Flavan, Department of Mental Health, Atascadero State Hospital, Atascadero, CA*

The listener will become familiar with the literature and the experience of those offering anti-androgen treatment to recurrent severe sexual Offenders.

Thirteen publications from the world literature are reviewed along with our experience showing that supervised anti-androgen treatment is one of the most effective means yet researched to prevent recidivism among sexually violent predators.

Antiandrogens, Sexual Violent Offenders, Lupron

18 Treatment of Violent Sexual Predators

Stanley R. Kern, MD, 519 South Orange Avenue, South Orange, NJ*

The audience will learn various methods of treatment of violent sexual predators.

- A. Introduction: Description of Special Treatment Unit for Violent Sexual Predators
- B. Psychological Treatment:
 - Process Groups
 - Victim Empathy
 - Anger Management
 - Cognitive Restructuring
 - Social Skills
 - Substance Abuse
 - Relaxation Management
- C. Behavior Modification
- D. Individual Treatment
- E. Pharmacological Treatment:
 1. Antandrogens:
 - Deproprovera
 - Medroxyprogesterone
 2. SSRI:
 - Prozac
 - Paxil
 - Zoloft

Sexual Predators, Treatment for Violent Sexual Predators

19 A Database of Completely Innocent Individuals Erroneously Convicted of Crimes

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The goal of this research project is to use wrongful convictions to understand the error that result in an erroneous assessment of guilt.

“Beyond a reasonable doubt” is the standard for a guilty verdict in the criminal courts of the United States. Despite this high standard for determining guilt, innocent people are arrested, tried and sent to prison for crimes they did not commit. Unfortunately, there is no systematic collection and review of the mistakes made in the criminal justice system in the United States. The object of this study was to create a database of wrongfully convicted individuals for the purpose of gaining a better understanding of the mistakes that can occur in criminal convictions.

The author sought to find and review all available reports that described a wrongful conviction overturned with convincing exonerating evidence. The cases were then analyzed with specific attention to the

original evidence that led to the erroneous conviction so the errors could be understood and hopefully not repeated.

Publications describing examples of wrongful convictions were collected and reviewed. Individuals who had evidence that established innocence, acquired after a conviction and who were then exonerated were included in the database. Emphasis was made to include only cases where the exonerated individual appeared completely innocent and to exclude cases where the individual was simply “not guilty”.

Two hundred and eighty seven cases in the United States and Canada were found and reviewed. The primary sources of information were: books describing wrongful incarcerations published before the frequent use of DNA technology and newspaper articles reporting exonerations with DNA evidence.

The most common errors in the erroneous convictions were eyewitness misidentification (167, 58%), false informants (88, 31 %), official misconduct (50, 17%) and false confessions (49, 17%). Fifty-three (18%) of the individuals had been sentenced to death while 86 (30%) had been sentenced to life in prison. One hundred and sixty-six of the wrongfully convicted were exonerated because the actual culprit was found (although not always prosecuted) and 82 were released as a result of DNA evidence.

This report describes the collection and analysis of a database dedicated to understanding the errors in wrongful incarcerations. A close examination of these cases gives a better understanding of the errors that occur in the determination of guilt and innocence. Erroneous eyewitness identification, dishonest informants and false confessions contributed to the mistaken conviction. One mechanism to decrease these types of errors would be to video tape identifications and confessions as they occur.

Since this database is limited to cases that have established clear innocence, it is reasonable to assume that there are many other individuals who were convicted based on equally erroneous evidence, but who lack crime scene evidence to be exonerated, e.g., body fluids to conduct DNA testing.

Clearly, what constitutes “beyond a reasonable doubt” is not always being sufficiently applied in the criminal courts of the United States and Canada. More scrutiny is warranted in determining what is considered significant evidence of guilt.

Eyewitness, False Confession, Wrongful Conviction

110 False Confessions: Guidelines for Evaluation

Scott Bresler, PhD, University of Massachusetts Medical School, Law & Psychiatry Program, 55 Lake Avenue North, Worcester, MA; Jeremy Holm, MA, University of Nebraska-Lincoln, Department of Psychology, 238 Burnett Hall, Lincoln, NE; and William S. Logan, MD, Logan & Peterson, PC, 228 West 4th Street, Kansas City, MO*

The learning objectives for this session are to present an up to date review of the literature on evaluation of persons suspected of confessing falsely and to demonstrate specific evaluation techniques used by forensic psychologists and psychiatrists with this referral question in mind. The attendee will learn how particular assessment tools were utilized in the assessment of a female defendant suspected of falsely confessing to the murder of her boyfriend.

This presentation will explore what factors seem to be salient in cases where a defendant gives a false confession to a specific crime. Most often, a false confession is a product of specific police investigative interviewing techniques and the cognitive status and personality dynamics of the defendant. For example, it is well known that low functioning defendants with limited cognitive capacities are more susceptible to “interrogative suggestibility” than others who are more highly functioning. “Interrogative suggestibility” is a term given to the phenomenon in which a person tends to shift reported information away from accurate answers previously given to police because of challenges mounted or negative feedback given by evaluators. It also refers to a defendant’s susceptibility

to be led or persuaded in a particular direction by the types of questions posed by interrogators. There are others with passive dependent personality traits who may succumb to the pressures of police interrogators and deliver a false confession as well. The approach police interviewers use can further influence the accuracy of information given by a criminal suspect.

In the case example to be presented, a young woman with no previous criminal history is suspected of killing her paramour. The victim was discovered in his bed at his farmhouse in a rural midwestern state. He was nude and had multiple gunshot wounds to the head. Evidence gathered at the crime scene did not conclusively show signs of forced entry and there appeared to be no struggle prior to death. There were signs of recent sexual activity with semen on the victim and on the bed sheets. Interviews with persons familiar with the victim revealed that he had planned to terminate his relationship with the suspect, and to pursue a relationship with a new girlfriend. After long hours of police interrogation and two polygraph tests, the defendant admitted to killing her boyfriend, though she was adamant that she had no specific memory for the event in question.

Her defense attorney requested a psychological evaluation of the defendant. A thorough assessment of her cognitive capacities including neuropsychological testing of attention/concentration skills and memory, as well as personality functioning was performed. In addition, instruments specifically designed to detect persons at risk for confessing falsely to crimes (e.g., The Gudjonsson Suggestibility Scales) were administered to the suspect. The results that emerged collectively suggested that this woman might have confessed falsely to murder. Eventually, the courts dismissed the case. It was concluded that the police used excessively coercive investigative procedures to extract a confession from the defendant. Videotaped selections of police interrogation will be shown and discussed.

Few forensic evaluators seem to use specific techniques for evaluating persons suspected of confessing falsely to crimes. A brief analysis of the legal considerations relevant to this kind of assessment will be presented. Lastly, a wider application of these assessment techniques will be discussed. For example, psychological and psychiatric assessment of witnesses to crime and victims of crime may benefit from approaches used to assess false confessors.

The issue of false confessions can emerge in cases of varying complexity and criminality. In high profile cases such as murder, a court's dismissal of a case can have serious political and legal implications. For example, it is not uncommon for police to be accused of using overly aggressive measures in pursuit of a suspect. Negative publicity about the police can lead to policy changes within crime investigative units. Moreover, there may be tort implications brought against police by defendants who were targets of criminal prosecution and subsequently, delivered false confessions. Amidst this charged atmosphere, the forensic evaluator must understand the limitations of his/her measures. The ethical considerations in drawing conclusions from these types of evaluations will be discussed in detail.

False Confessions, Interrogative Suggestibility, Forensic Psychology

I11 What Happened to Jeffrey?: A Neuropsychiatric Developmental Analysis of Serial Killing Behavior

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After attending this presentation, the participant will understand the current status of knowledge about basic elements of developmental

neuropsychiatry and the potential relevance for the study of serial killing behavior. This paper has two objectives: 1) to propose a neuropsychiatric developmental approach to the study of sexual serial homicidal behavior and 2) to use the case of a specific serial killer to demonstrate the utility of the proposed approach.

Serial homicide constitutes a rare though dramatic form of homicidal behavior. Because of the unusual psychological characteristics involved as well as the dangerous behavior posed by serial killers, this form of violent behavior has been the object of intensive study, substantial controversy and societal attention. During the last two decades, several FBI specialists, criminologists and other forensic behavioral scientists have especially studied serial killing behavior. Progress in the study of serial killing behavior is well documented in the area of behavioral profiling and classification. The search for the causes of serial killing behavior has also been the object of serious study and considerable discussion by forensic scientists, legal scholars and the public alike. Although there is agreement that both constitutional factors within the individual and environmental factors are likely to be decisive contributors in the causation of serial homicide, progress has been slow regarding the elucidation of specific causative factors. In particular, the integration of neuropsychiatric and developmental approaches has not been substantially achieved either through the systematic development of theory or empirical research. This situation is especially evidenced by the dearth of sophisticated research in serial killing behavior that use integrated and clearly articulated developmental, neurobiological, psychiatric and other behavioral paradigms. In this presentation, the case of serial killer Jeffrey Dahmer will be presented as a way to introduce an approach that seeks to integrate both developmental as well as neuropsychiatric perspectives in an effort to develop a more informed biopsychosocial conceptual framework for understanding serial killing behavior.

Jeffrey Dahmer is known to have killed 17 males mostly adolescent or young adults. Several proposals have been made to understand Dahmer's homicidal behavior using a developmental perspective. He has been consistently described as presenting various behavioral peculiarities dating to early childhood and adolescence. Several psychiatrists, psychologists or forensic specialists evaluated Jeffrey Dahmer. His killings conform to many characteristics of other perpetrators of sexual serial homicide, including planning of the homicides, dismemberment of the corpses, preservation of body parts and antemortem sexual behaviors. Mr. Dahmer also reported behaviors that are less frequently encountered in sexually motivated serial killers, such as postmortem sexual behaviors with the victims and to a lesser extent thoughts and activities involving necrophagia and drinking human blood. His psychopathology was variously conceptualized by different mental health professionals as necrophilia, sexual sadism, a psychosis, depressive illness, alcohol addiction and alcohol intoxication. All of these psychiatric disorders were hypothesized to have a crucial explanatory role for Dahmer's serial killing behavior. His sexual maladaptive patterns also suggested trends encompassing exhibitionism, fetishism and ego dystonic homosexuality. Given the confounding richness of proposals regarding Dahmer's psychopathology and otherwise abnormal behaviors, it is not surprising that behavioral models about the causation of his serial killing behavior that seek to integrate such behaviors into a unifying biopsychosocial construct, remain largely problematic.

In this presentation, we propose that available information on the Jeffrey Dahmer case indicates that his psychopathology and criminal behavior can be optimally and efficaciously organized largely as a function of a single neuropsychiatric process that in turn led to most of his sexual psychopathology and serial killing behavior. This process is explicitly outlined and discussed as a function of intrinsic psychological and possible neurobiological parameters. The role of psychopathy and stressful life events as mediating processes in Dahmer's primary neuropsychiatric problem and consequent criminality is discussed. Based on the proposed neuropsychiatric developmental model we provide a diagnostic impression for Jeffrey Dahmer, consistent with the fourth

edition of the Diagnostic and Statistical Manual of Mental Disorders, Text Revision, of the American Psychiatric Association (DSM-IV-TR). Implications for the proposed model for a broader application to the study of serial killing behavior will be briefly discussed.

Developmental Psychopathology, Serial Homicidal Behavior, Violence

I12 Psychological Autopsies— Mental Health Aspects

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The goals of this research project are to 1) learn the background of psychological autopsies in the military; 2) understand the difference between a psychosocial investigation of suicide and an investigation of an equivocal death; 3) define current military policy; and 4) outline training requirements for those mental health providers involved in doing psychological autopsies.

The Army has a 17-year history of programs that attempt to both reduce suicides and understand completed suicides. Psychological autopsies (PAs) were supposed to be performed on all suicides to gather psychosocial data, information about the reason for the suicide, and lessons learned for command. Local mental health practitioners did the interviews of unit and family members and forwarded their results to the Criminal Investigative Department.^[1]

The other Services (Navy, Air Force) did psychological autopsies only on equivocal manners of death and selected high-profile cases. A handful of psychologists on the staff of the criminal investigative organizations did all the psychological autopsies, working closely with the forensic scientists and investigators.

The Army method of compilation of all suicides provided much valuable information about the demographics and motivations of those who completed suicide. However, the quality of the PAs was uneven. Information from different sources was not always available to be synthesized by the mental health worker. Records were accessible to the media under the Freedom of Information Act (FOIA). Finally, lessons learned were not always provided to command or integrated into suicide prevention programs.

The term psychological autopsy has been used principally in two different ways: 1) to understand the psychosocial factors that have contributed to the suicide; and 2) as a forensic tool to assist in the actual determination of the manner of death classification (suicide, homicide, accident, natural causes, undetermined). Confusion sometimes arises because of the different uses of the term.^[2]

In 1996, the Inspector General (IG) suggested that the Services request and perform psychological autopsies in a uniform manner. A working group from all the Services and many disciplines worked to clarify and unify psychological autopsies.

The consequent policy governing psychological autopsies was issued in the summer of 2001. It declares that the primary purpose of a psychological autopsy is as a forensic investigative tool, to assist in ascertaining the manner of death. It is to be requested by and provided to the medical examiner.

A review of the literature on psychological autopsies provides scant guidance as to what training mental health professionals should have in order to conduct a forensic psychological autopsy, in order to determine the manner of death. Most have excellent interviewing skills, but may know little about blood spatter analysis, ballistics, toxicology, etc. A model curriculum for mental health professionals will be presented. An interdisciplinary approach is emphasized.

Other situations where the forensic psychological autopsy model is applicable are special conditions such as autoerotic asphyxia, drowning,

shootings, poisoning, motor vehicle accidents and hangings. All of these have behavioral aspects which can assist a forensic pathologist in determining the manner of death.^[3,4] Case examples will be used to highlight these issues. These techniques have also proven useful in missing persons cases and conducting victimology studies in homicides.

Privacy of the information collected is essential. Since the victim is dead, many medical privacy rules do not apply. Unrestrained access by the media must be avoided.

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Psychological Autopsies, Psychological Investigation, Suicide

I13 Legal Hurdles to Involuntary Medication for Competency Restoration Treatment of Federal Defendants

James K. Wolfson, MD, U.S. Medical Center for Federal Prisoners, Springfield, MO

Participants will learn about case law constraining involuntary administration of psychiatric medication to federal defendants found incompetent to stand trial because of mental illness. The manner in which questionable contentions about defendants' needs and medications' effects have become enshrined in case law will be explored.

Defendants in Federal Court found incompetent to proceed to trial are committed to the Federal Bureau of Prisons for competency restoration treatment. While some defendant/patients accept medication willingly and have the capacity to give informed consent, many refuse medication, and others will accept it but lack competence to give consent. Traditionally, case law governing such treatment (i.e., *Harper*; *Charters*) has largely deferred to psychiatric expertise concerning involuntary administration of psychiatric medication. While the ongoing case *U.S. v. Weston* in the Circuit Court of Appeals for the District of Columbia has brought the subject of involuntary treatment of incompetent defendants into the public eye, it is actually only one of several recent and pending cases in multiple circuits, in which litigants have sought to rewrite the rules under which such treatment can be administered. *Weston* injects further complexities into the topic because it remains potentially a capital case. The first of these recent decisions, *U.S. v. Brandon*, in the Sixth Circuit, relies to a significant degree on faulty characterizations of antipsychotic medications' actions and side effects, garnered from older cases and even decades-old source materials. Coping with such entrenched scientific misinformation in a new case can be challenging, and requires scrupulous attention to detail in building the record 'in a trial court that will be scrutinized later at the appellate level. Such an effort led to a second decision, *U.S. v. Morgan*, in the Fourth Circuit, that partly diverges from *Brandon*. *Brandon* also mandated new procedural requirements prior to involuntary administration of medication that have worrisome implications for defendants' welfare. Some of the mandated changes in legal process have proven difficult or unworkable to implement, both by those trial courts in the 6th Circuit for whom the decision is binding and for trial courts in other circuits who have elected to follow it, leading to improvisation about burdens and standards of proof between the parties. One directive, to appoint a guardian for such defendants, was brought forth notwithstanding the absence of any supporting federal statute or administrative law, and has not, so far, been complied with by any court following the other provisions in *Brandon*. It is certainly conceivable that

efforts may be made in the future to apply new restrictions on involuntary medication in other jurisdictions or other treatment settings. While litigation has been concluded in the two appellate decisions in the 4th and 6th circuit, and two non-binding published district court decisions in the 8th and 9th Circuits, new appellate cases are pending in the 2nd and 8th Circuits, and rulings may be released in the upcoming months. Just days before this abstract was prepared, a second D.C. Circuit Court of Appeals ruling in *Weston* was announced, ordering medication for the defendant, and further appeal to the Supreme Court is expected. The presentation will examine the reasoning behind this series of cases, outline the problems introduced by them, and provide an update on those still pending.

Competence to Stand Trial, Psychiatric Medication, Involuntary Medication

I14 Court Ordered Psychotropic Medications in the State of Illinois

Alan R. Felthous, MD and Angeline Stanislaus, MD, Chester Mental Health Center, Chester, IL; Jagannathan Srinivasaraghavan, MD*, Choate Mental Health Center, Anna, IL; Daniel Hardy, MD, JD*, Elgin Mental Health Center, Elgin, IL; Wenona Whitfield, JD*, Southern Illinois University, School of Law, Lessar Law Building, Carbondale, IL*

The goals of this research project are to present to mental health professionals and health law attorneys specific challenges and potential solutions to providing patients with appropriate pharmacotherapy while respecting their right to refuse in the State of Illinois.

Illinois Department of Mental Health and Developmental Disabilities Code Section 2:107.1 deals with court ordered treatment to non-consenting patients in non-emergency situations. This statute that went into effect August 13, 1991 requires presence of serious mental illness, deterioration of function, suffering, threatening or disruptive behavior, continuous or repeated episodic episodes, benefits outweighing the harm, lack of decisional capacity and other less restrictive measures having been found to be inappropriate. The evidentiary standard is clear and convincing. Dr. Srinivasaraghavan will highlight the Illinois experience with five studies. In the first three years, the burden of care for these patients who refuse psychotropic medications shifted to the public hospitals. Physicians wrote the overwhelming majority of the petitions. In the first five years in Cook County, the most populated county in Illinois, nearly two-thirds of the patients were from public hospitals: more than half the cases were dismissed or withdrawn and about one percent of the cases were denied their petitions. There were significant differences among the rates of petitions and outcome when the three public hospitals in Cook County were compared. In a study involving all cases filed at Union County and treated at the only public hospital in rural Southern Illinois, seven percent of petitions were denied. The medical records data revealed that females were more likely to have their petitions granted, longer in-patient stay was associated with granting and shorter stay with dismissal of petitions, and recidivists have longer stays compared to non-recidivists. Preliminary results from the study examining the relationship between peer review of professional performance and outcome in these trials revealed that the rating of overall performance of the psychiatrists followed by the rating of the performance of the defense attorney tended to be the most important factors in cases taken to court in Union County in Southern Illinois.

Dr. Angeline Stanislaus will summarize the issues involved in security forensic hospital settings. In Illinois, unfit to stand trial defendants and those found NGRI are committed to the forensic unit of the state hospitals for treatment. Treatment refusal by these patients leads to prolonged hospitalization and cause considerable clinical management dilemmas. This also raises significant legal and ethical issues, which would be discussed in this session. Dr. Hardy will present the experience at Elgin Mental Health Center in Northern Illinois where courts have not been unwilling to grant petitions for court ordered medications and where

the defense attorney requested jury trials can result in months of a delay without appropriate pharmacotherapy.

Professor Whitfield will review the Illinois Appellate Court decisions involving court ordered involuntary medications. In dozens of cases, the decision to allow involuntary administration of psychotropic medication has been overturned by the appellate court. In many instances, the court decisions directly disparage or ignore the testimony provided by mental health treatment professionals. This presentation examines the reasons Illinois appellate courts have frequently found the decision to involuntarily medicate was in error. Professor Whitfield examines ways in which the court can alleviate the tension between patients, mental health professionals and lawyers in the growing controversy regarding involuntary administration of medication.

Involuntary Medications, Court Ordered Psychotropic, Right to Refuse Medication

I15 The Hypnosis of Adolf Hitler

David E. Post, MD, Clinical Assistant Professor of Psychiatry LSU-MC & Tulane University, Jackson, LA*

The attendee will be able to demonstrate increased knowledge and awareness of Adolf Hitler's 1918 psychiatric hospitalization and treatment in Germany's Pasewalk Military Hospital where Hitler was admitted as a corporal during World War One after his regiment participated in combat and intense bombing while on the Belgian front.

An asterisk in John Toland's best selling biography *Adolf Hitler* vaguely refers to a hypnotic exchange between Adolf Hitler and a psychiatrist while Hitler was hospitalized in Pasewalk Military Hospital during World War One. Toland cited supporting references including: 1) a 1943 Naval Intelligence Report (De-Classified in 1973) 2) an out of print book *The Eyewitness*; and 3) the historical research of Rudolph Binion PhD. This passing reference to Hitler's psychiatric treatment in Pasewalk inspired the presenting psychiatrist to investigate further.

In mid-October 1918 Hitler served with the 16th Bavarian Infantry Regiment which was subject to intense mustard gas bombing. As a result of such bombing, Hitler was blinded and led to a first aid station by others. Subsequently, he was taken by train to Pasewalk Military Hospital back in Germany.

To complicate matters further, it has been reported that the Gestapo rounded up and destroyed all copies of the official medical record of Hitler's 29 day hospitalization. As well, Dr Forster committed suicide in 1933 after being placed under investigation for harboring a subversive attitude to Hitler's rising regime.

Yet, a record of Hitler's encounter with Dr Forster may have survived to date as recorded in a 1939 out of print book entitled *The Eyewitness*. It was written by a German Jewish physician Ernst Weiss, who also committed suicide in 1940 while living as an exile in Paris as the German occupying army took hold.

As Hitler lay recovering from symptoms of mustard gas poisoning, his vision began to return. However, in a dramatic fashion, one evening while in the psychiatric hospital, Hitler learned of the World War One armistice, which resulted in Hitler going hysterically blind. Such resulted in the consultation of Dr Edmund Forster (Chief of the Berlin Nerve Clinic).

The central chapter in *The Eyewitness* appears as "process notes" between Dr Forster and Hitler as Dr Forster attempted to use a form of reverse psychology to inspire Hitler to rise up to the challenge and regain his need sight such that he himself could lead the German people.

In fact, a passage in *The Eyewitness* references Dr Forster compares Hitler's potential to that of Jesus and Mohammed. As a result of this encounter, Hitler regains his sight and leaves the military hospital and goes directly to Munich where he begins a career inspiring others to follow his lead.

The presenting psychiatrist located and interviewed Pulitzer prize

winning historian John Toland and historian Rudolph Binion PhD. In particular, in the 1970s Dr Binion went over to Germany to investigate related aspects of Hitler's rise to power.

As little had been known or publicized about Hitler's combat experience and resultant blindness the author (as a forensic psychiatrist) attempted to review what information was available; and to focus on the psychiatric aspect of Hitler's psychiatric hospitalization, which had not previously been done. Hitler's chance encounter with Dr Forster may have had profound influence on the course of world history.

Although multiple variables can be cited as causal to Hitler's rise to power (notwithstanding his own temperament and mindset), the role of hypnosis; Hitler's encounter with Dr Forster; and his own experiences in combat on the Belgian front have largely been overlooked as contributing elements related to Hitler's rise to power. This oversight is understandable as the Naval Document was not declassified until 1973. This delay also kept secret the identity of Hitler's treating psychiatrist as Dr Forster until 1973.

The author's investigation and synthesis of data is presented in the format of 1) a 20 minute slide which organizes the chronological events and 2) a 20 minute videotape of the historians Toland and Binion.

Certainly, the author is not indicating that hypnosis was 'the' causal element' in Hitler's rise to power. Yet, the author is presenting data which indicates that 'hypnosis' was "one" contributing, formative element in Hitler's decision to enter a career in politics.

The author's resultant investigation was published in the Journal of Forensic Science 1998; 43(6):1127-32 and presented initially at the 15th International Congress of Hypnosis in Munich, Germany (October 2000).

Hitler, Psychohistory, Hypnosis

I16 Mental Disorders and Criminal

Responsibility—Application of Art-122-1 From the French Penal Law

Pierre A. Delpa, MD, Florent Trape, MD, Christophe Arbus, MD, Louis, Arbus, and Daniel Rouge, MD, Unité Médico-Judiciaire, CHU Rangueil, Toulouse, France*

The goal of this presentation is to describe and bring to discussion specific aspects of forensic psychiatry, particularly with regard to penal responsibility.

The new French Penal Code, implemented in March 1994, has substituted the << mental insanity >> of the previous Art. 64 for the << abolition of discernment >> (Art. 122-1 al.1) as a requirement for penal immunity. Furthermore, it has introduced for the first time in the French penal law the notion of << impairment of discernment >> and << obstacle to acting control >>, both new concepts that should be clarified from the psychopathological point of view.

Based on their own experience of court experts, the authors report on 30 criminal cases in which abolished discernment and/or abolition of acting control was determined resulting in the prejudiced being not responsible, impaired judgment, or out of control. This led to some amendment to the penalty once the suspect has been proven guilty

In the first group, the psychopathological findings were the following:

- Schizophrenia, six cases
- other chronic psychosis, five cases
- acute psychosis, one case
- mood disorder, one case
- drug abuse, two of these cases

The clinical features which imply impairment (and not absence) of judgment or control were as followed:

- antisocial personality disorders, three cases
- borderline, three cases
- mood disorders, three cases
- obsessive-compulsive sexual, two cases
- post-traumatic stress disorder, one case
- schizophrenia with no evidence of delusion, once case

Of among these cases, five were also drug addicted while five others showed some degree of mental retardation as well. Independent of each group, the concepts of dangerousness, punishment, and/or care access and re-adaptability are discussed.

Mental Illness, French Penal Law, Criminal Responsibility

Questioned Documents

J1 How Known Are Those Knowns?

Thomas W. Vastrick, BS, Altamonte Springs, FL*

Forensic document examiners are often called upon to make handwriting comparisons using course-of-business, or non-request, specimens. This type of specimen is a good source of natural writing, at times being clearly the best type of comparison material. However, there is also a down side. Examiners are taught to review the submitted known specimens for contamination of the evidence. This paper deals with some actual cases in which the known specimens were of questionable origin and what could, or could not, be done as a result.

Handwriting, Questioned Documents, Contaminated Evidence

J2 Issues Arising from the Limitations of Comparisons Involving Non-Original Handwriting

Dorothy-Anne E. Held, MA, Questioned Document Examiner, Federal Bureau of Investigation, Washington, DC*

The goal of this presentation is to open a dialogue regarding some of the secondary issues arising from the examination of non-original handwriting.

The Questioned Documents Unit (QDU) of the FBI Laboratory occasionally receives cases in which the questioned evidence is not original (photocopies, facsimiles, photographs), and for which handwriting comparisons are desired. This presentation examines some of the ancillary issues, which arise from such submissions. An example follows:

Over the past several months, the QDU has raised the issue of the limitations of these types of evidence in presentations. The focus has been for photocopies. However, the same problems of legibility pertain to facsimile writing and photographs (including microfiche) of writing. It is an issue that will become more pressing as our society moves away from paper retention into electronic and digital storage methods.

A document examiner who receives such evidence has certain responsibilities—paramount among them is informing the contributor that the examination will probably not yield opinions which are of substantive probative and/or testimonial value. A sensitive concern is when to do this. In our office, evidence is acknowledged upon receipt and it would be logical to discuss examination limitations at the same time. This is particularly important if the case has a tight deadline. For a routine case, it is always possible to issue a report without definitive conclusions and that includes a request for the originals. However, even in this circumstance, an examiner is uncomfortable not saying anything at the outset about the limitations of the evidence.

Such an initial discussion of limitations can, and sometimes does, put the examiner in a difficult position, especially should the contributor ask that the examination be suspended and the evidence returned unworked. For obvious reasons of professional ethics and avoiding the appearance of bias, this is not appropriate. This presentation will examine the appropriate and realistic responses to such requests.

Other scenarios discussed will include limitations arising from the use of photographed writing, which is less frequently received and has traditionally been perceived as clearer and more suitable for meaningful handwriting comparisons than photocopies or facsimiles. However, today's technologies have made it possible for substantive manipulation to occur with photographs. In addition, the issue of photographed writing is of particular concern in the field of proficiency testing when there is the necessity to supply the same material to a large group of people.

Non-Original Handwriting, Photocopies, Photographs

J3 Writer's Cramp in Questioned Document Examination

Nevzat Alkan, MD, Istanbul University, Istanbul Medical Faculty, Department of Forensic Medicine, Istanbul Tıp Fakultesi, Capa - Istanbul, Turkey; and Nurten Uzun, MD, Istanbul University, Cerrahpasa Medical Faculty, Department of Neurology, Istanbul, Turkey*

This presentation will give a different perspective to scientists about writer's health and questioned document examination.

Many factors influence handwriting and signatures. Among these factors can be listed some of them such as the position of body, writing surface, writing instrument, emotional state, various drugs, alcohol, neuroleptic or stimulant drugs, physical and mental diseases, and aging.

Writer's cramp is a focal dystonia that holds upper extremities as a most frequent dystonia type. This disease effects handwriting rapidly and seriously.

In our study, we evaluated the handwriting samples of 38 patients with writer's cramp. Handwriting and signatures of the patients that have been diagnosed as writer's cramp or writer's cramp and writer's tremor were examined according to the criteria used in questioned document examination.

Five of 38 patients were female. The patients' ages were between 24-80 and medium age was 46.5. Medium disease period were 3.3 years. Twenty of 38 patients started to write with a normal handwriting and deteriorated after writing a few sentences later and handwriting of 18 of 38 patients were broken in onset and got more deteriorated with writing. Handwriting of 6 of 38 patients displayed a puerile character.

Handwriting and signature examination is an important working area in daily forensic medicine practices in Turkey. Thus all document examiners must be careful and well-informed about various diseases and their effects upon handwriting and signatures. Otherwise, misinterpretation in the expertise reports will be inevitable in questioned document examination.

Writer's Cramp, Questioned Document Examination, Handwriting

J4 Erroneous Identification in a School Threat

A. Lamar Miller, MS, PO Box 420247, Summerland Key, FL*

The goal of this presentation is to explore an incorrect handwriting identification opinion by an untrained law enforcement officer in a school threat.

A case is presented in which an untrained law enforcement officer expressed an incorrect opinion regarding the author of a handwritten school threat note. Handwriting comparison charts are used to depict the questioned material and known handwriting samples of the suspect. The problems associated with untrained law enforcement officers offering opinions in handwriting identification are discussed.

Incorrect Identification, School Threat, Handwriting

J5 Forensic Document Examination Opinions and the Signal Detection Theory

Robert J. Muehlberger, BA, U.S. Postal Inspection Service Forensic Laboratory, 225 North Humphreys Boulevard, Memphis, TN*

The goal of this presentation is to present to the forensic community the relationship of the ASTM Standard E1658 Standard Guide for

Terminology for Expressing Conclusions of Forensic Document Examiners and the Signal Detection Theory (SDT).

The Forensic Document Examiner (FDE) community has long been aware of the limitations and interferences that can affect the analysis, comparison and evaluation of handwritten items. Through training and experience, the FDE learns to recognize the *potential for error* that can occur if due consideration is not given to the sufficiency and quality of the handwritten items being examined. When these limitations cannot be adequately resolved, less than definitive or “qualified opinions” are deemed to be the most appropriate conclusion.

ASTM Standard E1658 describes terms that reflect nine different degrees of confidence expressed by the FDE in handwriting comparisons. A draft, “*Standard Guide for the Examination of Handwritten Items*” being developed by the Scientific Working Group for Forensic Document Examination, includes some of the limitations (e.g. non-original and distorted handwritten items) that can interfere with its procedures. Other limitations; i.e., the quantity or comparability of the writing, are taken into account in the standard guide. The terminology in ASTM E1658 is used for reporting conclusions in this draft guide.

Phillips et al¹ advocate the use of SDT for decision-making in forensic science and, as one illustration, used data from a Forensic Science Foundation Test (1987-5) in Questioned Document Analysis to describe its possible application. They stress the usefulness of being able to discern and measure the factors of discrimination ability and decision thresholds, and thus gain an understanding of decision-making, particularly in ambiguous or fuzzy situations. Since the discrimination ability and the use of decision thresholds are components of accuracy in decision outcomes, it follows that the absence of either or both component(s) would lead to greater error. The fact that laypersons have been shown to make a far greater percentage of ‘*false-positive*’ decisions than the FDE, when comparing handwriting and signatures, illustrates the affect training and experience, and the use of standard procedures has on decision-making. The terminology of E1658 for the reporting of conclusions reached through the use of standard procedures such as the SWGDOC draft “*Standard Guide for the Examination of Handwritten Items*” is analogous in many ways to the application of SDT in decision-making as proposed by Phillips.

¹ Phillips V, Saks M, Peterson J. The application of signal detection theory to decision-making in forensic science. *J Forensic Sci* 2001; 46(2): 294-308.

Forensic Document Examination, ASTM Standard E1658, Signal Detection Theory

J6 Deciphering Obliterated Check Carbons With Adobe® Photoshop

Rigo Vargas, BA, Mississippi Crime Laboratory, 1700 East Woodrow Wilson Avenue, Jackson, MS*

This presentation will demonstrate how to better utilize Adobe® Photoshop to decipher obliterated documents.

A check fraud case recently received by the Mississippi Crime Laboratory contained two checkbooks submitted as known exemplars. The checks had all been removed, but the carbon copies remained. All of the signatures were obliterated by a black design printed on the carbons. Image enhancement techniques with Adobe Photoshop allowed the document examiner to decipher the signatures and make them suitable known exemplars for comparison.

Questioned Documents, Obliterations, Image Enhancement

J7 Digital Reconstruction of Torn Paper

Derek L. Hammond, BA, Forensic Document Examiner, United States Army Criminal Investigation Laboratory, 4553 North 2nd Street, Forest Park, GA*

Utilizing current digital technology, specifically Adobe® Photoshop®, a technique is described to assist forensic document examiners in the reconstruction of torn paper. The methodology described overcomes the shortcomings of previous methodologies while maintaining the integrity of the evidence for future forensic examinations/comparison.

Torn Paper, Digital Reconstruction, Questioned Documents

J8 Validation Study of Measurement of Internal Consistencies Software (MICS) as It Relates to Line Sequence and Line Quality Determinations in Forensic Document Examination

Arthur T. Anthony, BS, Georgia Bureau of Investigation/Division of Forensic Sciences, 3121 Panthersville Road, Decatur, GA*

Participants will learn the value of a software tool developed specifically for Forensic Document Examiners (FDEs) for the examination of the written line. Validation of MICS software as it relates to line sequence determinations, line quality assessments and its effectiveness, as a demonstrative tool, will be discussed.

First previewed in its prototype phase at the 15th Triennial conference of the International Association of Forensic Sciences in 1999 in Los Angeles, Measurement of Internal Consistencies Software (MICS) is currently commercially available and is in use by several forensic laboratories in both government and the private sector. MICS software developed by LIMBIC Systems of Bellingham, Washington was primarily developed for use by FDEs also has application in other areas of forensic work and in medicine. This discussion will limit itself to MICS use in document examination as it relates to line sequence determination, line quality assessments and as an aid for demonstrable evidence purposes.

This is continuation of previous reports concerning the software presented at the 52nd Annual Meeting of the American Academy of Forensic Sciences (AAFS), Reno, Nevada, February 2000, and the annual meeting of the American Society of Questioned Document Examiners (ASQDE), Ottawa, Ontario, Canada, August 2000.

In theory, pen-pressure characteristics if quantifiable might very well be attributable to an individual and therefore of extreme value to FDEs in the overall comparison process of handwriting. Of course if it were possible to put numbers to any aspect of writing presently not possible would certainly further the discipline of handwriting expertise and would move toward silencing critics of the field. Presently, the only means of accessing pressure patterns is of course visually with the aid of magnification. Although pressure changes in the written line are detectable through magnification, interruption of questionable areas is purely subjective. It is my opinion that there is a definite correlation between pen-pressure and density in the written line. MICS software permits for a more objective assessment of density habit patterns in writing. Someday MICS software might very well provide the means of actually quantifying density patterns in writing as individual. It is my understanding that although not presently practicable mathematicians using MICS may in the future be able to provide the answer to this elusive theory.

This study will report on validation work conducted using MICS to determine the sequence of intersecting written lines. The use of the software in examining sequence of writing and typewriting will also be discussed. Finally, a report on the use of MICS in line quality determinations, particularly in signature comparisons will be included.

Questioned Documents, Software, Density Measurement

J9 Is It Really Possible to Determine the Age of an Ink?

Peter C. White, PhD, University of Strathclyde, Forensic Science Unit, Royal College, 204 George Street, Glasgow, Scotland*

After attending this presentation, the attendee will understand some of the fundamental problems and difficulties of trying to determine the age of ink and beware of the limitations of published methods.

This presentation identifies and highlights the problems in trying to determine the age of an ink, something document examiners have been seeking to do for many years. There are, of course, some instances when the age of a document can be estimated. The earliest dates of materials that make up a document or changes in the materials used can certainly help the examiner. Dating by comparison with known undisputed material is possible, provided that document is prepared on the same paper, with the same ink and stored under similar conditions. Finally, the relatively reliable method of ink dating by detection of taggants added to ink on known dates could be used. However, the addition of tags to ink started in 1975 and continued for only a few years, thus limiting the usefulness of this excellent ink dating method.

In many cases, these methods are inappropriate as suitable data and reference samples are not always available. Therefore, numerous methods have been developed and published specifically for ball pen inks, which try and overcome these problems. Nearly all of these have been based upon the fact that after ink is applied to a document, an ageing process will start and the ink composition will change with time. With ballpoint pen inks, methods have been proposed for measuring the decay/time relationships of the volatile and/or the dye components. However, many scientists through the world have been unable to obtain reproducible results in their laboratories. There is also the difficulty of the decay curves being monotonic, with the rate of decay changing by only very small amounts over a period as the age of the document increases. This exponential behaviour of ink components with time can therefore give rise to major inaccuracies in estimating the age of ink.

The majority of the published methods appear to have overlooked or failed to take fully into account some of the fundamental physical and chemical properties of the ink components. For example, some inks contain dyes and/or pigments which are chemically and photochemically stable and will not change with time and yet there has been no study to identify which classes of dyes do decompose. With dyes that are known to decompose, no in-depth studies have been reported on what chemical properties of a paper (chemical composition, pH, water content, etc) or the volatile components in the ink, may have on the decomposition of dyes.

This presentation highlights some of these important factors. Results from experiments performed in the authors' laboratory will also be presented to illustrate the difficulties experienced in studying some of triarylmethane dyes. These dyes include Methyl and Crystal Violet, Victoria Blue B and Blue BO and malachite green. This class of dye is common in many of the inks used in ball-point pens. To overcome any problems associated with extraction of these dyes and inks from paper, a semi-microspectrophotometric *in-situ* method of analysis was used to examine their photochemical degradation and oxidative decomposition.

From the microspectrophotometric data obtained, chromaticity co-ordinates were generated and used to study the decay profiles of the dye standards and inks applied to paper and solutions of the dye standards. The decomposition studies were performed by subjecting these samples to UV radiation or chemical oxidation using several oxidising reagents. TLC and UV spectroscopy of extracted ink dyes and the dye solutions were also obtained. Even under controlled conditions the results of these preliminary studies that are presented must still raise the question in a document examiner's mind – is it really possible to determine the age of an ink?

Ink , Age, Determination

J10 Characterizing the Degradation of Methyl Violet From Inks on Paper Using Laser Desorption Mass Spectrometry for the Analysis of Questioned Documents

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At the conclusion of this presentation, the participant will understand the use of laser desorption mass spectrometry for the analysis of methyl violet and its degradation products, to determine the relationship between naturally aged and UV accelerated aged ballpoint pen ink-on-paper, as a potentially new ink dating technique.

Methods: LD MS can be used to detect dye components of ink directly on paper. In these experiments, a PE Biosystems matrix-assisted laser desorption/ionization (MALDI) mass spectrometer was used to perform direct laser desorption experiments, without using a matrix, on controlled (Speckin Laboratories, Okemos, MI) and uncontrolled (Michigan State University, Chemistry Department) naturally aged ink-on-paper samples, as well as on samples subjected to UV-accelerated aging. The UV aged samples were prepared by drawing single, straight lines across a piece of paper (Hammermill Fore DP) using a black Bic ballpoint pen and then irradiating the paper with a UV lamp (254 nm, 760 microwatts/cm²) 6 cm above the paper, for 15 minute intervals. The samples were introduced into the MALDI instrument using a modified sample plate, which is typically designed to hold electrophoretic gels. The instrument is equipped with a nitrogen laser (337 nm, 2 ns, 3 Hz), which can be focused directly onto the width of a pen stroke. Positive ion spectra were obtained and calibrated using a solution of CsI pipetted directly on the paper.

Results: Methyl violet is a very common mixture of cationic dyes that has been used in both blue and black ink formulations for the past fifty years. Since the dye is already ionic, methyl violet is easily detected in ink on paper using positive ion mode LD MS. The degradation of methyl violet, following a UV accelerated aging study, has previously been studied in our laboratory. It was determined that the dye degraded via an oxidative demethylation mechanism, in which each one of the molecule's 6 methyl groups was replaced by a hydrogen atom, yielding 6 degradation products. Evidence of this process appeared in the positive ion mass spectrum. The initial *m/z* 372 base peak, representing the intact crystal violet molecule (the main component of methyl violet), eventually decreased as the demethylated degradation product peaks, each separated by 14 mass units, appeared. The analysis of naturally aged samples confirmed that the same degradation products were formed as an ink ages. In order to relate UV-induced and natural aging and to ultimately determine the relative age of a questioned document, a single value needed to be calculated, which would ideally consider the distribution of all of the degradation products of the dye. The average molecular weight was found to be a fair representation of all of the data. Plotting the average molecular weight versus time produced relatively linear aging curves in the controlled natural and UV aging studies. The aging curve resulting from the uncontrolled natural aging study asymptotically leveled off over time, which is customarily seen in aging curves involving the well-accepted solvent extraction methods. Several experiments were conducted to explain the variation in the data. The results suggest that the normal variables considered in ink aging, such as paper, ink formulations, and storage conditions, also have a significant impact in dye degradation rates. The results of these experiments will be presented, as well as insight into the decision to use UV irradiation, as opposed to the commonly used thermal accelerated aging methods. Briefly, the addition of heat will accelerate the evaporation of volatile solvent components, however it will not induce the chemical changes involved in dye degradation. One catalyst for the degradation of methyl violet is light. UV light has been found to

accelerate the breakdown of methyl violet. Unfortunately, aging experiments conducted with a UV lamp have their limitations. Other light sources, such as a standard light bulb, are currently being tested, and would make this technique more reproducible and available.

Conclusion: LD MS serves as a minimally invasive analytical tool for the *in situ* analysis of questioned documents. Although only methyl violet was discussed in this paper, there are numerous other dyes, with similar alkyl amino substituted structures present in inks, which undergo similar degradation mechanisms, and therefore serve as potential age indicators. More work is currently being conducted in developing LD MS for the identification and characterization of dyes present in ink formulations.

Ink Dating, Mass Spectrometry, Accelerated Aging

J11 Molecular Level Information on the Aging of Dyes From Ink on Paper: What's There and How Does It Change?

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After attending this presentation, the participant will understand: 1) that laser desorption mass spectrometry can be used to detect a variety of ionic and neutral dyes used in inks; 2) many of these dyes degrade over time following common mechanisms; and 3) accelerated aging of dyes on paper can be used both for analysis and in relative age determination studies.

Methods:

Pen inks of various manufacturers and colors were identified using laser desorption mass spectrometry (LDMS) by dye recognition. A PerSeptive Biosystems matrix-assisted laser desorption ionization (MALDI) mass spectrometer was used to perform the LD experiments by direct (no matrix) analysis of the sample, ink on paper. The sample was mounted on a sample plate and introduced into the MALDI mass spectrometer. The nitrogen laser (the focused laser spot is roughly 0.03cm² in area), which generates 2 nanosecond pulses of 337 nm light at a rate of 3 Hz, was used to desorb and ionize the ink samples. The instrument is capable of generating both positive and negative ion mass spectra, and for this experiment both modes were used. Multiple spectra were averaged to improve the signal-to-noise ratio. In this experiment, the laser samples multiple sections of the written line, and generates a single mass spectrum from the results of 50 laser shots. The same ink samples were subjected to stresses to accelerate aging (dye decomposition), including heat, UV light, incandescent and fluorescent light. Spectra were also acquired for these samples. The dyes in each pen ink were identified and degraded by various accelerated aging approaches. Lastly, naturally aged ink samples were analyzed using LDMS in the same manner as previously described and compared to the artificially aged inks.

Results:

One common dye in blue and black pen inks is methyl violet/crystal violet. Over time, one way that this dye ages is by oxidative demethylation, and the aging of the dye can be monitored by LDMS. Methyl violet/crystal violet is a cationic triphenylmethane dye and is commercially available as a chloride salt. The cationic part is desorbed and detected in positive LDMS. Methyl violet/crystal violet contains methylated amino groups and oxidative demethylation results in the substitution of methyl groups (-CH₃) by hydrogen atoms (+H).

We have found that the degradation of methyl violet is just an example of a mechanism common to many other dyes used in inks. There are several dyes that are cationic with alkylated amino groups and have the ability to participate in similar degradation reactions. Rhodamine 6G and Rhodamine B are two cationic dyes that can be found in red pen inks.

These dyes both contain ethylated amino groups. By examining the dyes using a combination of natural aging, accelerated aging, and LDMS, oxidative deethylation products can be detected. The process of oxidative dealkylation appears to be universal for dyes with alkylated amino groups.

Examples will be discussed that are anionic dyes and neutral dyes. Anionic dyes only yield mass spectra in the negative ion LDMS mode. An example of this is metanil yellow, a dye used in black inks. The presence of neutral dyes is apparent since they yield both positive and negative ion spectra. Anionic and neutral dyes without alkylated amino groups appear to degrade very differently, in terms of both rates and mechanisms.

Conclusion: LDMS can be used to characterize a set or library of various inks. In this experiment, pen inks were examined, but there is a wider range of documentation that relies on typewriter, inkjet printer, and laser printer inks that should be investigated. Once LDMS determines the degradation standards for dyes found in inks, then eventually a more common tool in the forensic field can be used for the ink analysis of fraudulent documents. High performance liquid chromatography is definitely one tool that has great possibilities.

Ink Analysis, Laser Desorption Mass Spectrometry, Dye Degradation

J12 Ink Differentiation for the Fiscally Challenged

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Being asked to distinguish between two or more inks that may have been used to alter a questioned document is a common problem posed to the Forensic Document Examiner. In today's modern laboratory, sophisticated instruments have been made available, such as the VSC 4 and VSC 2000, Foster & Freeman, Worcestershire, England, that are specifically designed to aid in the differentiation of inks. However, the considerable expense may make these instruments unavailable to many government and private laboratories. The present study introduces a low cost ink differentiation system, comprised of simple commercially available components, and tests its ability to distinguish between various black inks.

Ink Differentiation, Question Documents, Ink

J13 An Update to the Classification and Identification of Checkwriters Monograph

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The American Board of Forensic Document Examiners published a monograph some years ago called *The Classification and Identification of Checkwriters*, authored by Thomas Vastrick. This paper will update the information in that monograph concerning the manufacturers and models available along with any model differentiation features that are present.

Monograph, Questioned Documents, Checkwriter

J14 An Unusual Rubber Stamp Case

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The goal of this presentation is to present the Questioned Document community an unusual case report involving a rubber stamp.

Given a questioned document and a questioned pre-inked rubber stamp, comparisons of each can be made with a microscope or similar magnification device. If sufficient evidence exists these questioned items can be linked even if the stamp was not used as it was originally designed.

Rubber Stamp, Pre-Inked Stamp, Rubber Stamp

J15 Toward a Unified Field of Identification

Stephen C. McKasson, BS, Document Consulting Service, 899 Rowan Road, Makanda, IL*

The goals of this presentation are to compare and contrast the various identification fields, with the intent to demonstrate that the similarities are fundamental and the differences are superficial.

For too long opponents of Identification as a science have attempted a divide and conquer strategy by first attacking handwriting, then fingerprints, then ear prints, etc. They have had but a single argument; lack of scientific standing, and although they have had very limited success, they have required repeated defenses as each topic is brought to the fore.

It is a monumental waste of time and energy to continue to defend these attacks piecemeal. What is needed is a unified approach; a single science defense. As in casework, we need to evaluate the similarities and differences between the various means of identification. It is proposed that such an evaluation will show that the differences between the branches of identification tend to be unimportant, whereas the similarities are significant. With a single theory of identification, we can use fingerprint research to support handwriting, handwriting identification to support firearms identification and so forth, to the benefit of all.

To carry this approach to its logical extreme, a unified training program for all the branches of identification science will also be proposed.

Identification, Handwriting, Training

J16 Off-Line Chinese Signature Verification Using the Multi-Experts Model and the Neural Network Classification

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The goals of this research project are to review the signature verification system classified features through expert-experiences and to demonstrate how those weightings will be evaluated in the multi-experts model and the neural network classification.

Signature verification is very important in many fields (e.g., money transaction, questioned documents, and high security accesses). Many signature verification systems have been developed and proposed. Two different classes of systems are designed for signature verification: off-line and on-line signatures. The off-line signature verification system deals with data acquisition using an optical scanner and CCD camera. On the other hand, the on-line signature verification system acquires the signature data with electrical devices, such as digitizers, generating electrical position signals in time sequence during writing processes.

This presentation will focus on the field of off-line handwritten signature verification. The verification system is operated in two modes: the multi-experts (testing) model and the neural network classification. The processes of off-line signature verification are data acquisition, pre-processing, segment extraction, feature extraction, and feature learning to build template and feature matching with template. After the state of feature matching, we will obtain the possible verification results.

In the state-of-the-art research of signature verification, there are few systems for signature verification considering the expert experiences. It is difficult to reach the state of fully automatic signature verification by machines and to get correct verification results without experts. In my

research program, I have built an off-line handwritten signature verification system with human-expert assistance. My colleagues and I will present novel methodology for off-line Chinese signature verification. The multi-experts model is based on the features of a signature to deal with the works of signature verification. The kinds of signatures we illustrate include shape similarity, geometric features, long stroke features, dark stroke features, complexity features, pen-down features and pen-up features. The multi-expert model gives scale-functions for the above features respectively. After the stages of feature extraction and scale-function are determined, back propagation neural network is employed to classify and make the final assessment. Experiments will show that 91% correct classification rate may be achieved in a database of over 1,800 signature images. The above features need to be classified through expert experiences and evaluated by different matching weightings.

Handwriting, Signature Verification System, Neural Network Classification & Multi-Experts Model

J17 Forensic Examination and Comparison of Dryer Sheets

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The goal of this project is to present to the questioned document community an unusual case involving the comparison of a questioned dryer sheet to a known box of dryer sheets in order to determine if it originated from a common source. Additional research in this area will also be presented.

This case was submitted to the Laboratory in March 2001. Background information submitted with this case involved the discovery of a homicide victim found in a hotel room. The victim's body was positioned partially beneath the box spring and mattress of one of the beds in the hotel room. A dryer sheet was found against a head wound suffered by the victim and the victim's head was covered with a white plastic garbage bag. A similar plastic bag was found on the floor next to the victim's body. A suspect was quickly developed and apprehended. A search of a cab, which the suspect had been seen in prior to his apprehension, revealed several white plastic bags filled with clothes and miscellaneous items. A search of his hotel room revealed two boxes of Bounce® 80-count dryer sheet fabric softener, one of which was open.

The request of the investigator included both an examination of the plastic bags and the dryer sheet found at the crime scene. Specifically, it was requested that the examiner determine if the dryer sheet found near the victim's head originated from the box of dryer sheets found in his hotel room. The FBI's Forensic Science Information Resource System conducted a literature search. A few articles were found; however, none of them related directly to the type of examination that was requested. Next, the Trace Evidence Unit (TEU) was contacted to determine the composition of the dryer sheets. Preliminary research by the TEU indicated the dryer sheets were produced using a synthetic, man-made fiber similar to paper.

Using the Video Spectral Comparator, the examiner conducted preliminary examinations of the dryer sheets taken from the submitted known box of dryer sheets. The examiner was able to observe paper fibers along the dryer sheet's edges that aligned to paper fibers of other dryer sheets, appearing to run continuously from one dryer sheet to the other. The questioned dryer sheet was then examined and compared to the known dryer sheets. It was determined that the questioned dryer sheet did not originate from the known box of dryer sheets.

Additional boxes of dryer sheets were purchased with the intent of conducting research to determine if other brands of dryer sheets could be examined in this way. The outcome of this research will be the focus of this presentation.

Questioned Dryer Sheet, Questioned Documents, Common Source

J18 Secondary Impressions From Mailing Envelopes

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The goals of this research project are to present to the forensic document examination community the results of an experiment regarding secondary impressions created as a result of address entries from mailing envelopes.

Several authors have dealt with the topic of secondary impressions detected during electrostatic processing of documents for indented writing. Secondary impressions are images of writing detected during electrostatic processing that mimic true impressions caused by the act of writing. It has been determined that secondary impressions are not caused by the act of writing, but are caused by subsequent contact with a written document. It has also been determined that pressure and friction are necessary elements in the creation of secondary impressions. It has been noted that deeply embossed writing is more likely to cause secondary impressions. Experiments have been conducted by some of these authors, with varying degrees of success, to create secondary impressions.

This paper reports on the construction of an experiment to determine if secondary impressions would be created on the contents of mailing envelopes, from the envelope address entry, as the result of normal postal handling. It was theorized that the pressure of being containerized with numerous other envelopes, and the friction caused by movement through the system, may cause secondary impressions on the envelopes contents.

Number 10 regular envelopes (4 1/8 inch x 9 1/8 inch 24 lb white wove) and photocopier paper (8 1/2 inch x 11 inch 20 lb) were selected for the purpose for the experiment. The author was successful in creating secondary impressions using the envelopes and paper under laboratory conditions.

In furtherance of the experiment, fifteen envelopes were addressed using a ballpoint pen by an individual known to use heavy pen pressure when writing. The writer was not informed of the purpose of the experiment. The writer was only instructed to address the envelopes. The author, purposely using heavy pen pressure, addressed fifteen additional envelopes. A sheet of the photocopier paper was folded and placed in each envelope. The envelopes were delivered to various locations in the United States where they were then placed into the postal system. Both writers addressed an additional envelope while the photocopier paper was in the envelope, but these envelopes were not mailed.

After processing through the postal system, the contents of the envelopes were examined for the presence of secondary impressions. This presentation will report on the result of the experiment.

Secondary Impressions, Indented Writing, ESDA

J19 Electrostatic Detection Apparatus (ESDA): Cascade Develop Method vs. Aerosol Method

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The objective of this presentation is to determine which method, cascade developer or aerosol, for processing writing using ESDA produces the best result.

An investigation into the Electrostatic Detection Apparatus (ESDA) has revealed that there has not been any documented survey completed regarding which development process, cascade developer method or aerosol method, produces the better result. The ESDA was introduced into forensic laboratories in the late 1970's and early 1980's and has continued to assist the document examiner significantly in the realm of indented writing. Due to the simplicity of the process and the quality of the image produced, there have been little to no improvements made in the ESDA machine. There are a few methods used to develop an image on the ESDA, but two of the methods are used the majority of the time. The first uses cascade developer, which is a combination of glass beads and toner, which

is poured over the bed of the machine to develop the image. The second uses a nozzle, which mists toner over the machine bed's surface. Both produce a similar image. ESDA processing involves a few simple physical principles. The ESDA operates in very much the same manner as photocopiers. The process of developing images using ESDA begins by applying a thin layer of polymer over the surface of the document to leave it unchanged following processing. A vacuum built into the machine is then used to bring the polymer into the closest possible contact with the document. Next the operator must charge the surface of the document via a corona wire. This wire possesses a positive charge and is passed over the surface of the document to create a charge difference between the impressions and the rest of the document. Due to the increased capacitance of the indented regions, a region of positive charge is created within the indented regions. Once the surface has been charged, the toner is applied by cascade or aerosol method. The toner, in both cases, is negatively charged and therefore adheres to the regions of positive charge, the indented regions. Once the process is complete, the product is a positive image of the indented writing in the document with a somewhat gray background. This investigation to determine which development process produces the better result involves a few variables. Multiple types of paper were used, which included 20 lb. white copy paper, lined legal pad paper, Post-It Notes, newsprint, and high-quality letterhead paper. A few writing implements were used in this investigation. These consisted of a standard wooden graphite pencil, a ballpoint pen, a Sharpie marker, a fountain-tip pen, and a gel pen. The writing was performed with 2 sheets of paper below that of the sheet written upon. The examination was performed on the sheet below the one that the writing was written upon. Each of the samples will be processed using the ESDA in the same manner, as best as possible. Each document resided in the humidity chamber for an equal period of time, approximately 3 minutes, which improves the state of the document. Dry documents tend to produce lower quality images. Then each sample was placed on the bed of the ESDA and covered in a layer of polymer. Each was charged equally via a consistent number of passes of the corona wire. To minimize errors, each sample will be tested twice. All of these processes were performed while attempting to reduce the number of external variables, such as handwriting pressure variation, fingerprints, and excess moisture. The processing time for each document was measured in order to draw some conclusions regarding the timeliness involved in each of the 2 methods. Once all of the samples have been processed they will be compared with one another to determine the clarity and completeness of the images. Conclusions will be made regarding the preferred method of ESDA development. If there is not any clear winner, determinations will be made as to the preferred method under specific conditions such as writing implement and type of paper. This investigation is intended to assist document examiners in making a decision as to the best method to process documents with indented writing to produce an image with the most evidential value, in terms of the clarity of the image and the amount of information expressed by that image.

ESDA, Toner, Electrostatic Detection Method

J20 An Instance of Inkjet Printer Identification

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The goal of this presentation is to demonstrate some identifying features involving ink jet technology to forensic document examiners.

Examination of a series of anonymous documents generated by inkjet printer technology, revealed the presence of several printing flaws. A suspect inkjet printer was received for examination. Test printing with the suspect printer reproduced the same flaws observed on the questioned documents. Examination of the suspect machine and its test prints, resulted in isolation of "class" flaws and a previously unobserved "individual" printing flaw. The accumulative presence of these features enabled an association between the anonymous documents and the suspect inkjet printer.

Inkjet Printer Identification, Identifying Features, Forensic Document Examination

J21 An Examination of Correlation Between Handwriting and Latent Fingerprint Examinations in the ATF Laboratory

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The Bureau of Alcohol, Tobacco and Firearms (ATF) Forensic Laboratory system in one form or another has a long history of providing forensic services to Federal Law Enforcement dating back to 1886. ATF currently has three laboratories located in Rockville, MD, Walnut Creek, CA and Atlanta, GA. In addition to providing forensic services, ATF performs regulatory analytical examinations on alcohol and tobacco products, ensuring they meet U.S. regulations and standards. Forensic capabilities include Questioned Documents, Latent Fingerprints, Trace Analysis, Explosive and Arson Chemistry, Firearms and Toolmarks Analysis, plus bullet and casing automated identification. ATF routinely provides forensic services to state and local agencies and its sister Federal agencies.

In an ongoing effort to provide independent validity and empirical data supporting results of forensic comparisons and analytical examinations, the Questioned Document and Latent Fingerprint sections of ATF have undertaken a pilot project of correlating results of their respective examinations over a period of two years. This presentation will reveal the initial results of data from the Rockville and Atlanta Laboratories.

A majority of the ATF Questioned Document cases are also submitted for Latent Fingerprint examination. Cases submitted for Questioned Document examinations that produced positive results were correlated to results from Latent Fingerprint examinations performed on those same cases. ATF Forensic Laboratories uses the accepted Nine Point System for reporting the results of Questioned Document examinations. Many ATF Questioned Document cases involve several items with varying conclusions, however, only those cases / items with identifications or highly probable results were queried for fingerprints results and later correlation.

The results reflect conclusions based on cases that meet the experimental criteria, submitted in calendar years 1999 and 2000. Based on the results of this pilot project a comprehensive examination of the independent corroborative nature of Latent Fingerprints Identifications to Questioned Document Identifications should be undertaken. This should span several years and encompass various examiners at all three ATF Forensic Laboratories.

ATF, Latent Fingerprint Examination, Handwriting

K1 A Review of Postmortem Diltiazem Concentration

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The objective of this work was to determine an appropriate therapeutic range for diltiazem in postmortem blood specimens.

Diltiazem is a calcium antagonist drug used to treat angina, supra ventricular arrhythmias, and hypertension. The drug has a plasma elimination half-life of 3-6 hours. It is extensively metabolized by N-demethylation, O-deacetylation and O-demethylation, with less than 5% of the administered dose appearing in the urine as unchanged drug. The volume of distribution is 3-13 mg/kg. Steady-state plasma concentrations following therapeutic use are in the range of 0.1-0.3 mg/L.

Diltiazem is routinely identified in this laboratory by gas chromatography-nitrogen-phosphorus detection following an alkaline extraction of the biological specimen. No derivatization is necessary. The drug elutes late on a DB-5 column, following most antidepressants, antihistamines, benzodiazepines, and narcotic analgesics.

Since the drug is alkaline extractable and has a high volume of distribution, there was some concern about postmortem redistribution of the drug. As a result, cases investigated by the Office of the Chief Medical Examiner, State of Maryland, over a three-year period were reviewed to ascertain whether postmortem heart blood diltiazem concentrations may be interpreted on the basis of antemortem pharmacokinetic studies or whether a different "postmortem" therapeutic range is more appropriate. An additional aspect of the study was to determine whether there is significant site dependence for postmortem blood diltiazem concentrations.

Over the three-year period, 78 cases containing diltiazem were identified. Seven of the deaths were caused by diltiazem intoxication or multiple drug intoxication where diltiazem was considered a significant factor. In the diltiazem-only drug intoxication cases (n=5), the heart blood concentrations ranged from 2.1 to 42 mg/L. These blood concentrations were consistent with blood concentrations found in other diltiazem intoxication cases and were an order of magnitude higher than the antemortem therapeutic range.

To examine the postmortem therapeutic range, "therapeutic use" cases were identified. Cases were considered "therapeutic use" if the death was caused by an acute, non-heart event such as multiple injuries, gunshot wounds, narcotic intoxication, pulmonary emboli, or other acute natural deaths. Chronic disease states such as atherosclerotic or hypertensive cardiovascular disease or cirrhosis were not included. Forty-two deaths were classified as "therapeutic use" deaths. In these cases, the mean heart blood diltiazem concentration was 0.5 mg/L and the median blood concentration was 0.3 mg/L. The heart blood diltiazem concentrations in these cases ranged from 0.03 to 1.9 mg/L. The mean and median heart blood diltiazem concentrations in these cases appear consistent with the antemortem therapeutic range.

Both heart and peripheral blood were measured for diltiazem in 16 cases. The average heart blood to peripheral blood diltiazem concentration ratio was 0.90 and the median ratio was 0.92. The ratios ranged from 0.33 to 1.50. Ten of the 16 cases had a ratio between 0.7 and 1.3. Of the remaining 6 cases, the heart blood diltiazem concentration exceeded the peripheral concentration in only two cases.

From this study, it was concluded that the postmortem therapeutic range for diltiazem was similar to the antemortem therapeutic range. Furthermore, heart blood was a reliable specimen in the interpretation of postmortem diltiazem concentrations.

Diltiazem, Postmortem, Therapeutic

K2 Analysis of GHB and Its Analogs by Capillary Electrochromatography

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The objective of this analysis was to improve the methods of detection for gamma-hydroxybutyric acid (GHB) and its analogs using capillary electrochromatography with monolithic polymer columns.

Drug facilitated sexual assault has become more prevalent in today's society. GHB and its drug analogs are among the sedative hypnotic drugs used by assailants. The testing of these drugs by conventional methods is often tedious and imprecise due to the frequent time lapse between the attack and when the victim decides to report the crime. This judgment can be compounded by the amnesiac properties of GHB. Current methods are cumbersome and contain complex derivatization steps. The primary concern with GHB is the new popularity of its chemically related drug analogs. Gamma-butyrolactone (GBL) and 1,4-butanediol are more loosely controlled and more difficult to detect by conventional methods than GHB. By the time samples are taken concentrations may fall below detection limits. Capillary electrophoresis (CE) methods are currently being implemented as forensic screening techniques because of their advantages over GC-NPD. CE instruments require a small sample volume and use pre-concentration methods that make it ideal for trace levels of substances without the need for derivatization. Since capillary electrochromatography (CEC) columns can be used in these instruments, the development of these new CEC methods will provide an exceptional new application of CE and CE/MS systems.

CEC is able to use the charged electro-osmotic flow of CE, while incorporating HPLC packing material into the capillary. This gives a separation that involves a combination of electrophoretic mobility and partitioning. To keep the silica gel uniformly packed in the columns, frits are used, but can often lead to severe band broadening and reproducibility problems. An alternative to particulate HPLC packings is a rigid polymer structure that adheres to the capillary wall. These monolithic columns are relatively inexpensive, just as efficient as packed capillaries, and do not require the use of frits. The column procedure for this separation was modeled after the research of Dr. Frantisek Svec and colleagues from the University of California Berkeley, CA. The advantage of these columns is the simplicity of the three-step column preparation: surface modification, polymerization, and washing.

The surface modification washes the capillary and changes the surface charges to secure the monolithic attachment to the capillary wall. The polymerization mixture includes a monomer combination of butyl methacrylate (BMA), ethylene dimethacrylate (EDMA), and 2-acrylamido-2-methyl-1-propanesulfonic acid (AMPS). The EDMA serves as the cross-linker for the methacrylate once the reaction is initiated by the presence of azodiisobutyronitrile (AIBN). The combination of these chemicals will produce a continuous cast inside the capillary with a rigid backbone of monomers in the presence of a fraction of pores. These include 1-propanol, 1,4-butanediol, and water to determine the permeability of the column and mass transfer effects with respect to band broadening. After the 12-24 hour incubation under UV light or in a 60-degree oven, washing is relatively simple. The porogens can be rinsed free of the capillary by either syringe pump pressure or introduction to the CE instrument.

The ultimate goal of this project is to achieve a complete separation of GHB, gamma-Butyrolactone (GBL), 1,4-butanediol, and gamma-Aminobutyric acid (GABA). Many of the current laboratory methods involve a conversion of GHB to GBL. The CEC method can not only

distinguish all of the analogs, but also maintain a steady pH to prevent the interconversion of GHB to the lactone. The additional separating power of CEC permits the analyst to distinguish between the neutral compounds that elute simultaneously with traditional CE. CEC results with an 80% acetonitrile 20% phosphate buffer mobile phases will be compared to a CE method consisting of sodium phosphate buffer with UV detection. Different urine extraction techniques will be examined in order to accomplish the best quantitation of the drugs.

Capillary Electrochromatography, GHB, Date-Rape Drugs

K3 Simultaneous Determination of Underivatized Diazepam and Nordiazepam in Plasma Using Gas Chromatography/Mass Spectrometry

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A sensitive and simple gas chromatography/mass spectrometry method has been developed for the quantitative determination of diazepam and its major metabolite nordiazepam in plasma.

Diazepam (DZ) is one of the most frequently prescribed drugs as an anti-anxiety agent, muscle relaxant, and anticonvulsant that sometimes cause intoxication due to accidental overdose, misuse, or abuse. Furthermore DZ has been used for drug-facilitated sexual assault during the past few years. DZ is metabolized to nordiazepam (NDZ, desmethyl-diazepam), oxazepam (OX), and temazepam (TM) which are also active, although OX and TM do not accumulate in blood or plasma to an appreciable extent. Screening or confirmation methods for DZ and NDZ in plasma are very important for clinical and toxicological studies and in forensic cases.

There are several literature methods available for the identification and quantification of DZ that are based on high performance liquid chromatography (HPLC) with various detection methods or gas chromatography/mass spectrometry (GC/MS). HPLC and GC/MS methods are also available for a major metabolite of DZ, nordiazepam.

Extraction of DZ and NDZ is often accomplished by solid phase extraction (SPE) or solid phase micro extraction (SPME), although liquid-liquid extraction methods are acceptable. The purpose of the current work is to develop a simple, rugged, sensitive, and specific method for the determination of DZ and NDZ using GC/MS. Midazolam is a structurally related benzodiazepine that was used as an internal standard.

In the current work, a method for the quantitative measurement of DZ and NDZ was developed. Human plasma samples were spiked with internal standard, adjusted to alkaline pH and extracted with ethyl acetate prior to detection by GC/MS.

Method: To human thawed plasma (1 mL) was added 40 μ L of midazolam internal standard solution (400 ng/mL in H₂O) and various amounts of DZ and NDZ. Plasma samples were adjusted to pH 9 by the addition of 2N-NaOH and were extracted with 5 mL of ethyl acetate. The volatile components were removed in a stream of nitrogen. The residues were reconstituted in 50 μ L of ethanol. The injection volume for GC/MS analysis was 2 μ L. Sample preparation time was less than 30 minutes.

GC/MS analysis was performed using an Agilent MSD 5973 mass spectrometer operated in the electron-impact mode equipped with an injector operating in the splitless mode (with a 0.75-min splitless period) and the column was a DB-5MS capillary column (30 m x 0.25 mm x 0.25 μ m) using helium as carrier gas. The quantification was performed in the selected ion monitoring (SIM) mode using the most intensive three ions of the two compounds (*m/z* 256, 283 and 284 for DZ and *m/z* 242, 241 and 269 for NDZ).

The detection limit was 0.5 ng/mL and the assay was sensitive to 1 ng/mL and linear to 100 ng/mL with correlation coefficients of > 0.999 for both DZ and NDZ. The recoveries of DZ and NDZ were 79%. The within-run CVs for DZ were 4.38%, 4.54% and 5.50% at 5.0, 20.0 and 60.0 ng/mL, respectively. The NDZ within-run CVs were 4.80%, 4.16% and 7.14% at the same concentrations, respectively. At these concentrations, between-run CVs for DZ and NDZ were less than 7.1% and 4.7%, respectively.

This sensitive and simple method is useful for plasma samples of forensic toxicological interest and in clinical studies when low concentrations of DZ are to be detected. Preliminary studies extended this approach to additional benzodiazepines. The results suggest that sensitive assay methods that do not require derivatization can be developed for midazolam (using an alternate internal standard), prazepam, and flurazepam. The method appeared to be less well suited for the development of methods for oxazepam, temazepam, lorazepam, flunitrazepam, alprazolam, and triazolam.

Diazepam, GC-MS, Method

K4 Influence of Ethylene Glycol Ethers and Other Organic Solvents on Quantitative Analysis of Breath Alcohol and an Introduction to Toxicology of 2-Butoxyethanol

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The participants will learn about the possible role of ethylene glycol ethers as interferents in evidentiary breath alcohol (BrAC) analysis and the toxicology related to ethylene glycol ethers.

Rules, statutes and *per se* laws provide for measuring ethanol concentrations in one of three principal media, *viz.*, blood, breath, and/or urine, with the ultimate goal of establishing the degree of intoxication either at sample collection time or another time. Breath analysis is the most frequently used method for the above purpose due to simplicity of sample collection and analysis. Breath analysis for ethanol is performed with the aid of IR-based instruments such as Intoxilyzer 5000EN®, the model used in the State of Minnesota for the purpose of evidentiary breath tests. BrAC measured by Intoxilyzer 5000EN® are often challenged in legal proceedings for many reasons including the presence of interferents in the breath analyzed for evidentiary purposes. These interferents are blamed for part or all of the BrAC measured in such occasions.

In a previous study, ~40 organic solvents and solvent formulations were tested for their possible role in erroneous measurement of BrAC by Intoxilyzer 5000EN®, and 12 substances (≤ 0.05 g/dL) that can increase BrAC by 0.01g/210L or more without being detected as interferents were identified. We have since tested an additional 5 compounds for their ability to significantly increase BrAC. These solvents, *viz.*, 2-methoxyethanol (ME), 2-methoxyethyl acetate (MEA), ethylene glycol (EG), propylene glycol (PG) and diethyl ether (DEE), were chosen due to their presence in household products. Simulator solutions containing various concentrations (0.0001-10 g/dL) of the above substances were prepared by dissolving them in *aq* 0.10g/dL ethanol solution. The simulator solutions were subjected to the Minnesota breath test sequence in duplicate and on two different Intoxilyzer 5000EN® instruments as described previously to determine whether the simulated breath tests are terminated due to interferent detection. Air and *aq* 0.1g/dL ethanol served as negative and positive controls, respectively.

The concentration of interferent required for Intoxilyzer 5000EN® to automatically terminate breath tests were 0.1, 0.05 and 0.00005 g/dL for ME, MEA and DEE, respectively. The highest concentration of ME, MEA and DEE that did not trigger an automatic termination of breath tests were 0.09, 0.04 and 0.00004 g/dL, respectively. At these concentrations, the increase observed in BrAC was <0.01 g/210 L and was considered insignificant as per the criteria established in the previous study. EG and PG, on the other hand, did not terminate the breath tests or increase the BrAC even when their concentrations exceeded 10 g/dL.

Ethylene glycol ethers [*e.g.*, ME, MEA, 2-butoxyethanol (BE)], in general and BE in particular is of interest, because (i) the Intoxilyzer 5000EN® does not detect its presence in *aq* ethanol solutions (0.05-0.4 g/dL) until the concentration of BE >0.05 g/dL and at such concentrations BE accounts for a BrAC of ~0.04 g/210L, (ii) About 700 million pounds BE is manufactured, and used in industrial and household products (concentrations range from 2-25%) per year, (iii) NOISH estimates ~2.6 million American workers belonging to ~222 different occupations, *e.g.*, janitors, dry cleaners, printing machine operators and automobile mechanics, are exposed to BE and other ethylene glycol ethers every year, (iv) the ultimate metabolic product of BE, 2-butoxyacetic acid (BAA), is responsible for the toxicity of BE, and (v) it is unknown whether the metabolites of BE also interfere with breath analysis by Intoxilyzer 5000EN®.

The human toxicities associated with BE include delayed encephalopathy (8-12 hr) characterized by agitation, confusion, and/or coma, and metabolic acidosis (when consumed orally). Acute exposure of experimental animals to BE is associated with hemolysis and hemoglobinuria, hypocellular bone marrow, renal tubular degeneration, and necrosis. For these reasons, OSHA suggested limits of human exposure to BE is 25 ppm or lower. Although BE and other ethylene glycol ethers are available for systemic uptake by all routes, pulmonary and dermal routes of absorption represent the most significant and potential routes of human exposure at workplace. For example, the pulmonary retention of BE is ~57% in human volunteers. The concentration of BE detected in blood upon inhalation (air concentration 200 ppm; exposure time 3 hr) has been reported to be 0.0008 g/dL. The half-life of BE has been estimated to be 0.75-3 hr.

Using whole animal models, the metabolism of BE has been defined to resemble ethanol metabolism, *i.e.*, BE is first converted to 2-butoxyacetaldehyde (BAL) and then to BAA by alcohol and aldehyde dehydrogenases, respectively. Since BAA is more toxic than BE, then formation of BAA from BAL catalyzed by aldehyde dehydrogenases (ALDHs) seems to be the rate limiting step for toxicity due to BE. Human ALDHs exhibit allelic (isoforms) as well as non-allelic (isozymes) polymorphisms. The role of these polymorphic ALDHs in conversion of BAL to BAA is not known either in animals or in humans. In this regard, we have initiated research to identify the ALDH isozymes responsible for oxidation of BAL to BAA. BAL required for these studies was synthesized via Swern oxidation of BE. Human ALDHs, *viz.*, ALDH1A1, ALDH2 and ALDH3A1, required for this study were purified as described previously. Human cDNA clones overexpressing ALDH1A1 and ALDH2, respectively, in *E. coli* were the sources for ALDH1A1 and ALDH2, and human stomach mucosa was the source for ALDH3A1. Oxidation of BAL to BAA by ALDHs was determined as described previously using BAL as substrate. Each of the above ALDHs catalyzes the oxidation of BAL to BAA. ALDH2, the mitochondrial ALDH primarily responsible for oxidation of ethanol derived acetaldehyde ($K_m < 1 \mu M$) in humans, exhibits a K_m of ~40 μM for BAL. ALDH3A1, the cytosolic ALDH mainly responsible detoxification of lipid peroxidation aldehydes, exhibits a K_m of ~300 μM for BAL. Isolation of other ALDHs, determination of their affinity to BAL and their relative contribution towards the oxidation of BAL is on going. Whether the circulatory metabolites of BE, *e.g.*, BAL and BAA, interfere with quantitative analysis of ethanol, as in the case of BE, by Intoxilyzer 5000EN® is also being evaluated.

Based on the data collected thus far and given the tight regulations and limits of exposures imposed by OSHA, it is unlikely that any of the compounds we have tested will ever be found in breath samples at concentrations that significantly affect BrAC without being detected by Intoxilyzer 5000EN®. However, BE and other solvents are known to be abused. Whether, such scenarios lead to erroneous BrAC measurements is yet to be demonstrated.

Breath Alcohol Interferents, Toxicology of 2-butoxyethanol, Aldehyde Dehydrogenase

K5 Decomposition of Opiate Analgesics in the Presence of Formaldehyde

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The objective is to provide the forensic community with data describing the compound, pH and formaldehyde dependent decomposition of various opiate analgesics and the time course of this decomposition.

Background and Hypothesis: Opiate analgesics are commonly used in the treatment of pain, particularly severe pain, and are quite effective for this purpose. However, due to their potential to cause dependence, they have also been abused and thus have become drugs of forensic and toxicological interest since they may be involved in accidental or intentional deaths due to overdose. Thus, it is important to understand the chemical fate of these compounds since it may become necessary to assay for their presence at autopsy, following embalming or in preserved tissues. These latter two situations are the focus of the present work.

Formaldehyde is generally the primary component of embalming fluids and is also the standard chemical used to preserve tissue following autopsy. It is not uncommon to either require additional forensic toxicology testing either post-embalming or from tissue preserved from autopsy when foul play is suspected or the death appears suspicious following later evaluation of the evidence. However, formaldehyde is a highly reactive compound and as such possesses a quite complex chemistry. Previous work suggests that formaldehyde reacts with other drugs such as the tricyclic antidepressants, benzodiazepines, and fenfluramine to form new chemical products and thus hasten their decomposition. Thus, it was hypothesized that formaldehyde would also react with the opiate analgesics in an analogous manner and promote their decomposition which could complicate forensic analysis.

Methods: Codeine, morphine, hydromorphone, meperidine, methadone, oxycodone, nalorphine, and pentazocine were reacted with 5, 10 or 20% formaldehyde solutions at pH 3.5 (no pH adjustment of the solution), pH 7 and pH 9.5 to simulate the range of conditions to which tissues might be exposed either following embalming or upon preservation. Samples were analyzed by high performance liquid chromatography (HPLC) with UV detection for each of the opiates and time 0, 1 day, 7 days and 30 days, post-initiation of the reactions.

Results: Oxycodone decomposition was the most rapid of all the opiates with it achieving greater than 95% decomposition under pH 7 and 9.5 conditions at day 1 regardless of the formaldehyde concentration. Hydromorphone decomposed rapidly with greater than 70% decomposition noted at day 1 at both pH 7 and pH 9.5 regardless of formaldehyde concentration. Morphine decomposition was observed at pH 7, reaching ~50% decomposition at day 30, whereas at pH 9.5 almost 50% decomposition was noted at day 1 and approaching 100% decomposition at day 30 with the rate dependent on formaldehyde concentration. Nalorphine was relatively stable at pH 3.5 and pH 7, with only ~30% decomposition noted at pH 7 at day 30 but under pH 9.5 conditions, almost 100% of nalorphine had decomposed by day 30 with no difference among the various

formaldehyde concentrations. Methadone decomposed rapidly at both pH 7 and pH 9.5, both reaching essentially 100% decomposition at day 30 but the rate being faster at pH 9.5. Codeine, meperidine, and pentazocine did not appear to decompose over the 30 day time course regardless of pH or formaldehyde concentration with less than 10% decomposition noted under any of the conditions.

Conclusions: There appears to be compound dependent, pH dependent, and to some degree, formaldehyde concentration dependent decomposition of the opiate analgesics in formaldehyde solutions. These findings are of forensic interest in that they may establish a time profile for compound decomposition so as to permit determinations of whether drugs should still be present or whether alternate analytes might be appropriate. *This work was supported in part by FBI contract #J-FBI-98-081.*

Opiates, Formaldehyde, Decomposition

K6 Low Level Detection of THC-COOH Using Negative Ion Chemical Ionization (NICI) GC/MS

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An analytical procedure for the low level detection of 11-nor- Δ^9 -THC-9-carboxylic acid (THC-COOH) is described using a Varian 1200 Triple Quad Mass Spectrometer.

The use of various specimen types in forensic toxicology has made the determination of THCCOOH at low levels increasingly necessary in order to detect marijuana use. Instruments operating in chemical ionization modes (both negative and positive) coupled with selected ion monitoring and/or MS/MS are now widely available and affordable for the laboratory, although the number of published procedures using these methods is much lower than those using traditional electron impact modes of fragmentation. A sensitive and specific method has been developed for the quantitative assay of THC-COOH using a triple quadrupole mass spectrometry system. The system can be operated in selected ion mode or mass spectrometry/mass spectrometry (MS/MS) in order to improve the sensitivity of detection. A common disadvantage of chemical ionization, the production of a single m/z ion, is eliminated by the use of MS/MS. The single ion is further fragmented to a characteristic "daughter" ion allowing for absolute identification of the analyte.

A Varian 3800 GC with a septum equipped programmable injector (SPI) was employed. The column was a 15m RTx 5 connected to a CombiPal autosampler and a Varian 1200 triple quadrupole mass spectrometer. The initial injector temperature was 90°C with a temperature ramp at 100°C/min to 300°C. The initial column temperature was 90°C, held for 2 minutes then ramped at 25°C to 300°C. The carrier gas was helium, pumped at a constant flow of 1.4 mL/min. The transfer line was set to 270°C and the mass spectrometer was tuned in negative ion chemical ionization mode using PFTBA (calibration gas) for the tuning compound and methane was used as the reagent gas. The chemical ionization (CI) pressure was 7.8×10^{-4} Torr. The first quadrupole (Quad 1) was set in the selected ion monitoring (SIM) mode collecting 4 ions; 422.3, 425.3 (d_3), 590.3 and 593.3 (d_3).

THC-COOH and deuterated THC-COOH- d_3 were evaporated to dryness and derivatized using trifluoroacetic anhydride (TFAA, 40 μ L) and 1,1,1,3,3,3 hexafluoroisopropanol (HFIP) (20 μ L). The mixtures were heated at 80°C for 45 minutes, then re-evaporated to dryness under vacuum, and reconstituted in toluene for injection into the MS system.

The following concentrations of THC-COOH were prepared: 100pg/ μ L, 10pg/ μ L, 1pg/ μ L, and 0.1pg/ μ L. Using the SPI injector, 1 μ L injections were made to determine limits of detection for the NICI GC/MS

method on the Varian 1200 triple quadrupole. The lowest concentration tested (0.1 pg/ μ L) was readily detected, and repeated injections showed reproducibility and linearity over the range of 0.1-100pg/ μ L using a 1 μ L injection.

Triple Quadrupole Mass Spectrometer, THC-COOH, MS/MS

K7 Metabolic Profile of Amphetamine and Methamphetamine Following Administration of the Drug Famprofazone

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The attendee can expect to learn the profile of the metabolically produced amphetamine and methamphetamine following the ingestion of famprofazone.

Several drugs lead to the production of methamphetamine and/or amphetamine in the body that subsequently excreted in the urine. These drugs raise concerns when interpreting positive amphetamine drug testing results. Famprofazone an analgesic is found in a multi-ingredient medication used for pain relief (Gewodin, Geistlich). Famprofazone is not available in the United States, but is available over-the-counter in European countries such as Germany.

Two tablets (50 mg of famprofazone) were administered orally to five volunteers with no history of amphetamine, methamphetamine, or famprofazone use. Following administration, urine samples were collected ad lib for up to seven days and pH, specific gravity, and creatinine values determined. To demonstrate the excretion profile of amphetamine and methamphetamine, samples were analyzed using liquid/liquid extraction, derivatized with heptafluorobutyric anhydride, and analyzed by gas chromatography/mass spectrometry (GC/MS).

Peak concentrations for amphetamine ranged from 148 to 2,271 ng/ml and for methamphetamine 614 to 7,361 ng/ml. Concentrations of both compounds peaked between 3 to 14 hours post dose. Amphetamine and methamphetamine could be detected (LOD= 5 ng/ml) 121 hours and 143 hours post dose, respectively. Using a cutoff of 500 ng/ml, all subjects had individual urine samples that tested positive. One subject had 14 samples that were above the cutoff. The last positive being detected over 48 hours post dose.

Interpretation of results is a critical part of forensic drug testing due to potential repercussions to an individual. As demonstrated by the current study, a positive amphetamine test does not necessarily indicate illicit drug use. Evaluation of results with regard to those found in this study will assist in determination of the possibility of use of this medication as a source of methamphetamine and amphetamine.

Famprofazone, Amphetamine, Methamphetamine

K8 Effect of Freezing and Thawing on the Concentration of Ethanol in Urine Samples Stored in Leak-Proof Plastic Bottles

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The participants will learn how freezing and thawing affects concentration of ethanol in urine samples stored in leak-proof plastic bottles.

Social use of ethanol and its abuse continues to be important from the viewpoint of clinical and forensic interest. For forensic purposes, State and Federal legislatures, including Minnesota, have crafted rules, statutes, and *per se* laws to provide for measuring ethanol concentrations in one of

three principal media, *viz.*, blood, breath, and/or urine. The ultimate goal of measuring ethanol concentrations is to establish the degree of intoxication either at the time of sample collection or another time. These provisions often limit the choice to a single evidentiary sample and ethanol concentrations in the other samples may need to be derived. If the choice of evidentiary sample is urine, the above interpretation would be difficult but not impossible. Accordingly, the accuracy of measurement of ethanol concentrations in evidentiary samples and their interpretation, especially in the case of urine, are extremely important.

The accuracy of measurement and interpretation of ethanol results may be compromised for many reasons. For example, presence of relatively high concentrations of sugar, contamination of such samples by ethanol producing/metabolizing bacteria and/or yeast, *e.g.*, *E. coli* and *C. albicans*, and their storage at room temperature has been shown to result in *in vitro* ethanol production. This may be prevented by the addition of sodium fluoride (10 mg/mL) to samples at the time of collection and by storing them at 0-4°C prior to analysis. The above situation may also result from improper storage methods and procedures, especially in the case of urine samples. The laboratory at MN BCA, like most other laboratories, routinely stores evidentiary urine samples at 4°C prior to ethanol analysis, and frozen at -20°C post-ethanol analysis until they are (a) tested for drugs of abuse, (b) returned to the agencies that collected them, (c) transferred to dependents for re-testing when the results are disputed, or (d) destroyed when the samples are no longer required. Experience showed that re-testing the previously frozen urine samples for ethanol leads to the determination of ethanol concentrations that are significantly lower than those obtained prior to them having been frozen. This study was undertaken to establish the basis for lowering of ethanol concentrations in post-frozen urine samples and suggest corrective measures to prevent it.

Samples used for this purpose were (i) urine samples spiked with known concentrations of ethanol (n=100) and stored frozen for up to one year, (ii) actual case samples designated for disposal and stored frozen for up to two years (n=345), and (iii) urine samples collected from subjects participating in controlled drinking studies (n=38) and stored frozen for up to one year. Ethanol concentrations in these samples were quantified by head-space gas chromatography and the concentrations were expressed as g/67 mL as per Minnesota State Statutes. The containers used for this purpose were 100 mL leak-proof plastic bottles containing 1g NaF, routinely used for the collection of evidentiary urine samples in the State of Minnesota.

The frozen urine samples were either allowed to thaw slowly at 4°C in a walk-in cooler or allowed to thaw quickly at room temperature (RT) in a chemical hood. The method of thawing did not influence the magnitude of loss of ethanol concentrations in urine samples. The before freezing and after thawing ethanol concentrations (mean ± SD) in urine samples (n=90) thawed at 4°C were 0.15±0.048 and 0.10±0.058, g/67 mL, respectively. The before freezing and after thawing ethanol concentrations (mean ± SD) in urine samples (n=255) thawed at RT were 0.15±0.048 and 0.10±0.05, g/67 mL, respectively. Decrease in ethanol concentrations were not significant in urine samples (n=38) stored at 4°C (without ever being frozen) for zero (0.071±0.014 g/67 mL), 1 (0.071±0.013 g/67 mL), 3 (0.072±0.012 g/67 mL) and 6 (0.070±0.015 g/67 mL) months. Concentration of ethanol in the urine samples had little or no effect on the magnitude of ethanol lost during the above thawing process. For example, ethanol concentrations in urine samples (n=10; volume = 60 mL in each case) spiked with 0.05, 0.10, 0.15, 0.30 and 0.40 g/67 mL, frozen for one month and thawed at RT were 0.039±0.008, 0.081±0.007, 0.11±0.011, 0.23±0.025 and 0.32±0.03 g/67 mL, respectively. Ethanol concentrations in a second set of these samples thawed at 4°C (n=10; volume = 60 mL in each case) were 0.038±0.008, 0.080±0.008, 0.10±0.015, 0.24±0.030 and 0.31±0.04 g/67 mL, respectively. On the other hand, the decrease in ethanol concentrations observed above were dependent on the sample volume present in leak-proof plastic bottles used for their storage before analysis (4°C), during freezing (-20°C) and after thawing (at RT or 4°C). This correlation obtained for samples thawed at RT is shown in the table.

AC (Mean ± SD), g/67 mL (n)			
Urine, mL	Before Freezing	After Thawing	% Diff
1-10	0.15±0.03 (7)	0.14±0.03 (7)	7.9±5.3
11-20	0.18±0.04 (9)	0.16±0.04 (9)	11±11
21-30	0.15±0.05 (17)	0.14±0.05 (17)	8.3±9.4
31-40	0.14±0.04(11)	0.12±0.04 (11)	9.8±19
41-50	0.13±0.04 (17)	0.12±0.04 (17)	7.2±11
51-60	0.15±0.04 (22)	0.12 ±0.04 (22)	18±23
61-70	0.13±0.05 (19)	0.09±0.04 (19)	23±20
71-80	0.15±0.05 (29)	0.11±0.05 (29)	26±20
81-90	0.15±0.04 (37)	0.10±0.04 (37)	32±23
91-100	0.16±0.05 (87)	0.08±0.04 (87)	47±26

Ethanol concentrations in urine samples were unaltered when they were frozen and thawed (at RT) in air tight vactainer tubes (n=38; volume = 6 ml each; frozen for one year); the original and after thawing ethanol concentrations of such urine samples were 0.069±0.014 and 0.071±0.015 g/67 mL, respectively. Ethanol concentrations of the above samples (n= 38; volume = 60 ml each) processed identically but stored in leak-proof plastic bottles were 0.067±0.014 and 0.048±0.01 g/67mL, respectively. These studies suggest that the decrease in ethanol concentrations observed in post-frozen urine samples is due to improper sealing (likely due to decreased flexibility of plastic at -20°C) between the rim of plastic bottle and inner lining of its cap. The leak-proof 100 mL plastic bottles used for urine evidence collection contain an inner Styrofoam integrity seal attached to their mouth and complete removal of this seal before sample collection cannot not be easily accomplished. Further, during the process of thawing of frozen urine samples (ethanol does not freeze at -20°C), ethanol evaporates and escapes from the bottle via the small gaps/pores created due to improper sealing and thus leads to significant decrease in the ethanol concentrations. The pronounced loss of ethanol from the bottles containing larger volumes of urine samples is most likely due to expansion during freezing leading to disruption of Styrofoam seal and efficient evaporation of ethanol from smaller head space volume. Support for this notion comes from the observation that the ethanol concentrations of urine samples (n=19; sample volume 10-100 mL) before freezing (0.11±0.065), and after freezing (up to three months) and thawing (0.11±0.061 g/67 mL) were identical when the storage containers were essentially identical leak-proof 100 mL plastic bottles except that they did not have inner Styrofoam integrity seal. Accordingly, we have recommended and successfully adopted the use of leak-proof 100 mL plastic bottles (Tri-Tech, Inc., NC) that do not contain the inner Styrofoam seal, but contain an outer and across the cap tape integrity seal.

Ethanol, Urine, Head-Space Gas Chromatography

K9 DWI Cases Involving Anesthetics

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The objective is to illustrate the utility of using multiple GC columns with dissimilar retention characteristics for identification of unusual and unsuspected volatile substances in Driving While Intoxicated (DWI) cases.

During blood and urine headspace gas chromatographic analysis for ethanol in suspected Driving While Intoxicated (DWI) cases, toxicologists also routinely screen for acetone, methanol, and iso-propanol. Additional substances are sometimes observed and identified whenever possible. Minnesota statutes have criminal provisions for driving while under the influence of "hazardous substances" including solvents and other volatiles, as well as controlled substances. In most instances the observation of a volatile other than ethanol is germane to the driving behavior and the criminal case; however, occasionally it is not relevant. Cases illustrating both situations will be presented.

Analytical Procedure: Routine samples are diluted with a solution containing NaF and n-propanol (internal standard). Samples being examined for volatiles other than ethanol, methanol, isopropanol, or acetone may be analyzed undiluted as well. Analysis is via Perkin-Elmer Autosystem XL chromatographs containing capillary columns (either Restek BAC-1 or Restek BAC-2), or a Perkin-Elmer 8420 chromatograph containing a packed column (5% Carbowax 20M on Carbowax B); all instruments are equipped with Perkin-Elmer headspace samplers. When only ethanol is suspected, the isothermal analysis takes 4-5 minutes per sample. If other substances are suspected, the analysis may be extended to 20 minutes or longer. Subject samples are chromatographed on at least two dissimilar columns to detect the possible co-elution of substances on a particular column, and thus to establish the unique identity of the chemical observed in each peak. Relative Retention times (RRT) have been measured for a wide variety of compounds on these columns. A spreadsheet program aids identification of "unknowns" by calculating expected retention times (RT) for all known compounds when the RT of the internal standard is entered. Among the compounds examined were:

Compound	RRT(BAC-1)	RRT(BAC-2)	RRT(Carbowax 20M)
Methanol	0.638	0.411	0.326
Ethanol	0.707	0.533	0.498
Isoflurane	0.805	0.611	unk.
Diethyl Ether	0.807	0.396	0.421
Isopropanol	0.811	0.627	0.692
Acetone	0.937	0.578	0.432
n-Propanol	1.000	1.000	1.000

Case 1: A urine sample arrived by mail requesting "test for: cannabis (sic), inhalants, depressants." It was noted that no valid breath test was possible since the Intoxilyzer 5000 had detected an interferent. The subject had been examined by a Drug Recognition Expert (DRE) whose report mentioned several other possible intoxicants including ether, cyproheptidine, and a brand of cough syrup. Routine chromatography using the 5% Carbowax 20M column initially demonstrated two small peaks corresponding to ethanol and acetone. However, chromatography using the BAC-1 and BAC-2 columns demonstrated three peaks: a small "unknown" peak, as well as a trace (less than 0.01 g/100mL) of ethanol, and a trace of acetone. The third substance was identified as diethyl ether by its RTs on the BAC-1 and BAC-2 columns. Diethyl ether co-chromatographs with acetone on the Carbowax 20M column.

Additional drug of abuse screening was positive for 11-nor-9-carboxy-delta-9-tetrahydrocannabinol. Police reports furnished the additional information: PBT results at the scene were negative for breath alcohol. The subject admitted to smoking marijuana, and his breath had the odor of marijuana. He admitted previous abuse of inhaled chemicals (starter fluid) but denied use during the prior week. However, he had been observed by a reliable witness inhaling a chemical two days prior. The urine sample was obtained approximately 7.5 hours after the subject was apprehended.

Case 2: The same subject was stopped for DWI again one month later. He was immediately recognized and examined by the same DRE officer who had been involved in Case 1. Breath testing with the Intoxilyzer 5000 failed (instrument range exceeded). A blood sample was drawn approximately two hours after the subject was apprehended and submitted for "alcohol and ether" analysis. Chromatographic analysis of the blood showed a large peak with the RRT of diethyl ether, and a trace of acetone, but no ethyl alcohol. No other drugs or intoxicants were suspected or tested for.

Police reports furnished the additional information: PBT at the scene gave the false result of 0.135 (as ethanol). The subject's breath had a strong chemical smell (ether). The subject admitted to "huffing up" using Prestone Premium Starting Fluid (contains ethyl ether and hydrocarbon distillates) which was found in his car, and stated that he usually went through a 10 oz. spray can daily.

Case 3: A blood sample arrived by mail appearing to be a routine DWI; no drugs or other intoxicants were mentioned. Analysis revealed a

prominent peak of an unknown substance, but no ethanol. Its RTs on the Restek BAC-1 and BAC-2 columns differed from any volatile we had previously examined. However, literature values suggested the possibility of the anesthetic Isoflurane. It was later discovered that the sample had been obtained while the subject was in the surgical operating room. A known sample of Isoflurane was obtained and shown to chromatograph identically with the substance in the subject's blood.

Conclusion: The observation of an "unusual" volatile substance, diethyl ether in Cases 1 and 2, was significant in their prosecution. The surprising observation of isoflurane in Case 3 was later determined to be irrelevant to its prosecution. Identification of these substances was possible through gas chromatography on multiple columns with dissimilar retention characteristics.

DWI, Volatiles, Chromatography

K10 Comparison of Drug Concentrations in Postmortem Cerebrospinal Fluid and Blood Specimens

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The objective is to gain insight into the usefulness of cerebrospinal fluid (CSF) for detecting different classes of drugs in postmortem analysis.

The ability to detect drugs of abuse in CSF specimens, such as opiates, has been well documented. This poster will present data which demonstrates that postmortem CSF specimens may be useful in the detection of a wide range of drugs as well.

The concentrations of drugs and their metabolites in cerebrospinal fluid and blood were determined in 282 autopsied cases using liquid-liquid extraction techniques and gas chromatographic analyses. All drugs were confirmed in one matrix by GC/MS. Blood was collected from the heart and placed in screw cap polyurethane tubes containing sodium fluoride (200 mg) and potassium oxalate (400 mg) and refrigerated at 4 °C. CSF was collected by cisternal puncture and stored in Vacutainer™ tubes containing 25 mg of sodium fluoride and 20 mg of potassium oxalate. CSF specimens were stored at -20 °C and were not tested until the result of the blood screen was known. For summarizing the results, the drugs were separated into different classifications with each class being represented by the major drugs found.

Some of the drugs found in the CSF specimens had a very wide range of CSF/blood ratios which skewed the average. For these drugs the median is also reported and tends to be a better representation of the values encountered. For example, amitriptyline ratios ranged from 0.03 – 2.93 with an average of 0.30 and a median of 0.10.

Benzodiazepines were detected in 55 of the 62 CSF specimens for which the blood was positive. Diazepam (n=43) and its major metabolite nordiazepam (n=51) accounted for most of the cases with average CSF/blood ratios of 0.36 (median=0.17) and 0.37 (median=0.21), respectively. Alprazolam was found in four cases with an average CSF/blood ratio of 0.85 (median=0.66).

The anticonvulsants, phenytoin (n=23), phenobarbital (n=8), and carbamazepine (n=5) were detected in 35 of the 36 cases analyzed. They had similar CSF/blood ratios of 0.33, 0.63, and 0.40, respectively.

Sedative drugs were represented mainly by carisprodol (n=10) and meprobamate (n=21) and demonstrated higher average CSF/blood ratios than any other class of drugs (approx. 1.0). All the cases analyzed were positive.

Antihistamines were detected in 25 of the 37 CSF specimens analyzed with diphenhydramine (n=25) being the major drug with an average CSF/blood ratio of 0.34.

The narcotics, propoxyphene (n=21), methadone (n=8), and meperidine (n=7) all had CSF/blood ratios in the range of 0.3-0.4 and were detected in 32 of the 36 cases tested. Other narcotics found included tramadol and oxycodone.

Of the tricyclic antidepressants, amitriptyline (n=20) was the major drug found with an average CSF/blood ratio of 0.3 (median =0.1), while nortriptyline, the major metabolite, had a lower ratio of 0.06 and was only detected in half of the cases. Similar results were obtained for imipramine and desipramine. Some of the other antidepressants detected included bupropion, sertraline, fluoxetine, citalopram, and trazodone with CSF/blood ratios ranging from 0.02 – 0.4.

Anesthetic drugs found were lidocaine (n=45), phencyclidine (n=7), and ketamine (n=2). Lidocaine had high average CSF/blood ratio of 1.19 with a lower median ratio of 0.47. Phencyclidine had a lower ratio of 0.17.

Very few of the drugs that were analyzed were not readily detected in CSF specimens. The average CSF/blood ratios for most drugs was in the range of 0.05-0.50. Interpretation of these results are difficult since CSF drug concentrations will vary significantly with the amount of time between drug usage and the time of death. The half-lives, hydrophobic properties, and pKa's of the drugs will also influence the CSF/blood ratios. However, CSF specimens do provide a viable alternative testing matrix when blood specimens are not available but should not be used to estimate blood drug concentrations.

Cerebrospinal Fluid, Postmortem, Analysis

K11 Evaluation of the Protective Effect of N-acetylcysteine on the Lungs of Paraquat Intoxicated Rats

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The aim of the present study was to evaluate the protective effect of N-acetylcysteine on the lungs and liver of Paraquat intoxicated rats.

Paraquat is an herbicide widely used in agriculture. Death from paraquat intoxication has been reported both in humans and in experimental animals with involvement of lung, kidney, myocardium, central nervous system, liver, spleen, adrenals, and muscles. Progressive pulmonary damage occur due to irreversible changes in the pulmonary tissues which are not recognizable clinically until they are sufficiently advanced, leading to respiratory failure and causing most of the fatalities due to the selective concentration of paraquat in the lung parenchyma. It is now accepted that the toxicity of paraquat is based on an oxygen free radical mechanism. To counteract paraquat toxicity, induction of reactive oxygen species must be decreased. Different pharmacological strategies have been explored to reduce the formation of these reactive oxygen species and/or prevent their toxic effects in the treatment of paraquat poisoning. N-acetylcysteine (NAC) is a known antioxidant and free radical scavenger. The underlying mechanisms of its effects include its action as a precursor of the natural antioxidant glutathione, or to the direct reaction between the reducing thiol residue of NAC and the oxygen species formed under the influence of an oxidant, or from activated macrophages and neutrophils during inflammation. From this point of view the present study was carried out in order to evaluate the protective effect of NAC on the lungs and liver of paraquat intoxicated rats. Forty-five male albino rats (180-200 g) were used in the present study, The animals were divided into five groups (nine animals in each group):

(I) Control group; (II) NAC group; (III) Paraquat intoxicated group; (IV) Paraquat intoxicated NAC-treated group, given NAC at the same time with paraquat; and (V) Paraquat intoxicated NAC-treated group, given NAC 4 hr after paraquat intoxication. The intoxicated rats received 20mg/kg paraquat IP and were treated with NAC in a dose of 50mg/kg IP. Histological examination of the lung and liver sections was done using:

- (1) Haematoxylin and Eosin stain (for routine histological examination);

- (2) VVG stain (for elastic tissue); and
- (3) Trichrome stain (for collagen fibers).

From our results, it could be concluded that intraperitoneal administration of NAC at the same time with paraquat as a prophylactic agent had no protective effect against paraquat induced lung and liver injury in rats. On the other hand, NAC when administered 4 hr after paraquat intoxication as a curative agent did have an obvious therapeutic effect against paraquat toxicity in rats' lung and liver

Paraquat, N-acetylcysteine, Lungs

K12 Peak Δ^9 -Tetrahydrocannabinol (THC), 11-hydroxy-THC (11-OH-THC) and 11-nor-9-Carboxy-THC (THC-COOH) Excretion & Detection Times in Human Urine Following Controlled Administration of Smoked Marijuana

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After attending this presentation, the participant will be better informed on interpretation of THC, 11-OH THC & THC-COOH in urine following smoked marijuana

Marijuana and hashish, derived from Cannabis Sativa, produce physiological and behavioral subjective intoxication following cannabis smoking. The main psychoactive compound of Marijuana is THC, which is rapidly bio-transformed to an active metabolite, 11-OH-THC. Further oxidative metabolism forms the inactive, more polar metabolite, THC-COOH. THC-COOH and its glucuronidated metabolite are the major metabolites found in urine. In routine criminal justice, treatment and workplace drug monitoring programs, evaluation of marijuana exposure is usually accomplished by measuring THC-COOH in urine following alkaline hydrolysis. As suggested by Kemp et al (*JAT* 1995;19:292), enzymatic hydrolysis with *E. coli* Type IX bacteria permitted release and subsequent measurement of both active components, THC and 11-OH-THC. We have further developed this idea by combining an enzymatic hydrolysis with *E. coli* Type IX-A bacteria followed by an alkaline hydrolysis, solid phase extraction with a dual elution solvent and sensitive electron impact gas chromatography-mass spectrometry (GC/MS) analysis. We suggest that THC and 11-OH-THC will be present in the urine for a shorter period of time than THC-COOH, but their presence may provide important information on the recency of marijuana smoking, especially during excretion in heavy users.

This study examined the timecourse of THC, 11-OH-THC, and THC-COOH in urine following controlled administration of smoked marijuana. Subjects (N=11) were healthy volunteers with a history of marijuana use. The study was conducted under the guidelines for the protection of human subjects, and each volunteer gave written informed consent. During the study, all subjects resided on a closed research ward at the NIDA Intramural Research Program under medical surveillance to prevent self-administration of additional drugs. Each subject smoked a single 2.78% THC cigarette on two dosing sessions separated by seven days. All urine specimens were collected ad lib throughout the study. Urine was processed and frozen at -20°C until GCMS analysis. Prior to analysis, 2 mL of urine was hydrolyzed with 10,000 units of *E. coli* β -glucuronidase type IX-A for 16 hrs at 37°C. This was followed by base hydrolysis with 10N NaOH and heated at 60°C for 15 minutes. The hydrolyzed samples were processed by solid phase extraction (Clean Thru DAU, UCT), derivatized with BSTFA (1%TMCS). Mean peak THC concentration in the urine was 6.9 ± 2.3 ng/mL (range 0-42.8).. Peak THC concentration occurred within the first half-hour after marijuana smoking.

Mean peak 11-OH-THC concentration in urine was 42.1 ± 10.5 ng/mL (range 4.4-231.1) and occurred at 3.7 ± 0.7 hrs (range 0.5-10.9). Mean peak THC-COOH urine concentration was reached at 14.7 ± 1.7 hrs (range 5.6-39.1) and varied from 9.2 to 315.2 ng/mL (mean 81.4 ± 15.1).

In addition to the controlled drug administrations, the three cannabinoids were quantitated in urine specimens collected from the time of admission to the secure research unit until completion of elimination (wash-out period). The wash-out period ranged from 12.8-28.5 days for four subjects. Peak THC, 11-OH-THC, and THC-COOH concentrations occurred within the first four urine voids. THC was measurable (5.8 and 7.3 ng/mL) in two of the four participants, indicating recent marijuana smoking. Peak 11-OH-THC urine concentrations ranged from 11.0 to 104.0 ng/mL and occurred prior to 7.5 hrs. Peak THC-COOH urine concentrations ranged from 61.9 to 1081.7 ng/mL and occurred prior to 3.5 hrs.

Each of the eleven subjects participated in two controlled smoking sessions for a total of 22 sessions. The detection times of THC, 11-OH-THC, and THC-COOH in the controlled administration sessions were in the ranges indicated below.

Detection Times (hrs)	THC	11-OH-THC	THC-COOH
0 – 10 hrs	22	0	0
>10 – 24 hrs	0	4	1
>24 – 36 hrs	0	4	1
>36 – 48 hrs	0	4	2
>48 – 72 hrs	0	2	5
> 72 hrs	0	8	13

These preliminary data indicate that detection of THC in urine may be a good indicator of recent marijuana smoking; however, 11-OH-THC appears to be present in some subjects for more than 72 hrs, well beyond the period of intoxication, and may, therefore, be less useful in documenting recent exposure.

Smoked Marijuana, Controlled Administration, Urine

K13 Characteristics of Calibration Curve Resulting From the Use of a ^2H -Analog of the Analyte as the Internal Standard—Methamphetamine Example

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The objective is to familiarize the participants with the complicating factors affecting the linearity of the calibration curve resulting from the use of a ^2H -analog of the analyte as the internal standard (IS). Specific parameters studied include (a) reconstitution and injection volume that may affect the molecular abundance of the analyte and the IS in the ion source, and (b) column temperature programming conditions and the number of the ^2H -atom incorporated in the IS that may affect the separation of the analyte and the IS.

While evaluating the effectiveness of ^2H - and ^{13}C -analogs of the analytes in serving as the ISs in various barbiturate systems, it was noted that the intensity ratio of an ion-pair designated for an analyte and its ^2H -analog increases as the extraction-derivatization residue is reconstituted with increasing amount of solvent. Realizing the effects of this phenomenon on the characteristics of the calibration curve, this current study is designed to: (a) confirm the occurrence of this same phenomenon in the amphetamine drug category, (b) examine the effect of this phenomenon on the calibration curve, and (c) study factors underlying this phenomenon.

$^2\text{H}_5$ -, $^2\text{H}_9$ -, and $^2\text{H}_{14}$ -analogs of methamphetamine were adapted as the ISs for calibration curve evaluation. Well-established solid-phase extraction and pentafluoropropionyl (PFP) derivatization procedures were used to pretreat standard solutions prepared in urine matrix. A series of standard solutions containing 100-9600 ng/mL methamphetamine and 500 ng/mL IS were used to examine the characteristics of the calibration data.

Calibration lines shown in Figure 1 clearly indicate the difference when the calibration line is established with different injection volumes. Apparently, the intensity ratios of the designated ion-pair at the higher concentration end derived from smaller injection volume are relatively higher. It is believed this is caused by the non-proportional decrease (relative to the IS) in the ionization efficiency of the analyte as its molecular abundance at the ion source increases.

To further study the molecular abundance issue, a second series of experiments was performed, in which 50, 150, and 450 mL ethyl acetate was used to reconstitute the extraction-derivatization residue. Data shown in Table 1 clearly demonstrate that, as the reconstitution volume increases (i.e., the molecular abundance at the ion source decreases), the ion intensity of the designated ion-pair at the higher concentration end stays closer to its "expected" value, i.e., the "linearity" of the calibration curve can be extended to a higher concentration level.

Thus, it was confirmed that the methamphetamine/ $^2\text{H}_{14}$ -methamphetamine system exhibits the same characteristics as the barbiturate/ $^2\text{H}_5$ -analog systems. Since parallel barbiturate/ ^{13}C -analog systems are free of this interference phenomenon, it was hypothesized that the retention time difference between the analytes and their ^2H -analogs is the underlying cause for the observed non-proportional decreases in ionization efficiency in the analyte/ ^2H -analog systems. (Analytes and their ^{13}C -analogs have identical retention time.) Thus, retention time difference is the parameter studied in the next series of experiments. Data shown in Table 2 clearly indicate that, as the analyte and its ^2H -analog IS are further overlapped (by programming at a higher rate), the designated ion-pair intensity ratios for the standards with higher analyte concentrations become closer to their "expected" values, i.e., the "linearity" of the calibration can be extended to a higher concentration level.

To further study the retention time difference parameter, another series of experiments are performed, in which $^2\text{H}_5$ -, $^2\text{H}_9$ -, and $^2\text{H}_{14}$ -methamphetamine (showing increasing retention time difference with the analyte) are used as the ISs. Resulting data shown in Table 3 indicate that, compared to the methamphetamine/ $^2\text{H}_9$ -analog and the methamphetamine/ $^2\text{H}_{14}$ -analog systems, the intensity ratio of the ion-pair designated for methamphetamine/ $^2\text{H}_5$ -methamphetamine at the higher concentration end is closer to their "expected" values. Again, this will allow the extension of the linearity of the calibration curve to a higher concentration level.

It has been demonstrated that establishing a calibration line within a desired concentration range, in addition to careful selection of the internal standard, requires careful consideration of the extraction-derivatization reconstitution volume, injection volume, and temperature programming parameters.

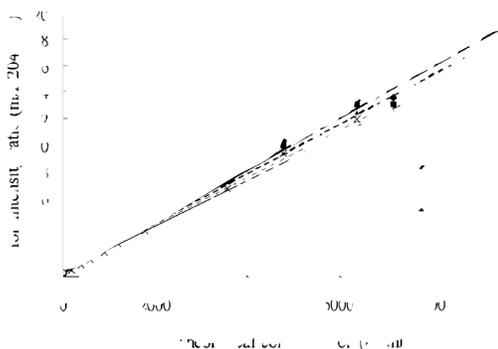


Figure 1. Effects of injection volume on calibration line characteristics—Methamphetamine/ $^2\text{H}_9$ -analog: m/z 204/211.

Table 1. Effect of reconstitution volume on the linearity of the calibration line—Methamphetamine/²H₁₄-analog: m/z 204/211

Theor. Conc. (ng/mL)	50 μL reconstitute volume		150 μL reconstitute volume		450 μL reconstitute volume	
	Ion ratio	Dev. (%)	Ion ratio:	Dev. (%)	Ion ratio:	Dev. (%)
			Ratio change (%)†		Ratio change (%)†	Dev. (%)
100	0.247	17.5	0.239: -3.23	16.4	0.250: 1.21	14.9
200	0.429	2.14	0.413: -3.73	0.59	0.434: 1.17	-0.17
400	0.841	Calibrator	0.822: -2.26	Calibrator	0.870: 3.45	Calibrator
600	1.246	-1.25	1.224: -1.77	-0.69	1.299: 4.25	-0.45
900	1.870	-1.16	1.828: -2.25	-1.14	1.967: 5.19	0.50
1200	2.403	-4.77	2.379: -1.00	-3.53	2.546: 5.95	-2.46
1800	3.629	-4.12	3.606: -0.63	-2.51	3.906: 7.63	-0.22
2400	5.119	1.44	5.140: 0.41	4.22	5.585: 9.10	6.99
3600	7.082	-6.44	7.135: 0.75	-3.55	7.825: 10.49	-0.06
4800	9.123	-9.60	9.373: 2.74	-4.98	10.278: 12.66	-1.55
6400	11.657	-13.37	11.974: 2.72	-8.96	13.385: 14.82	-3.84
7200	13.328	-11.96	13.601: 2.05	-8.08	15.197: 14.02	-2.96
9600	17.216	-14.70	17.757: 3.22	-9.99	19.633: 14.04	-5.97

† Ratio changes are calculated by dividing the ratio observed with the reconstitution volume of 50 □L by the ratio observed with the reconstitution volume of interest.

Table 2. Effect of variation in Methamphetamine/²H₁₄-analog (m/z 204/211) retention difference (resulting from different temperature programming) on the linearity of the calibration line—²H₁₄-analog: 400 ng/mL.

Recons. Vol. (μL)	200 ng/mL methamphetamine		3600 ng/mL methamphetamine		9600 ng/mL methamphetamine	
	Ion ratio:	Ratio change (%)†	Ion ratio:	Ratio change (%)†	Ion ratio:	Ratio change (%)†
	25° temp. ramp	5° temp. ramp	25° temp. ramp	5° temp. ramp	25° temp. ramp	5° temp. ramp
150	0.509	0.483	8.174	8.139	22.285	20.935
300	0.495: -2.75	0.501: 3.73	8.334: 1.96	8.513: 4.60	23.576: 5.79	23.312: 11.35
450	0.505: -0.79	0.496: 2.69	8.606: 5.29	8.693: 6.81	24.395: 9.47	25.055: 19.68
600	0.498: -2.16	0.476: -1.45	8.758: 7.14	9.516: 16.92	25.399: 13.97	26.898: 28.48

† Ratio changes are calculated by dividing the ratio observed with the reconstitution volume of 150 □L by the ratio observed with the reconstitution volume of interest.

Table 3. Effect of variation in analyte/²H-analog IS retention difference (resulting from the use of the ²H-analogs with different number of ²H-atoms) on the linearity of the calibration line—IS: 400 ng/mL.

Theor. Conc.	Methamphetamine/ ² H ₅ -analog (m/z 204/208)		Methamphetamine/ ² H ₉ -analog (m/z 204/211)		Methamphetamine/ ² H ₁₄ -analog (m/z 204/211)	
	Ion int. ratio	Deviation (%)	Ion int. ratio	Deviation (%)	Ion int. ratio	Deviation (%)
100	0.226	-1.79	0.307	10.02	0.263	11.24
200	0.467	1.51	0.572	2.43	0.475	0.61
400	0.921	Calibrator	1.117	Calibrator	0.945	Calibrator
600	1.398	1.17	1.703	1.64	1.378	-2.79
900	2.047	-1.23	2.613	3.96	1.993	-6.26
1200	2.782	0.69	3.324	-0.82	2.844	0.32
1800	4.215	1.69	5.035	0.16	3.988	-6.22
2400	5.646	2.17	6.540	-2.42	5.514	-2.76
3600	8.487	2.39	9.891	-1.62	7.979	-6.18
4800	11.23	1.59	12.69	-5.30	10.82	-4.56
6400	14.86	0.84	17.79	-0.45	14.64	-3.19
7200	16.81	1.37	20.00	-0.55	16.14	-5.11
9600	22.63	2.36	26.15	-2.46	22.16	-2.32

Internal Standard, Ion Intensity Ratio, Methamphetamine

K14 Detection of Gamma-Hydroxybutyrate (GHB) and Gamma-Butyrolactone (GBL) in Driving Under the Influence Cases Within the New Jersey State Police Forensic Science Bureau

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The objective is to present findings regarding the detection of Gamma-Hydroxybutyrate (GHB) and Gamma-Butyrolactone (GBL) in blood and urine from driving under the influence cases and describe the methodology used.

The New Jersey State Police Forensic Science Bureau has seen an increase in driving under the influence cases containing GHB and/or GBL. A summary of the results seen within the laboratory and the methodology used is presented. A procedure was established for screening and quantitation of GHB/GBL using an adaptation of the Headspace GC-FID method developed by the FBI Chemistry Unit.

Alpha-methylene-gamma-butyrolactone internal standard is added to two aliquots of biofluid. Concentrated sulfuric acid is added to one aliquot to convert any GHB present to GBL. A four point GHB calibration curve (10 μg/mL-100 μg/mL) is prepared and also treated with concentrated sulfuric acid. All aliquots are extracted with methylene chloride and concentrated. Extracts are screened and quantitated using Headspace GC-FID. Samples calculated to be greater than or equal to 15 μg/mL are confirmed using full scan GC-MS. The confirmation of GBL employs the alpha-methylene-gamma-butyrolactone internal standard and a simple methylene chloride extraction.

The GHB confirmation procedure utilizes the solid-phase extraction method developed by United Chemical Technologies, Inc., with modifications to utilize full-scan GC/MS. Blood samples containing GHB require a cleanup step with acetone. Urine samples containing GHB are treated with a urease solution to break down the urea into ammonia, water, and carbon dioxide. These samples are then spiked with GHB-D6 internal standard and buffered with phosphate buffer. Clean Screen® GHB extraction columns are used on the Zymark Rapid Trace™ SPE Workstation providing a rapid procedure for the extraction of GHB from blood and urine samples. The eluate is evaporated to dryness and reconstituted with ethyl acetate and BSTFA with TMCS. Full scan GC-MS (EI) confirmation of GHB is then obtained from the GHB-diTMS. This procedure provides sufficient sensitivity for the screening, quantification, and confirmation of GHB/GBL in toxicology cases involving driving under the influence.

Gamma-Hydroxybutyrate, Gamma-Butyrolactone, Toxicology

K16 Methyl Alcohol Intoxication Resulting in Death in Turkey: An Eight-Year Autopsy Study

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The objective is to establish the general specifications of methyl alcohol intoxication in Turkey.

The aim of this study was to examine methyl alcohol poisoning cases from the medico-legal point of view. The records of the morgue

department of the Council of the Forensic Medicine were reviewed retrospectively for all methyl alcohol poisonings for the period of 10-27-1992 to 05-30-2001. The victim's age, sex, date of death, death place, blood methyl alcohol levels, the source of methyl alcohol, accompanying laboratory results, and histopathologic tissue changes were recorded.

Blood samples were collected from the pericardial sac for the measurement of alcohol concentration. All samples were steam distilled with n-butanol (0.5 ml of 80 mg/dl) as internal standard before gas chromatographic analysis. Methyl alcohol analysis was performed on a Hewlett-Packard model 5890 series Gas Chromatograph-Flame Ionization Detector (FID) equipped with a Hewlett-Packard model 7694 Headspace Sampler. The injection port and detector temperatures were 200°C and 280°C, respectively.

According to the Forensic Medicine Morgue Department records, the total number of the deaths between 1992-2001 was 24,206. The number of the deaths due to the methyl alcohol poisoning was 271 (1.12%) during this period. Two hundred forty-two (89.3 %) of the total 271 methyl alcohol fatalities were men and 29 (10.7 %) were women. The ages varied from 16 years to 68 years. The largest group was 36-40 years old, followed by 41-45.

The number of methyl alcohol poisonings was increasing gradually with respect to the annual distribution from 1992 to 2001.

The blood methyl alcohol concentrations ranged widely from 50 to 755 milligrams per 100 ml. There were 222 cases (81.9 %) with the blood methyl alcohol concentrations over 100mg/dl. In six cases the victims were treated in different hospitals and they had blood methyl alcohol levels under 50 mg/dl. Formaldehyde was detected in 12 of these cases and 75 of them had also ethyl alcohol in blood samples. Two of them also had barbiturate derivatives in their blood and urine samples. Formic acid wasn't detected in any of the cases.

Twenty-nine (10.7 %) victims were poisoned through the consumption of cologne and three of them with an alcoholic beverage named "Rak?." Consumed products were not known in all other cases because of insufficient history and data. All of these cases were suspicious – 61 (22.5%) died in hospital, 103 (38%) died at home, and 44 (16.2%) on a road etc.

In Turkey, section 21 of the regulation Nr. 3/15481 about foodstuffs and goods and containers effecting the public health and hygiene prescribes: ethyl alcohol must be used in contents of all alcoholic beverages, must be used in all distilled alcoholic beverages and methyl alcohol mustn't be used in alcoholic beverage named "Rak?."

In conclusion, methyl alcohol deaths are gradually increasing and have a great significance in toxicological deaths. There were no specific histopathologic findings and the significance of the laboratory analysis to legal investigation was shown. Preventative strategies for the production and consumption of illicit alcoholic beverages must be developed.

Methyl Alcohol, Intoxication, Forensic Medicine

K17 Issues Related to Simulator Temperature Measurement in a Breath Alcohol Simulator

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The attendee will learn about the limitations of temperature measurement and stability in breath alcohol simulators, the impact of this on the breath test, and the forensic implications of thermometer record keeping in breath alcohol testing.

Breath alcohol test instruments are typically calibrated and checked for accuracy with vapor from an alcohol water solution at a known temperature, based on Henry's law. During the process of validating new software for the DataMaster breath test instrument (National Patent Analytical Systems, OH), it was discovered that a mercury-in-glass

thermometer in at least one Guth 34C breath alcohol simulator (Guth Laboratories Inc., PA) was reading inaccurately. Further investigation revealed that as many as 25% of the custom made, NIST traceable thermometers, designed to measure accurately between 33.5 and 34.5 degrees centigrade, were inaccurate by as much as half a degree. This inaccuracy and its scientific and forensic significance has become the focus of extensive litigation in Washington State, resulting in suppression of hundreds of breath alcohol test results on grounds of failure to comply with appropriate regulations, rather than because of any inaccuracy of the breath test result itself.

During this litigation the authors conducted a review of the scientific literature on mercury in glass thermometers, performed experiments demonstrating the influence of the thermometer inaccuracy on the simulator ethanol result, used the field test database to examine the instrument's ability to accurately measure the ethanol concentration of the simulator solution compared to an independent gas chromatographic measurement, and examined the stability of the thermostat controlled simulator temperature over both the short term (20 minutes – 24 hours), and the longer term (up to 30 days).

Because of the multiple cross checks and other safeguards imposed on the breath test program by both administrative rule and by protocol, it was successfully demonstrated that the unreliability of the mercury-in-glass-thermometers did not affect the accuracy of the test results.

The lessons learned from this experience were as follows:

- In contrast to popular belief, even NIST certified mercury-in-glass thermometers can lose calibration over time, and should be periodically checked.
- Inaccuracy in the mercury in glass thermometers had no effect on the accuracy of the breath alcohol test, a position that was not disputed in any subsequent litigation.
- The thermostat-controlled temperature of the Guth 34C simulator can exceed the specifications claimed by the manufacturer.
- Digital thermometers are not necessarily any more reliable than mercury in glass thermometers, and may in fact have greater limitations.
- Demonstration of scientific reliability may not be sufficient in a forensic setting; literal compliance with written rules must be checked and complied with.
- The wording of administrative rules is critical regarding the "interpretive compliance" of analytical protocols.
- The language of administrative rules defining test admissibility are best kept to a minimum with technical analytical details reserved for policy and analytical protocol manuals.
- Record keeping and disclosure are critical in all aspects of a forensic breath test program.

Breath Alcohol, Thermometer, Calibration

K18 Detection of Cortisol and Cortisone in Human Hair

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The participant will learn that cortisol and cortisone can be detected and quantified in human hair and that there is evidence for their integration through sweat.

Since the 1960s, corticosteroids have been used by athletes to improve their performances. Their use is restricted in sports. Hair can document chronic abuse and is therefore a complementary matrix to urine for doping control.

The authors have developed a new extraction, purification, and separation technique using liquid chromatography and mass spectrometry for the identification and quantification of two endogenous

corticosteroids: cortisol and cortisone. Forty-five hair samples (17 males, 28 females; age ranging from 2 to 90 year-old) were studied. Hair strands were washed in methylene chloride, the first two centimeters of the strand were cut and pulverized in a ball mill. The powdered hair was incubated in 2mL Soerensen buffer, pH 7.6 for 16 hours at 40°C, in the presence of cortisol-d₃ as an internal standard. Purification of the incubation medium was achieved on SPE C18 Isolute extraction columns followed by an alkaline liquid-liquid extraction with diethylether. The eluate was evaporated to dryness and resuspended in 25µL of acetonitrile/ammonium formate (1:1,v/v). The chromatography was operated on a LC Packings Superba® Nucleosil C18 column using a linear gradient of acetonitrile from 30 to 70% in 10 min. The detector was a Perkin Elmer Sciex API 100 mass spectrometer. The detector's response was linear for cortisol and cortisone concentrations ranging from 1 to 500pg/mg. Extraction recovery at 50pg/mg was 74% for cortisol and 32% for cortisone. Repeatability (CV values) evaluated on 1g homogenized hair and 7pg/mg cortisol was 11% and at 50pg/mg cortisone was 11%. The limit of detection was 1pg/mg and the limit of quantification 5pg/mg. Cortisol concentrations in hair ranged from 5 to 91pg/mg (mean 18 pg/mg). Cortisone concentrations in hair ranged from 6 to 163 pg/mg (mean 68pg/mg). No influence of hair color could be found. Influence of sex on cortisone concentrations seemed possible but could not be statistically demonstrated. Cortisone concentrations in hair are significantly higher before the age of twenty.

Type 2 11β-Hydroxysteroid-dehydrogenase (HSD) converts cortisol to cortisone, whereas Type 1 HSD, which is mainly present in the liver converts cortisone to cortisol. Type 2 HSD is present in cells where mineralocorticoid receptors are present (kidney, sweat, salivary glands, gastro-intestinal tracts). In human epithelia, Type 2 HSD has been located in sweat glands whereas it is absent from sebaceous glands and hair follicles. Also its activity is higher in children, protecting the child's growth against cortisol effects by converting cortisol to cortisone. The results show that cortisone concentrations are higher than cortisol concentrations in hair unlike blood ratio and that cortisone concentrations are significantly higher before the age of 20. It is known that cortisone is less polar than cortisol and therefore one would expect a better incorporation of cortisone than cortisol into hair from bloodstream. But as the blood ratio of cortisol to cortisone is not different between adults and children, the incorporation through bloodstream and the different polarity of cortisone and cortisol cannot explain why cortisone concentrations are significantly higher in children. This suggests a relationship between cortisone concentrations in hair and type 2 HSD. Incorporation of cortisol and cortisone in hair could follow a passive diffusion through sweat after conversion of part of cortisol to cortisone by Type 2 HSD in sweat glands.

Corticosteroids, Hair, Sweat

K19 Distribution of Selegiline Metabolites in Pigmented and Senile White Hairs From Parkinson Patients

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During this presentation the participants will learn about the influence of melanin on the incorporation of methamphetamine and amphetamine, major metabolites of the anti-Parkinson drug selegiline, in human hair. The data is important for the interpretation of forensic hair samples. Distribution of Selegiline metabolites in pigmented and senile white hairs from Parkinson patients. The objective of this study was to investigate drug concentrations in senile white hair and pigmented hair

from the same patient separately. The study was approved by the regional ethics committee of the Faculty of Health Sciences, University of Linköping, Sweden.

Background: Considerable research effort has been directed towards the issue of bias associated with hair color in drugs of abuse testing. One way of studying the potential influence from melanin is to measure drug content in pigmented and non-pigmented hair from the same animal or human subject. Several animal studies have shown that weakly basic drugs such as cocaine, codeine, and amphetamine are preferentially incorporated into pigmented hair rather than non-pigmented hair. Also in studies on people with gray hair have shown that cocaine, haloperidol, and amitriptyline are found in significantly higher concentrations in pigmented hair than in senile white hair. The concentration profile in pigmented hair differs widely, probably because of different melanin content. It was previously shown that incorporation of methamphetamine into human hair depends on melanin content. Studying the distribution of the amphetamines in pigmented and senile white hair from the same individual will improve the means of correctly interpreting drug concentrations in hair.

Experimental: Hair samples were obtained from nine gray-haired patients with Parkinson's disease receiving Selegiline daily for at least three months prior to sampling. Dose, age, gender, hair color, weight, and height of the patients were recorded. Hair samples (triplicates) were obtained from the posterior vertex, and cut with scissors as close to the scalp as possible. The samples were folded in aluminum foil and stored in darkness at room temperature until analyzed. Hair was weighed in a screw-capped glass tube and internal standard was added (2.0 ng of each methamphetamine-d₅, and amphetamine-d₅). One mL of 1 M KOH was added and the hair sample was heated at 80° C for 10 minutes with occasional shaking.

After cooling to room temperature the sample was extracted with 4 mL of iso-octane for 10 minutes, centrifuged at 4200 g for 5 minutes, before the iso-octane was transferred to a clean tube and re-extracted into 0.5 mL 0.1M sulfuric acid. After centrifugation for 5 minutes at 4200 g the iso-octane was aspirated and discarded and 0.5 mL of 1 M KOH was added.

Then 3 mL of iso-octane was added and the sample was extracted for 10 minutes. After a 5 minute centrifugation at 4200 g the iso-octane was transferred to a new 10-mL screw-capped glass tube and 20 µL of MeOH:HCl (99:1 v/v) was added. The sample was mixed and evaporated under a gentle stream of nitrogen at room temperature. When about 30 µL of the iso-octane remained 50 µL of TFAA was added and the tube was capped and heated for 20 minutes at 60°C. After cooling to room temperature the sample was evaporated and reconstituted in 50 µL iso-octane, and transferred to a GC-vial. GC-MS was used for analysis. The ions monitored were m/z 118.0 and m/z 140.0 for amphetamine, m/z 110.0 and m/z 154.0 for methamphetamine, m/z 118.0 and m/z 178.0 for desmethylselegiline. For the internal standards the ions monitored were m/z 144.0, m/z 158.0 for amphetamine-d₅, and methamphetamine-d₅, respectively.

A 13-point calibration curve was performed by addition of the analytes to 20 mg drug-free hair (obtained from a laboratory employee). Calibration levels were at 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 1.0, 2.0, 4.0, 8.0, and 20.0 (ng).

Results: All samples contained both methamphetamine and amphetamine, while in some samples, especially the white portions of hair, desmethylselegiline could not be detected. The concentrations in pigmented hair were significantly higher than in senile white hair (p<0.01 using paired t-test). The mean concentration ratio between pigmented and senile white hair was 3.7 (range 1.8-7.9) for methamphetamine and 2.9 (range 1.8-5.2) for amphetamine. Concentrations ranged from 0.2-3.6 ng/mg for methamphetamine and 0.1-1.4 ng/mg for amphetamine. The mean ratio between amphetamine and methamphetamine was 0.35 (range 0.24-0.60) in pigmented hair with no significant difference from senile white hair (p>0.10).

Discussion: The results of this study show that pigmentation plays a role in the incorporation of methamphetamine and amphetamine into human hair. However, because both drugs could be detected in senile

white hair, pigmentation cannot be the only factor involved. Binding to hair proteins might account for a significant part of the drug accumulation in hair suggesting that individuals with low or no pigmentation are still suitable for hair-drug testing programs. The concentration range for both methamphetamine and amphetamine in the Parkinson patients was of the same order as for people abusing methamphetamine although the metabolite/parent drug ratio was higher in the patients receiving Selegiline. Care is needed to avoid misinterpretation of the results as methamphetamine intake, when analyzing forensic samples. Measuring the specific metabolite desmethylselegiline does not solve this problem because not all samples were positive for this substance.

Hair Analysis, Selegiline, Mass Spectrometry

K20 Detection of Ketamine in Nonhuman Primate Hair

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Participants will learn about: 1) principles of extraction and detection of ketamine (KET) in hair using GC-MS, 2) concentrations of KET in nonhuman primate hair after repeated doses of the drug, and 3) detection of KET in hair of young baboons not exposed to the drug but born from mothers treated with KET.

The general anesthetic ketamine (Ketalar®) used in human and veterinary medicine for induction of anesthesia in short surgical procedures and routine veterinary procedures has been identified as a so-called “date-rape” drug for the purpose of “drugging” unsuspected victims and raping them while under the influence of the drug. Its illicit use by teenagers at rave parties has also been reported. The objective of this study was to determine the feasibility of KET detection in hair collected from hair growing primates treated with the drug once a month for longer periods of time. In addition, several hair samples were collected from three young baboons previously not exposed to KET but born from mothers treated with the drug. The aim of this study was: 1) to develop and validate sensitive EI-GC-MS method for the quantitation of KET in hair, and 2) to determine if nonhuman primate hair can be used as an animal model for detection of KET.

Method: Hair was collected from eight stump-tail macaques (*Macaca arctoides*), four females and one male living together in a social colony, and two females and one male caged individually. The animals in the social colony received KET twice during the six-month period of time (dose range 7-21 mg per animal). The other three monkeys received 10-13 mg of KET once per month during the twelve-month period. In addition, hair samples were collected from three baboons (*Papio anubis*) less than one year old previously not directly exposed to KET. One hair sample was collected prior to injection of a single dose of KET and others were similarly collected 1, 3, 5, 10, and 20 days after treatment.

Extraction: Hair samples (3-50 mg) were extracted using HCL solid phase extraction columns. Standard curve for KET was prepared by spiking aliquots of negative hair. The LOQ for KET was 20 pg/mg. All standard, control and study samples were spiked with deuterated internal standard, D₅ diazepam and sonicated in methanol for 1 h and incubated in 0.1 N HCl (1ml) over night. A solution of 1.93 M acetic acid (1 ml) and deionized water (10 ml) were added. An analytical column was conditioned with methanol (3 ml) deionized water (3 ml) and 1.93 M acetic acid (1 ml), the sample was added and the column was washed with deionized water (3 ml), 0.1 N HCl (1ml) and methanol (3ml). The final

elution from the extraction column was achieved using methylene chloride: isopropanol: ammonia (78:20:2, v/v/v, 3 ml). All extracts were evaporated to dryness in the stream of nitrogen, dissolved in ethyl acetate (35 μ l) and transferred to autosampler vials.

Analytical Procedure: A Hewlett-Packard GC-MS instrument (6890 GC and 5973 MSD) operating in electron ionization (EI) mode was used for the analysis. The column was an HP5-MS. The monitored ions for KET were *m/z* 182 (used for quantitation), 180, and 209, and for D₅ diazepam *m/z* 289.

Results: In general, much lower concentrations of KET in hair were observed in all monkeys from the social colony (737-2,713 pg/mg) than in animals which were receiving KET more frequently (2,869-6,608 pg/mg). In each hair sample collected from young baboons before KET administration, high concentrations of the drug were discovered (2,198-4,500 pg/mg). This strongly suggests *in utero* exposure to KET. No significant differences in KET hair concentrations were observed after a single dose of this drug. KET remained in hair at high concentrations (685-2,435 pg/mg) throughout the 20-day study period.

Date-Rape Drugs, Hair Analysis, Ketamine

K21 Analysis of Drugs From Paired Hair and Urine Samples—Casting a Broader Net of Drug Detection in Pre-Employment Specimens

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During this presentation, the participants will learn about the prevalence of drugs in the hair and urine of job applicants. The participants will also gain an understanding of the different time windows of drug detection in hair and urine and how the pharmacokinetic profile of a particular drug can influence its probability of being detected in urine and/or hair.

Background: The laboratory offers a test for clients in which urine and hair are simultaneously collected from donors for the purpose of drug detection. Urine samples were collected from donors and also hair from the posterior vertex region of the head, as close to the scalp as possible. Hair collected was aligned and the first 3.9cm of hair from the root end, representing an approximate time window of 3 months, was cut and assayed. Drugs detected in urine typically represent the recent past of the potential drug user, within a few days, with the exception of marijuana, which can be present for longer periods in the urine after cessation of use. Drug use in hair represents a much longer time window than urine and a 3-10 day delay may exist before drugs can be detected just above the scalp after entering the hair follicle. Therefore both specimens collected simultaneously, do not reflect the same time window but encompass a broader window than each specimen does alone. By collecting specimens, hair, and urine, the chance of detecting drug should increase. From January 1, 2001 to August 1, 2001, a total of 7,207 paired hair and urine samples were screened for the SAMHSA five (Cocaine, PCP, Amphetamines, Opiates, and Marijuana) drugs of abuse by EMIT for urine and ELISA for hair. Presumptive positives in urine and hair were confirmed by GC/MS or GC/MS/MS.

Experimental: Urine specimens were screened by EMIT utilizing an AU600 Olympus analyzer and Dade Behring reagents for amphetamines, cocaine, barbiturates, marijuana, PCP, opiates, and ethanol. Barbiturate and ethanol results were excluded from the study since they were not assayed in the paired hair sample. If a urine sample screened positive for any of the above drug classes a second aliquot was obtained, extracted by a solid phase extraction or liquid-liquid technique, derivatized (except PCP) and subjected to GC/MS analysis for the appropriate drug(s) and metabolite(s).

Hair specimens aligned in a foil envelope were cut at 3.9 cm from the root end, then further cut into 2-5 mm segments, mixed to ensure homogeneity and 20 mg weighed. The hair was washed with methanol and then placed in hot methanol for 2 hours. The methanol was transferred to a separate tube, evaporated and reconstituted in phosphate buffer. Five separate microtiter plate ELISA assays from International Diagnostic Systems Corp. (IDS) for cocaine, amphetamines, marijuana, opiates, and PCP were used to screen the extracted hair specimens. If positive by ELISA, a second portion of hair from the original 3.9 cm segment was used for confirmation. Cocaine, PCP, amphetamines, and opiates were confirmed by GC/MS and THC and THC-COOH were confirmed by tandem mass spectrometry (GC/MS/MS).

Results: A total of 505 (7.0%) of the 7,207 paired hair and urine samples tested were positive for drugs in both hair and urine, while 723 (10.0%) were positive for drugs in hair only and 329 (4.5%) were positive for drugs in urine only. The total urine positive rate for this population was 11.6% (834), and the total hair positive rate was 17.0% (1,228) with a combined detection rate of 21.6% (1,557). For marijuana, a total of 124 (1.7%) donors were positive in both hair and urine for THC-COOH while 154 (2.1%) were positive in hair only and 93 (1.3%) were positive in urine only. A combined 217 (3.0%) were positive for THC-COOH in urine and 278 (3.8%) were positive in hair. For methamphetamine and/or amphetamine 115 (1.6%) donors were positive in hair and urine and 328 (4.5%) were positive in hair only while only 27 (0.4%) were positive for amphetamines in urine only. Comparing the total urine positive rate to total hair positive rate for amphetamines, 142 (2.0%) donors were positive in urine compared to 443 (6.1%) in hair. For cocaine the most significant difference was seen comparing hair and urine positives. A total of 52 (0.7%) of donors tested positive for cocaine in both hair and urine and only 5 (0.07%) tested positive in urine only while 273 (3.8%) were positive for cocaine in hair only. The overall detection rate in hair for cocaine was 4.5% (325) compared to 0.8% (57) in urine specimens from the same population.

This study shows that the analysis of hair increases the number of specimens which are positive for drugs of abuse, when compared to urinalysis using laboratory established cut-offs for both hair and urine. Furthermore, the combination of both urine and hair provides the greatest chance of detecting drug use. The most dramatic differences were seen with cocaine and methamphetamine positive rates, while the incident of marijuana positives in hair versus urine was considerably less marked. One possible explanation is the pharmacokinetic differences between these drugs. Drugs which have relatively short half-lives (i.e., cocaine) are more likely to go undetected in the urine of a drug user while hair provides a longer history of drug use. Another explanation may be due to the pattern of drug use or the abuse liability of a particular compound. Drugs used in a more regular or chronic fashion would be more readily detected in hair due to accumulation of drug than drug that is used rarely or occasionally.

Paired Hair and Urine, Prevalence, Drug Testing

K22 Relationship Between In Utero Methadone Exposure and Neonatal Outcomes

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The objective is to present information on the relationship between maternal methadone dose and neonatal outcomes in an agonist therapy program for opiate dependent pregnant women.

In utero drug exposure has been associated with a host of negative maternal and fetal outcomes. Currently, the only recommended pharmacotherapy for opiate dependence in pregnant women is methadone, a full μ agonist. It is still a matter of controversy whether maternal methadone dose is correlated to the severity and duration of neonatal abstinence syndrome (NAS). This syndrome is characterized by increased startle reflex, tremors, inability to self-quiet, poor feeding, abnormal sleep patterns, diarrhea, fever, and seizures in the infant. Depending on the severity of NAS, pharmacotherapy intervention may be required. Unlike other studies, this research protocol has documented illicit drug exposure and methadone dosage over an extended gestational period. This study evaluates in utero methadone exposure in pregnant heroin abusers participating in an agonist therapy program and the effects of this treatment on neonatal outcomes. The authors hypothesized that maternal methadone dose would not correlate to birth weight, length, and head circumference, but could influence the severity and duration of NAS.

Eighteen heroin dependent pregnant women were enrolled in an intensive methadone and behavioral modification treatment program at the Center for Addiction and Pregnancy (CAP), between 8 to 28 weeks of gestation and followed throughout their pregnancy. Each participant provided informed consent and submitted to tri-weekly observed urine specimens which were analyzed for cocaine and opiates by EMIT (Dade Behring, San Jose, CA). The mean number of weeks on the study was 20.8 ± 6.2 (SD). Mean fetal age at delivery was 37.9 ± 4.0 (normal gestation 40 weeks) with a range from 26 to 42 weeks. The mean daily methadone dose was 76.4 ± 14.4 mg with a range of 45 – 100 mg/day. Of the 18 women, 44% were positive for hepatitis C, 11% for hepatitis B and 6% for HIV. All women had a history of cocaine and opiate abuse, 78% used nicotine and 17% self-reported using alcohol while pregnant. 39% of the women self-administered cocaine and opiates during gestation as documented by urine test results. Illicit opiates were self-administered by 11% of the women. 22.2% had positive toxicology tests at delivery for opiates, cocaine and/or barbiturates. The mean NAS peak score was 8.8 ± 4.9 (range 3-19) and the mean duration of withdrawal was 8.6 ± 6.7 days (range 3-24). Mean birth weight, length, and head circumference were 2889.2 ± 911.2 g, 46.6 ± 7.2 cm, 32.8 ± 1.9 cm, respectively. There were no significant differences in birth weight, length, and head circumference between methadone exposed and reported normal values for non-exposed babies (Britton, J. Reproductive Medicine, 1993;38:215). No significant correlation was seen between methadone dose and NAS peak or duration. However, there was a correlation between NAS peak score and the duration of NAS symptoms ($r = 0.94$, $p < 0.001$). In this preliminary report of 18 methadone maintained pregnant women, followed for the majority of their gestation, methadone dose did not significantly affect neonatal outcome measures, including physiological parameters, and the severity and duration of NAS.

Methadone, In Utero Opiates, Neonatal Abstinence Syndrome

K23 Stability of Many Prevalent Drugs Found in Postmortem Bloods From Medical Examiner Cases

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This study was designed to measure the stability of certain drugs of abuse in postmortem blood specimens taken from previous medical examiner cases. The objectives were to: 1) examine the preservation of drugs over a ten-year period to measure the rate of change in drug concentration as related to drug stability and whether the stability increases or decreases at a greater rate after five years; and 2) find the optimum storage

time for specimens before the validity of the drug concentration is questioned. As a result of this study, the findings showed that all but two of the twenty-one drugs examined exhibit a good stability in concentration within the initial two years, prior to showing decreases in drug stability. Due to these findings, the optimum storage time for postmortem blood specimens stored under similar conditions should not exceed two years.

Analytical Methods: The drug analysis for this study was performed using the same instrumentation and methods as the initial analysis of the blood specimens, specifically the 5880 Hewlett Packard (HP) gas chromatograph, equipped with dual nitrogen phosphorous detectors, two fused silica columns (DB-5, 15m, 0.25mm i.d., film thickness 0.25um; and a DB-17, 15m, 0.25mm i.d., film thickness 0.15um). Two HP 5880A integrators were used to monitor the signals and an HP 7673A autosampler was used to automate the runs. For the volatile analysis of ethanol, a Perkin-Elmer HS-40 autosampler injected the headspace into a Perkin-Elmer Autosystem gas chromatograph equipped with a 30m x 0.32mm, 1.8um film Restec BAC1 column.

The drugs analyzed were: Benzodiazepines (Diazepam, Nordiazepam, Chlordiazepoxide and Nordiazepam), Cocaine, Opiates (Codeine, Hydrocodone and Oxycodone), Tricyclics Antidepressants (Amitriptyline, Nortriptyline and Imipramine), Doxepin, Nordoxepin, Diphenhydramine, Fluoxetine, Thioridazine, Methadone, Verapamil, Propoxyphene, Norpropoxyphene, Meperidine, and Ethanol. The postmortem blood specimens were stored at 6°C in 20ml glass tubes containing 55mg of sodium fluoride preservative and sealed with rubber stoppers.

Results: Diazepam showed good stability for the first three years with decreases in drug concentration ranging from 7-19%, but poor stability in subsequent years with an average decrease of 33%. Decreases of 44% and 57% were noted at the fourth and fifth year, respectively. Similarly, nordiazepam showed variable stability for the first three years, followed by poor stability for the remaining seven years. Chlordiazepoxide is unstable in stored or decomposed biological specimens; it tends to form in vitro desoxychlordiazepoxide, which further degrades to nordiazepam. Chlordiazepoxide in this study shows poor stability, whereas nordiazepam showed a variable decrease in concentration ranging from 0.2% at year seven to 5% at year ten. Cocaine showed decreases in concentrations of 94% in year one to 98% in year four. This phenomenon is concentration-dependent, lower levels of cocaine were not detected even after one year before reanalysis. These findings are consistent with previous studies¹⁻³ examining the stability in blood of 1.0 mg/L cocaine concentration at 16°C, where a 30% loss occurred after 36 days, and a 7% loss after one day. Codeine showed good stability over the entire course of the study. Hydrocodone showed good stability for the first two years of the study, while a significant decrease of 48% concentration was noted in the eighth year of the study. Oxycodone revealed a variable decrease in concentration over the first eight years reaching a 58% decrease at the ninth year. Amitriptyline demonstrates a variable decrease in concentration over the years, ranging from 17 to 50%. Nortriptyline has a decrease in concentration of 75 to 78% between years five and seven, respectively. Imipramine shows a variable decrease in concentration for all of the years. Doxepin showed a variable decrease in concentration, ranging from 7 to 74% in the ten-year period. Nordoxepin showed decreases in concentrations as high as 73% in the ninth year and 80% in the tenth year. Diphenhydramine is a very stable drug, averaging a decrease of only 15% from one to ten years. Fluoxetine has a good stability for the first two years of the study and variable stability thereafter. Thioridazine shows good stability over the course of the study, with an average decrease in concentration of 11% for the first four years, increasing to 45% by the tenth year. Methadone shows good stability throughout the study. Verapamil reaches the highest decrease in concentration of 42% at year ten, averaging a decrease of 17 to 39% during the previous years. Propoxyphene is more stable for the first six years of the study and shows

a decrease in concentration of 34% for the tenth year. Norpropoxyphene exhibits good stability for the first four years and a decrease in concentration of 60% for the eighth year. Meperidine averages only a 15% decrease in concentration from year one to year ten.

The differences detected in the ethanol analyses were not statistically significant by the student t-test except for the seven year-old specimens ($p=0.04$).

Drug Stability, Gas Chromatography, Postmortem Blood Specimens

K24 Postmortem Tissue Distribution of Olanzapine and Citalopram in an Overdose

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The objective is to determine the tissue distribution of olanzapine and citalopram in an overdose fatality and to contribute to the scientific literature pertaining to the therapeutic and toxic concentration of these drugs.

Olanzapine is a thienobenzodiazepine derivative used as an antipsychotic for the treatment of schizophrenia in the U.S. since 1996. It interacts with dopamine- d_2 and serotonin 5-HT 2A receptors, and antagonizes dopamine- d_1 , d_4 and serotonin 5-HT 2C, 5-HT3, α -1-adrenergic, H1 histaminic and muscarinic receptors. Citalopram is among the newest orally administered selective serotonin reuptake inhibitor antidepressants currently prescribed. Its chemical structure is unlike that of other SSRIs, tricyclic, tetracyclic, or other antidepressants. The mechanism of action of citalopram as an antidepressant is presumed to be linked to the potentiation of serotonin in the central nervous system resulting from its inhibition of CNS neuronal reuptake of serotonin. Olanzapine is dispensed as 2.5, 5, 7.5, and 10 mg tablets for oral administration. The recommended starting daily dose is 5-10 mg in adults, with peak plasma concentrations averaging 5-10 ng/mL after approximately six hours. Citalopram is available as a racemate as 20 and 40 mg tablets. Oral doses of 30-60 mg per day result in serum concentrations of 9-200 ng/mL. To date, little scientific literature exists about the therapeutic concentrations or postmortem tissue distributions of these drugs.

The case of a 40-year-old Caucasian male with a medical diagnosis of paranoid schizophrenia found dead in a group home is presented. No anatomic cause of death was determined at autopsy and multiple biological samples including heart blood, femoral blood, urine, vitreous humor, cerebrospinal fluid, brain, liver, kidney, spleen, lung, bone, heart, and gastric contents were collected. The heart blood and urine were subjected to routine comprehensive toxicological analysis. This testing included volatile analysis by headspace gas chromatography; enzyme immunoassay screening of the urine for amphetamines, benzodiazepines, cannabinoids, cocaine metabolites, opiates, and phencyclidine; acidic/neutral, benzodiazepine, and basic drug screening by GC; opiate screening by modified immunoassay; and acetaminophen, salicylate, and ethchlorvynol screening by colorimetry. Electrolyte analysis was performed on the vitreous humor. Olanzapine and citalopram were the only drugs detected through routine analysis, both at overdose concentrations.

Quantitation of olanzapine and citalopram in biological specimens was performed by GC-NPD. Specimens were diluted when necessary so that the concentrations were within the calibration curve. Liver, lung, brain, spleen, kidney, and heart tissues were homogenized with deionized water (6g + 30 mL deionized water) in a commercial blender. Bone was prepared by soaking whole pieces (1 g) and slivered pieces (1 g total mass) overnight in aliquots of both water and methanol. A basic liquid-liquid extraction with promazine as internal standard was performed, followed by back extraction with sulfuric acid. The acid phase was buffered to pH 9.2 with Tris buffer, re-extracted in hexane:isopropanol (9:1) solvent, evaporated to dryness, and reconstituted in methanol. A stock standard

reference solution of each olanzapine and citalopram (100 mg/L) was prepared in methanol. Calibrators were prepared by spiking drug-free blood with the stock methanolic solution to give concentrations of 0.5, 1.0, 1.5, and 2.0 mg/L for citalopram and 0.1, 0.3, 0.5, 0.8, and 1.0 mg/L for olanzapine. A positive control was prepared at 0.6 mg/L. Olanzapine and citalopram concentrations in the control and specimens were calculated from linear regression of the calibrator responses based on peak-area ratio. The presence of olanzapine and citalopram was confirmed by a combination of GC retention time and full scan electron impact mass spectrometry. The table below presents the drug quantitations for each tissue. As can be seen from the table, citalopram and olanzapine were readily detected in both biological fluids and tissues.

Specimen	Drug Concentrations- mg/L or mg/kg	
	Citalopram concentration	Olanzapine concentration
Heart blood	3.35	1.38
Femoral blood	1.65	1.11
Urine	32.43	60.24
Vitreous humor	0.84	4.47
CSF	0.33	Not detected
Spleen	11.12	2.78
Liver	10.71	6.47
Brain	7.41	2.13
Kidney	7.00	2.39
Heart	4.59	1.72
Lung	49.16	38.36
Gastric contents	56.48	4.47
Bone	3.56	Not detected

The heart blood concentrations of olanzapine and citalopram were several times the reported therapeutic levels. Therefore, the cause of death was ruled acute intoxication by the combined effects of citalopram and olanzapine, and the manner was ruled accidental.

Citalopram, Olanzapine, Postmortem Forensic Toxicology

K25 Distribution of Quetiapine in Postmortem Specimens

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After attending this presentation, the attendee will: (1) understand the pharmacological action of Quetiapine, (2) be able to describe a simple assay for its detection in biological matrices, and (3) possess information regarding drug concentrations in postmortem specimens.

Quetiapine is a second generation antipsychotic medication approved for use in the U.S. in 1997. Preclinical studies have suggested that this dibenzothiazepine is an atypical antipsychotic with many similarities to clozapine. It is structurally related to clozapine and olanzapine. The recommended dose for clinical efficacy is 300-450 mg/day administered in two doses. The pharmacological effect is primarily due to antagonistic binding to serotonergic (5HT₂) and dopaminergic (D₂) receptors. After oral administration, peak plasma concentrations are achieved at 1.5 h with an elimination half life of 6 h. A single oral dose of 75 and 450 mg produced peak serum quetiapine concentrations of 0.14-0.37 mg/L and 0.19-0.63 mg/L, respectively. Steady state plasma concentrations are achieved within two days after the start of dosing. Quetiapine is extensively metabolized, primarily by sulfoxidation and oxidation, to inactive metabolites. The most common clinical effects reported in overdose were hypotension, tachycardia, prolonged QTc, and somnolence due to α -adrenergic and histaminic receptor blockade.

Since this drug has only recently been released on the U.S. market, there is limited published data regarding therapeutic, toxic, and lethal concentrations. Therefore, determination of quetiapine in 4 postmortem cases is reported:

Case #1 A 27-year-old black male found dead at home on the bathroom floor.

Case #2 An 80-year-old white female found dead in bed at a nursing home.

Case #3 A 71-year-old white male found dead at home on the kitchen floor.

Case #4 A 39-year-old black female admitted to hospital after being found unresponsive at home.

Blood and urine specimens were subjected to comprehensive toxicological testing which included volatiles by headspace gas chromatography; acetaminophen, salicylate, and ethchlorvynol screening by colorimetry; acidic/neutral and basic drug screening by liquid-liquid extraction followed by GC-FID or GC-NPD; benzodiazepine screening by GC-ECD; modified opiate immunoassay screening of blood; and immunoassay for amphetamine; cocaine metabolite, cannabinoids, phencyclidine, benzodiazepines, and opiates in urine.

Quetiapine was identified by capillary column (RTx-50) gas chromatography with nitrogen phosphorus detection (Hewlett-Packard [HP] 5890 or 6890) after basic liquid-liquid extraction. Promazine was utilized as the internal standard. Quantitation was achieved by assaying a single point calibrator at 1 mg/L concurrently with case specimens. Specimens were diluted when necessary to produce a relative area similar to the calibrator. Negative and positive (0.5 mg/L) matrix matched control samples were assayed with each run. Confirmation was achieved by full scan electron impact gas chromatography/mass spectrometry using an HP 5973 MSD with a DB-5 capillary column. For cases #1 and #4, tissues were also assayed for quetiapine using a three point calibration curve (0.50, 1.0, and 2.0 mg/L) with a correlation coefficient typically >0.99.

Quetiapine had a relative retention time of 1.59 minute on the RTx-50 column, eluting after the I.S. and after thioridazine but before trazodone. By GC/MS, the base peak of quetiapine was *m/z* 210, with a molecular ion at *m/z* 383 and other prominent ions at *m/z* 144, 239 and 321.

The table below illustrates the quetiapine and other drug concentrations (mg/L) determined in the biological matrices from four postmortem cases with the cause and manner of death:

Case	Heart Blood	Femoral Blood	Other Drugs (ht bld)	Cause	Manner
#1	0.72	0.28	Haloperidol 0.02	Acute Intoxication by quetiapine	Accidental
#2	0.51	-	ND	Atherosclerosis Ankle Fracture	Accidental
#3	0.44	-	Diazepam 0.27 Nordiazepam 0.13 Oxycodone 0.66 Hydroxyzine 0.38 Venlafaxine 2.08 DMVenlafaxine 1.98	Hypertensive ASCVD	Natural
#4	11.20	7.76	Ibuprofen 29.4 Verapamil 1.72 (f)	Acute Intoxication by combined effects of IBU/QT/TCA/V	Suicide

ND= Not detected; -=Specimen not collected; ht bld= heart blood; f= femoral blood.

The heart blood concentrations of quetiapine measured in cases #2 and #3 were within the established therapeutic range for patients prescribed high daily doses of quetiapine. For case #1, the heart blood quetiapine concentration was only slightly elevated compared with published therapeutic levels. However, there were no significant findings at autopsy and empty pill vials were found beside the deceased. This death suggests that quetiapine may exhibit a low therapeutic index. In case #4, the deceased survived for 20 hours in the hospital. Hospital urine drug testing was positive for tricyclic antidepressants. The quetiapine concentration in a hospital serum specimen collected on admission was 5.36 mg/L.

Forensic Toxicology, Antipsychotic, Quetiapine

K26 The Distribution of Gamma-Hydroxybutyric Acid (GHB) in Both Ante and Postmortem Specimens, of a Single Fatality After Long-Term Storage

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The objective is to document GHB concentrations in various specimens collected from a single GHB fatality at four different times of specimen collection and after long-term storage.

Content: A 15-year-old female victim allegedly consumed an unknown amount of a drink laced with a mixture of GHB/GBL on 1/16/99 at approximately 11:30 p.m. She became violently ill and her friends decided to take her to the hospital when she stopped breathing, arriving on 1/17/99 at approximately 5:00 a.m. In the course of her treatment, several specimens were collected from her at three different times. Upon admission to the hospital, five tubes of blood with the following color tops were collected: red, yellow, green, blue, and purple. Also an admission urine specimen was collected. At 11:00 a.m. a spinal fluid specimen was collected and between 12:35 and 12:55 p.m., four more tubes of blood were collected with the following color tops: yellow, green, purple, and gray. At 7:34 p.m. on 1/17/99 she was pronounced dead, having never regained consciousness. The cause of death was GHB intoxication with no other drugs present including ethanol. At autopsy the next day (1/18/99) the following specimens were collected: urine, heart blood, femoral blood, vitreous fluid and bile. All of the specimens were analyzed either soon after the autopsy or after long-term freezer storage. The original specimens analyzed were the 5:00 a.m. red top blood, the hospital urine, the postmortem heart blood, and the postmortem urine. These specimens were sent out to a reference laboratory for analysis on 1/19/99. The remaining specimens were stored in the refrigerator until March 6, 1999, at which time they were moved to the freezer where they remained until July of 2001. At this time the specimens were analyzed in duplicate at the Wayne County Medical Examiner's Office using a modified version of the United Chemical Technologies GHB solid phase extraction method which derivatizes GHB with no conversion to GBL. This method directly measures the GHB di-TMS derivative by EI GC/MS with no conversion to GBL and utilizes d-6 GHB as the internal standard with a specimen size of 200 microliters. The method has a linearity range from 2.5 to 100 mcg/mL, and a recovery between 35% and 60% (specimen type dependent). Variation in concentration between analytical runs of both internal and external controls and specimens was no greater than 15%, n=54. Table 1 shows the results of analysis of the antemortem specimens and Table 2 shows the results for the postmortem specimens.

Table One - Antemortem

Specimen	GHB in mcg/ml	
	original analysis	re-analysis
Red Top Bld 5:00a.m.	510	466
Yellow Top Bld 5:00a.m.	NP	566
Yellow Top Bld 12:55p.m.	NP	187
Green Top Bld 5:00a.m.	NP	QNS
Green Top Bld 12:35p.m.	NP	232
Purple Top Bld 5:00a.m.	NP	QNS
Purple Top Bld 12:55p.m.	NP	242
Blue Top Bld 5:00a.m.	NP	418
Gray Top Bld 12:55p.m.	NP	93
Spinal Fluid 11:00a.m.	NP	220
Urine 5:00m	2300	QNS

NP = test not performed

QNS = quantity not sufficient for analysis

Table Two – Postmortem

Specimen	GHB in mcg/ml		Endogenous GHB in postmortem specimens*
	Original analysis	Re-analysis	
Heart Blood (NaFl)	15	12	1.6 – 36 Average = 12
Femoral Blood	NP	18	1.7 – 48 Average = 11
Urine	150	102	0 – 14 Average = 4.6
Urine at pH = 14 for 30 min.	NP	167	NA
Bile	NP	48	Unknown
Vitreous Humor	NP	127	Less than 10 mcg/ml

*Anderson, D.T., Kuwahara, T., "Endogenous Gamma Hydroxybutyrate (GHB) levels in Postmortem Specimens", Abstract CAT/NWAFS/SWAFS/SAT combined meeting, Las Vegas, Nevada, Nov. 7, 1997.

The concentrations of GHB at the various collection times would indicate a reduced clearance of GHB in a patient who is alive but severely compromised by respiratory and metabolic acidosis (admission blood pH=6.8) from the respiratory depression caused by the high dose of GHB. The lower GHB concentration in the 12:55 p.m. gray top tube blood as compared to the yellow, green, and purple top tubes collected at around the same time cannot be explained at this time. The *apparent* half-life of GHB calculated in narcoleptic patients is 53 +/- 19 minutes for two 3gram doses (Scharf et al., 1998) but this is dose dependent. Even after 14 hours there is still evidence of past GHB ingestion in the postmortem urine and vitreous fluid and perhaps even the bile. More bile specimens should be analyzed to determine a postmortem GHB range in this specimen type. Table 3 has vitreous humor results from two other GHB fatality cases, both of these cases involved deaths with less survival time and no hospitalization with both victims being found dead some 5 to 7 hours after they were last seen alive. Also it is apparent that GHB conversion to the lactone does occur over time especially in a postmortem urine with a low pH such as in this case. The conversion back to GHB was accomplished because any GBL in the urine should have been from GHB excretion. Ingested GBL is rapidly converted enzymatically in the blood and liver to GHB by a lactonase enzyme. The converted GBL is then excreted as GHB. However, due to the pH dependent chemical equilibrium that exists between GHB and GBL, the low pH (4.2) of the postmortem urine would facilitate a shift in the equilibrium over time such that some of the GHB is converted to its lactone GBL. GBL analysis was not performed on any of these specimens.

Table 3 – Two Additional GHB Fatality Cases

Postmortem Specimen Case 1	GHB in mcg/mL	Ethanol in g/dL
Heart Blood	66	ND
Femoral Blood	77	ND
Vitreous Humor	85	ND
Urine	1260	ND
Postmortem Specimen Case 2		
Blood	400	.22
Vitreous Humor	212	.12

Specimen Storage, GHB Distribution, Ante and Postmortem Specimens

K27 Zolpidem Intoxication

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The participant will learn the tissue distribution of zolpidem in three cases.

Zolpidem (Ambien®) is a hypnotic agent. Case histories and toxicological findings from three zolpidem intoxication cases are

presented. In the first case, a 31-year-old white female was found unresponsive in her bed. A suicide note and two empty medication bottles labeled as Ambien® and Benadryl were found at the scene. In the second case, a 49-year-old white male was hospitalized due to an overdose and died nearly two days later. In the third case, a 35-year-old female was found unresponsive in her bed. Ambien® and other medication bottles were found at the scene. She had a previous suicide attempt.

Zolpidem was detected in postmortem specimens using screening procedure for basic drugs. Two milliliters (2 mL) of blood were extracted with 10 mL of hexane-ethyl acetate (1:1) at pH 10 using 100 μ L of 20 mg/L trifluoperazine as an internal standard. After back extraction with 2 mL of 1N sulfuric acid, and re-extraction with 6 mL of hexane-ethyl acetate (1:1) at pH 10, the residue was reconstituted with 50 μ L of ethyl acetate and analyzed by dual column GC/NPD. One 10m x 0.53mm HP-5 column and one 10m x 0.53mm HP-17 column were used. The retention times of zolpidem and the internal standard, trifluoperazine, on the HP-5 column were 8.23 min and 7.37 min, respectively. The retention times of zolpidem and the internal standard, trifluoperazine, on the HP-17 column were 12.4 min and 7.81 min, respectively. Zolpidem was quantified by GC/NPD. The presence of zolpidem was confirmed by full spectrum GC/MS. The base peak and the molecular ion peak of zolpidem were m/z 235 and m/z 307, respectively. Some of the other characteristic ions were m/z 72, m/z 92, m/z 115, and m/z 219.

The tissue distribution of zolpidem for the first case was as follows: blood 44.5 mg/L and liver 81.2 mg/kg. The first case also had the following in blood: diphenhydramine 34.6 mg/L and ethanol 83 mg/dL. The cause of death for the first case was zolpidem and diphenhydramine intoxication. Suicide was listed as the manner of death.

The tissue distribution of zolpidem for the second case was as follows: pleural fluid 0.13 mg/L and liver 0.27 mg/kg. The second case also had the following in pleural fluid: verapamil 6.18 mg/L, propranolol 1.03 mg/L, amitriptyline 0.53 mg/L, meprobamate 3.83 mg/L papaverine 0.10 mg/L and nordiazepam 0.17 mg/L. The cause of death for the second case was multiple drug intoxication, and the manner of death was suicide.

The tissue distribution of zolpidem for the third case was as follows: blood 0.39 mg/L and liver 1.49 mg/kg. The third case also had the following in blood: temazepam 1.20 mg/L and sertraline 0.25 mg/L. The cause of death for the third case was sertraline, temazepam, and zolpidem intoxication, and the manner of death was suicide.

According to Baselt, two adults who die following acute overdose with zolpidem and ethanol had postmortem blood concentrations of 0.8-0.9 mg/L for zolpidem and 240-250 mg/dL for ethanol (Khodasevitch; Deveaux et al.). Two women who died after acute overdosage with zolpidem as a sole agent had postmortem heart blood concentrations of 4.3 mg/L and 7.9 mg/L (Baselt; Lichtenwalner and Tully). The first case had a postmortem blood concentration of 44.5 mg/L of zolpidem.

Zolpidem, Toxicology, Ambien

K28 Medications, Strange Intoxications, and Violent Crime: Psychiatric, Toxicology, and Legal Considerations

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The proliferation of newer psychotropic drugs has been accompanied by criminal defenses attributing blame to these medicines for violent and other crimes. These cases were popularized by early suggestions that the antidepressant Prozac might increase the likelihood of suicide. Criminal and civil complaints invoking medicine-induced crime inspired

consideration of other psychotropic and other prescriptions that might also be raised as contributing factors to crime. The lecture begins with a forensic psychiatrist-psycho-pharmacologist's review of cases in which drugs have been implicated, successes and failures.

This program explores the role medicines – psychotropic and others – may play in violent behavior. The presenting psychiatrist reviews potentials of single medicines, drug interactions, and idiosyncratic intoxication, separating myths and facts based on case reports and available literature. The problem of drug reporting is also raised.

Violent crimes have also been reported in individuals who were using newer man-made drugs, such as flunitrazepam, crystal methamphetamine, and gamma hydroxybutyrate. In that regard, the courts' sophistication about the influence of designer drugs has lagged published reports about their effects. The presenting toxicologist review case reports linking intoxication with these newer agents with violence, and the nature of the associated behavior.

Next, a toxicologist lab director presents the program the relationship, metabolically, of legal and illicit drugs to violent crime. This includes research findings from the literature about when individuals under the influence would be expected to erupt in violence, and special considerations at the level of the laboratory for assessing the drug-violence link.

Detection of drugs and medicines, and their relationship to the instant offense, also challenges the forensic scientist. Techniques and standards for the laboratory measurement and analysis of suspected drug or medicine influenced cases is reviewed.

Finally, the forensic psychiatrist presenter offers guidelines for forensic psychiatrists who are charged with assessing possible medication-related criminal cases. In addition, strategies for approaching and assessing such cases – from the both the defense and prosecuting attorney's perspective – are presented.

A legal perspective is also included in the program; a prosecutor discusses the dilemmas of charging offenses that may be drug mediated in a climate of alternatives to incarceration and prison overcrowding. Participants gain insight into decision-making that distinguishes how such cases are handled and disposed of in such serious cases, such that they better recognize the history and findings to which a prosecutor of judge might be especially sensitive or responsive.

Toxicology, Forensic Psychiatry, Criminal Law

K29 Fentanyl Related Deaths on the Rise in North Carolina

Kenneth S. Snell, MD, Ruth E. Winecker, PhD, and Jeri D. Roper-Miller, PhD, Office of the Chief Medical Examiner, Chapel Hill, NC*

After observing this presentation, the participant should have an understanding of the increased incidence of fentanyl related deaths, especially in the State of North Carolina.

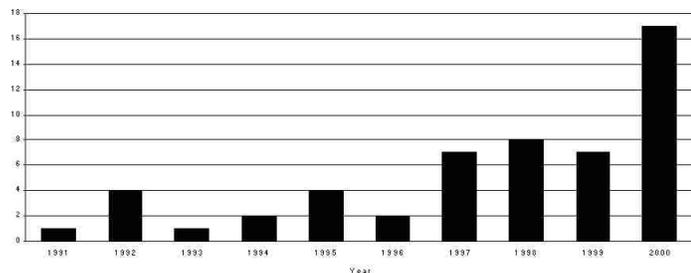
Fentanyl is a synthetic narcotic analgesic that has dramatically increased in medical use since 1990. The increase in medical use, in part, is directly related to the fact that in 1990, fentanyl was released in a transdermal patch form, Duragesic®. A recent report documented that the increase in medical use contrasted to a decrease in abuse during the six-year period from 1990. At the North Carolina Office of Chief Medical Examiner (NC-OCME), an increase in the number of fentanyl positive results the last few years was noted. Therefore, all fentanyl positive results in the State of North Carolina from 1991 to 2000 were retrospectively reviewed to determine if there was an increase in the number of fentanyl-related deaths.

Methods of analysis: Testing for fentanyl is not an automatic screen in the authors' laboratory. Instead, assignment of a fentanyl screen is determined by case history and autopsy findings or may later be assigned

if there is no anatomic cause of death and routine toxicology is negative. Specimens were screened utilizing either RIA (1990-1999) or ELISA (1999-present) with a 1 ng/mL cutoff. Prior to changing immunoassay methodology, a parallel validation study analyzing actual specimens was performed to compare sensitivities and specificity. Quantification and confirmation analyses were performed by first isolating fentanyl by basic extraction of a 1-5 mL (g) specimen. Underivatized specimens were analyzed by gas chromatography/mass spectrometry (GC/MS) utilizing selective ion monitoring and a four-point calibration curve with a linear range of 0.005 to 0.10 mg/L. Quantification of fentanyl (245, 146, and 189) was based on the ion ratios of integrated ion peak-areas compared to one of two internal standards, fentanyl-d5 (250, 151, 194) or codeine (299, 229, 162).

Study design and results: A total of 71 fentanyl positive deaths were identified by NC-OCME for the 10-year period. Eighteen of the cases were rejected on the bases of non-drug related causes of death. The non-drug related causes of death include homicides, surgical, and natural deaths with therapeutic fentanyl levels. The average number of medical examiner cases per year during the study period was 8609, standard deviation of 206. The number of fentanyl related deaths averaged two cases per year for the first six years of the study (see figure). During this period, the fentanyl blood levels ranged from 0.007 to 0.044 mg/L. From 1997 to 1999, the average number of cases increased to seven per year, a three-fold increase over the previous six years. During this period, the fentanyl blood levels ranged from 0.002 to 0.055 mg/L. In 2000, the number of fentanyl-related deaths increased to 17 cases. This represents a two-fold increase over the previous three years and an eight-fold increase over the first six years of the study. In 2000, the fentanyl blood levels ranged from 0.004 to 0.077 mg/L, which included the highest fentanyl level reported in the study. Liver fentanyl levels during the study period ranged from 0.01 to 0.31 mg/kg. Of the 53 accepted fentanyl positive deaths, 27 of the cases had additional drugs detected on toxicological evaluation. The fentanyl blood level in these 27 cases ranged from 0.002 to 0.022 mg/L. It should be noted that in only 10 of the 27 cases were the additional drugs determined to be of significance by the medical examiner and/or forensic pathologist. In these 10 cases, the fentanyl blood level ranged from 0.008 to 0.027 mg/L. The most common manner of death in the reviewed cases was accidental. White males were the most common decedent with whites representing 92% of the cases and males representing 64% of the cases. Two case studies will be presented: a case of a 44-year-old white male who died from the abuse of Duragesic® patches and a case of a 27-year-old white male who died from the accidental misuse of a prescribed Duragesic® patch.

Number of Fentanyl Fatalities



Conclusions: This study indicates that fentanyl use and subsequent fentanyl-related deaths in the State of North Carolina has dramatically increased over a four-year period since 1996. In contrast with previous reports, the data indicate that while medical use of Duragesic® patches increased, fentanyl related deaths from abuse/misuse either remained stable or increased over the ten-year time period of our study, instead of declining.

Fentanyl, Duragesic®, Medical Use

K30 Driving Under the Influence of Methadone—Experiences From Berne, Switzerland

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Practical cases and an overview showing the problems associated with driving under the influence (DUI) of methadone, focusing on drivers treated in a medical substitution program, are presented. Methadone alone is not regarded as impairing coordination and alertness sufficiently to compromise driving. However, the data show multiple drug abuse in these drivers, 35% of those showing such patterns of abuse being involved in severe road accidents. Since multiple drug abuse in some methadone recipients is clearly occurring, is compromising driving, and is a public health risk, this must be addressed in any new law on DUI.

Current laws on DUI are inconsistent. Consistency and improvement are recommended. An analysis of practical cases from the view of a forensic toxicologist is necessary for gathering data that can serve as a practical basis for the regulatory decisions of federal authorities. Furthermore, these results may serve as an additional element in preparing practically applicable future law for the protection of driver and traffic safety.

Currently, based on a "Methadone Report" of the Swiss National Bureau of Public Health 1995, driving under the influence of methadone is regarded as not affecting the capability to drive a car, if certain conditions are fulfilled. These are: 1) methadone must be prescribed for at least six months by a physician and the personality of the patient must be judged as stabilized, 2) methadone is administered orally on a daily basis (maximum dose 120 mg/day), 3) the consumption of alcohol and other psychotropic substances is "forbidden," and 4) the assumption is that all methadone recipients consume no other psychotropics. The data show that this is not the case.

Driving under the influence of alcohol results in withdrawal of the driver's license for a period of several weeks to several months. In cases of chronic alcoholism and repeated offenses the driver's license is withdrawn permanently, until abstinence from alcohol is proven and a psychiatric evaluation and psychological tests indicate full recovery and driving capability. However, this is currently not the case in cases associated with driving under the influence (DUI) of methadone. There is no obligation to report a person on methadone substitution therapy to the legal or administrative authorities due to medical confidentiality. Furthermore, there is no obligation to report the additional use or misuse of drugs such as neuroleptics, antiepileptics or licit or illicit psychotropic substances, even if such use or misuse is recognized by the physician. Currently, driving under the influence of methadone and additional prescribed medicines or illicit drugs usually results in a rather short withdrawal of the driver's license. An existing law (drug-dependent persons are not allowed to drive) is often not applied to persons driving under the influence of methadone due to the lack of facts and experience with problems associated with such driving.

A population of 941,000 were analyzed retrospectively. The eligible drivers (age group 20–64) consisted of 580,000 people, from which 2,042 were currently known to be in a methadone substitution program (paid by public health agencies or medical insurances). From these, an unknown percentage are permanently driving.

The number of the cases of "driving under the influence of alcohol" resulting in withdrawal of the driver's license is rather constant in the last years (1997-2000: 2,200 cases/year). Also the known number of DUI on methadone remained rather constant (1997-2000: 45 cases/year). However, the situation of DUI of alcohol in combination with cannabis or DUI of cannabis alone changed dramatically in the last years due to the availability of cannabis and its widely tolerated consumption. Typically, urine tests, which are positive for only one drug, reveal THC-metabolites.

Importantly, in contrast, urine tests of DUI of methadone cases revealed the abuse of a variety of prescribed and/or illicit drugs, also in

combination with alcohol. From 1997-2000, 166 DUI cases of patients in a methadone substitution program, who underwent a routine police control or were stopped by the police after a violation of traffic rules or a traffic accident were retrospectively analyzed. Only 6 of 166 patients revealed methadone as the only detectable psychotropic substance. Therefore 160 patients in a methadone substitution program revealed the abuse of multiple substances, sometimes in combination with alcohol. Of these, 35% resulted in severe traffic accidents. This clearly demonstrates that multiple drug ingestion is occurring in patients on methadone substitution programs and this is contributing to driving risk.

The authors support the authorities in protecting those individuals in these programs who genuinely wish to abstain from drugs and ingest only methadone, whilst penalising polydrug abusers who drive and pose a risk to themselves and others. The authors strongly recommend the application of systematic, random screening tests for patients in substitution programs, to detect multiple drug use, enforce the obligation to report such patients to administrative or federal authorities due to the potential hazard for other people, and to create regulations or laws on a federal level to withdraw the driver's license permanently from these polydrug abusers until drug abstinence, recovery, and full driving capability has been proven. Hair analysis has been used effectively in other countries.

Methadone, Drugs and Driving, Traffic Safety

K31 New Studies on the Pharmacokinetics of Ethanol

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Those attending this presentation will learn about the absorption, distribution, metabolism and excretion, of man's favorite drug - ethyl alcohol. Results of new experiments on the disposition kinetics of ethanol in arterial and venous blood will be presented as well as studies on absorption kinetics of ethanol in patients operated on for gastric bypass. These topics have importance in forensic science because impairment of a person's performance and behavior after drinking alcohol is linked to speed of absorption and the concentration in arterial blood reaching the brain.

Background: Ethanol is a major drug of abuse and the blood-ethanol concentration (BAC) reached after drinking has important ramifications in clinical and legal medicine. Threshold limits of blood-ethanol concentration exist for driving a motor vehicle, such as 0.05 g/100 mL or 0.08 g/100 mL, which apply in most countries. Accordingly, variability in the rates and extent of absorption, distribution and elimination of ethanol are much discussed and debated during the prosecution of drinking drivers.

Arterial-venous differences: The pharmacokinetics of ethanol were determined in venous (V) and arterial (A) blood in healthy men (n = 9) and women (n = 6). They drank ethanol (0.60 g/kg) on an empty stomach and parameters representing absorption, distribution, and elimination processes were calculated for blood samples obtained through indwelling catheters in radial artery and cubital vein on the same arm. The specimens were taken every 10-15 min for up to 6-7 h post-dosing. Ethanol was determined by headspace gas chromatography. The peak concentration of ethanol in arterial blood was 0.103 g/100 mL (SD 0.022) compared with 0.092 g/100 mL (SD 0.021) in venous blood (p<0.05). The mean ascending rate of change in ABAC was 0.171 g/100 mL/h, being faster than 0.138 g/100 mL/h for VBAC (p<0.05). The C_{max} for ethanol occurred 5 min earlier in arterial blood than venous blood. The maximum A-V difference in concentration of ethanol occurred 10 min after drinking ended [0.019 g/100 mL (SD 0.0107)], decreasing thereafter as absorption progressed. Between 90-110 min post-dosing, the A-V ethanol difference was zero and at all later times VBAC always exceeded ABAC by 0.0 to 0.01 g/100 mL. The rate of

ethanol disappearance from A-blood (k_e) was 0.013 g/100 mL/h (SD 0.0021) compared with 0.012 g/100 mL/h (SD 0.0022) in V- blood (p<0.05). The ABAC always reached zero before VBAC (410 min, SD 43) compared with 436 min (SD 47). The distribution of ethanol in the body as reflected in AUC, volume of distribution, and C₀ were not significantly different for the A and V sampling sites. Arterial-venous differences in ethanol concentration reflect the uptake of ethanol into tissue water during the loading phase and extraction from tissue water as ethanol is cleared from A-blood during the post-absorptive phase.

Gastric bypass patients: The absorption, distribution, and elimination kinetics of ethanol were studied in 12 healthy women who had undergone gastric bypass surgery for morbid obesity at least three years earlier. As a control group 12 other women closely matched in terms of age and body mass index (BMI) served as controls. All subjects received the same dose of ethanol (0.30 g/kg) mixed with orange juice (20 % v/v). This drink was consumed in 5 min on an empty stomach. Specimens of venous blood were taken from an indwelling catheter before and at 10 min intervals for up to 3½ hours post-dosing. In gastric bypass patients, the peak blood-ethanol concentration was higher (0.074 ± 0.021 g/100 mL vs 0.058 ± 0.011 g/100 mL) with a marked overshoot peak amounting to 62.1% compared with 29.6% in the non-operated control group (p<0.05). The peak blood-alcohol concentration was reached 30 min sooner in the gastric bypass women. Beyond 45 minutes post-drinking, blood-alcohol concentration was not significantly different in the two groups (p>0.05). The rate of alcohol disappearance from blood was the same in operated and control groups (0.014 g/100 mL/h) although the curves reached zero BAC earlier in bypass patients (211 ± 34 min) compared with controls (227 ± 10 min). The distribution volumes of ethanol were 0.616 ± 0.10 L/kg vs 0.592 ± 0.087 L/kg, in operated and control groups, respectively. The more pronounced feelings of inebriation in gastric bypass patients who consume alcohol can be explained by a transient, but more rapid absorption, of ethanol from the gut.

Short-term fluctuations in blood- and breath-ethanol concentration: Concentration-time profiles of ethanol were determined in venous whole blood and end-expired breath after taking a large number of successive specimens at short intervals. Moderate doses of ethanol (0.3-0.4 g/kg) were administered either orally or intravenously to healthy volunteers. Specimens of venous whole blood were taken from an indwelling catheter at 5-min intervals post-dosing for two hours and then every 10 min for an additional two hours. Ethanol was determined in blood samples by highly reliable method based on headspace gas chromatography having an analytical precision (coefficient of variation, CV) of less than 1%. The concentration of ethanol in breath was determined with the aid of a quantitative infrared analyzer (Datamaster) immediately after blood samples were taken. The analytical precision (CV) of the breath-analyzer was about 2%. When alcohol was taken orally, there was a tendency towards zig-zag BAC profiles during the first one hour after drinking corresponding to the absorption phase. This observation probably reflects intermittent gastric emptying. However, sporadic fluctuations in BAC and BrAC did not exceed more than 0.005 g/100 mL. No evidence was found for major oscillations in BAC or BrAC profiles during the post-peak phase. During this post-absorptive period, the average scatter of data points (residual SD) was ±2% for BAC profiles and ±4% for the corresponding BrAC profiles. The means that the magnitude of differences in replicate measurements with 95% probability (2 × SD) are ± 4% and ± 8% for BAC and BrAC, respectively, and this includes both analytical and biological sources of variation.

Conclusions: The results of these new studies conducted under controlled conditions show the importance of blood sampling site (artery vs. vein) for the underlying pharmacokinetic parameters of ethanol, being especially evident during the absorption phase. In gastric bypass patients the lack of a functioning pyloric sphincter caused more rapid absorption of ethanol into the blood and exaggerated feelings of inebriation, albeit for a short time post-dosing. The existence of marked

short-term oscillations in the time course of blood-and breath-alcohol profiles when successive samples are taken a 5-min interval could not be confirmed.

Alcohol, Pharmacokinetics, Toxicology

K32 Blockade of Physiological and Subjective Effects of Smoked Marijuana by the First CB1-Selective Cannabinoid Receptor Antagonist SR141716

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The objective is to report results of the antagonism of marijuana smoking by the first cannabinoid receptor antagonist, SR141716. New advances in understanding the important role of the endocannabinoid system in cognitive processes, motor control, and appetite will be presented.

Delta-9-tetrahydrocannabinol (THC), the primary psychoactive component of marijuana, produces behavioral, cardiovascular, analgesic, psychomotor, and cognitive effects that are mediated through the cannabinoid CB1 receptor, a G-protein linked receptor, located primarily in the central and peripheral nervous system. A second cannabinoid receptor subtype (CB2) appears to be concentrated in the peripheral immune system. The identification of specific cannabinoid receptors has led to the discovery of endogenous cannabinoid agonists, including the arachidonic acid derivatives anandamide and 2-arachidonoylglycerol. SR141716, a recently developed CB1-cannabinoid receptor antagonist, blocks acute effects of THC and other CB1 cannabinoid agonists in vitro and in animals and precipitates withdrawal signs in animals treated chronically with THC. These findings suggest that CB1 receptors mediate many of the effects of marijuana, but this has not been evaluated in humans.

Sixty-three healthy males (mean [SD] age 27.7 [5.4] years, 70% African-American, 10.3 [5.9] years of lifetime marijuana use, 15.3 [10.2] days of marijuana use in the prior month) participated in the research study. Their health status was evaluated by medical history, physical examination, blood chemistries, complete blood count, urinalysis, viral antibody screening (hepatitis B, hepatitis C, HIV), TB skin testing (with chest X-ray as clinically indicated), electrocardiogram, EEG, pulmonary function tests, clinical psychiatric interview, and standard psychological tests. To avoid the possibility of precipitating marijuana withdrawal, SR141716 was not administered until urine cannabinoid concentration was below 20 ng/mL (EMIT II Cannabinoid 20 ng Assay, Behring Diagnostics, Inc., Cupertino, CA). The study was approved by the NIDA Institutional Review Board. All subjects gave written informed consent and were paid for their participation. Subjects were randomly assigned to receive a single oral dose of SR141716 or placebo double blind in an escalating dose (1, 3, 10, 30, 90 mg) design. An active (2.64 % THC) or placebo marijuana cigarette was smoked two hours after oral SR141716. Subjects' subjective response to marijuana was assessed before and after SR141716 and marijuana administration using 100-mm visual analog scales (VAS) and the marijuana subscale of the Addiction Research Center Inventory (M-scale). Heart rate and blood pressure were measured prior to, during, and after SR141716 and marijuana administration.

Marijuana smoking produced the expected cardiovascular effect of tachycardia. There was a significant orthogonal polynomial linear trend for SR141716 dose-dependent blockade of marijuana-induced tachycardia. The 90-mg SR141716 dose reduced tachycardia by 59% and reduced symptomatic episodes of hypotension to 0% of marijuana-smoking sessions (vs. 20% incidence on placebo SR141716). Marijuana produced expected psychological responses reflecting intoxication. The 90 mg dose of SR141716 produced significant (38 to 43% reductions) dose-dependent blockade of marijuana effects (as compared to placebo SR141716) on composite VAS ($t=2.23$, $df=47$, $P=0.03$) and individual VAS ($t=2.49$, $df=47$, $P=0.02$; $t=1.97$, $df=47$, $P=0.05$; and $t=2.37$, $df=47$, $P=0.02$ for "How high do you feel now?," "How stoned on marijuana are you now?," and "How strong is the drug effect you feel now?," respectively) and produced a trend (a 75% reduction) toward reduced M scale peak effects ($t=1.97$, $df=47$, $P=0.06$). Orthogonal polynomial trend tests indicated a significant linear trend for SR141716 dose on composite VAS ($F_{1,47}=5.59$, $P=.02$) and M scale ($F_{1,47}=6.22$, $P=.02$). SR141716 alone produced no significant effect on heart rate or blood pressure or psychological effects and did not affect peak THC plasma concentration or area under the time X concentration curve. SR141716 was well tolerated by all subjects. No subject left the study because of adverse events related to SR141716. There was no difference in frequency of occurrence of adverse events between the 43 subjects receiving active SR141716 and the 20 subjects receiving placebo SR141716. These findings show a direct pharmacodynamic blockade of smoked marijuana effects by SR141716, with no evidence of pharmacokinetic interaction. They confirm for the first time the essential role of CB1 receptors in mediating the cardiovascular and subjective effects of smoked marijuana in humans. SR141716 was well tolerated, suggesting it may be a useful tool for studying the function of the endogenous cannabinoid system in humans.

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Marijuana, Cannabinoid Receptor, Antagonist, SR 141716

K33 Evaluation of a Solid Phase Extraction Method for BZE Urinalysis in a High Throughput Forensic Drug Testing Laboratory

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Attending this presentation, the participant will learn technical details of a novel urinalysis procedure for benzoylecgonine. The results of a validation and advantages of the method will be discussed.

Although cocaine use has been steady or declining in recent years, the international trafficking network remains intact and has thwarted numerous attempts to limit importation (1). Adding to the threat, cocaine is sold on the street at lower cost and higher purity despite the coordinated efforts of law enforcement. Consistent with these trends, cocaine use has been a constant concern for the United States Navy. In 1980, the Department of Defense (DoD) established a zero-tolerance drug policy to deter the use of illicit drugs. The program has been very successful, and currently, the U.S. Navy tests approximately 1.6 million urine samples per year. To meet the high sample volume, a novel extraction and derivitization procedure for a major cocaine metabolite, benzoylecgonine (BZE), was developed and evaluated for use in a high-volume forensic urinalysis laboratory.

Urine specimens were spiked with the internal standard ($^2\text{H}_8$ Benzoylcegonine) and extracted utilizing a Speedisk 48 positive pressure extraction manifold and polymer based cation exchange extraction column. Samples were derivitized by the addition of pentafluoropropionic anhydride (PFPA) and pentafluoropropanol (PFPOH) (2). All confirmation testing was performed by Gas Chromatography/Mass Spectrometry (GC/MS) in the single-ion monitoring mode (SIM); ions included m/z 421, 300, 272, 429, 303 with m/z 421/429 used for quantitation.

The validation protocol included the determination of sensitivity and linearity, an interference study, and statistical analysis. Sensitivity and linear range were established utilizing twenty samples spiked at the cutoff concentration of 100 ng/ml and thirteen concentration levels ranging from 12.5 to 20,000 ng/ml. The limit of detection was determined to be 12.5 ng/ml; the limit of quantitation was at 12.5 ng/ml, and the assay was linear from 12.5 to 20,000 ng/ml with an r^2 of 0.99932 ($F=38319$, $df=27$). Excellent correlation between measured and expected results was observed over a wide range of concentrations. The interference study consisting of a series of 100 ng/mL control samples spiked with 74 common medications demonstrated no significant chemical interferences.

The method was further validated by comparison to the analytical procedure currently employed by the laboratory for the reporting of positive cocaine urinalysis results. Specifically, a set of 79 archived samples, previously reported positive for BZE, were extracted, analyzed, and compared to the previously reported quantitations. In addition, aliquots of seventeen of the 79 samples were assayed independently at the Navy Drug Testing Laboratories in San Diego CA, and Great Lakes IL. Results between the three laboratories and prior quantitations were analyzed by one-way ANOVA. The BZE results were not significantly different between laboratories nor were they significantly different from the prior quantitations ($F=0.05309$, $P=0.99463$).

The new assay is reproducible in comparison to previous methods used in our laboratory. Since implementation, the new procedure has been pivotal in improving laboratory efficiency, and a significant improvement in turn-around-time has been observed. The procedure will provide a reliable and efficient procedure for BZE urinalysis.

1. P. L. Clawson and R. W. Lee. *The Andean Cocaine Industry*. St. Martin's Press, New York, New York (1996).

2. D. R. Knapp. *Handbook of Analytical Derivatization Reactions*. John Wiley and Sons, New York. (1979).

Urinalysis, Solid Phase Extraction, Cocaine

LW1 The Resurrection Man: Has He Too Been Resurrected?

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The goals of this research project are to learn the details of the study of skeletal and other remains during remodeling of the Old Medical College of Georgia, and about life at the College in the mid- to late 1800s.

Most people have heard about grave robbers in England who acquired corpses for the purpose of medical education. But right here in Georgia, in the mid-19th century, the Medical College of Georgia in Augusta was home to Grandison Harris, the so-called "Resurrection Man." Harris, a slave purchased in Charleston by the MCG medical school faculty, served the faculty as an upper class slave; and, in addition to serving as a "porter," another one of his duties was the procurement of corpses from local graves for purpose of medical school dissection and study.

In 1989, a construction crew renovating the Old Medical College in Augusta discovered skeletal and other relics within the earth of the basement. Ultimately, bones from hundreds of bodies were found along with other relics which allow some reconstruction of 19th century life at the college. A multi-disciplinary study was undertaken to learn as much from the find as possible.

One of Grandison Harris' favorite sites for cadaver procurement was Cedar Grove Cemetery. This cemetery contained the remains of many black individuals, and analysis of remains found at the college showed an over-representation of skeletons from black individuals. In fact, an outgrowth of the study was a book edited by Robert Blakely and Judith Harrington entitled *Bones in the Basement: Postmortem Racism in Nineteenth-Century Medical Training* (Smithsonian Institution Press, 1997).

Citizens of Augusta new of Grandison's "occupation." Most of them did not look favorably upon it, although, he was admired by those at the medical college as an assistant and teacher. When he died at age 95 in 1911, the "Resurrection Man" was, ironically, and against his own wishes, buried in Cedar Grove Cemetery—the same place where he had engaged in much of his nocturnal "work." Was Grandison Harris a victim of post-mortem "payback?" Are his remains still within the earth at Cedar Grove Cemetery? The whereabouts of his remains are not currently known because a 1929 flood washed away the burial location records that existed. There are records that Harris was buried there, however.

This presentation will include a discussion of Grandison Harris and a brief summary of the information gained by the study of the anthropological and other evidence found in the medical college basement. Others are now conducting a study called the "Cedar Grove Project" in which the sites of graves and other characteristics are being mapped. If the remains of Grandison Harris are located, you will be provided with an update. As of June 2001, the gravesite had not been identified. The presenter wishes to emphasize that he had absolutely nothing to do with the analyses and studies of the Old Medical College site or Cedar Grove Cemetery. The work of the many professionals involved deserves recognition and acknowledgement. The details presented here grew out of personal interest in the story and are based on books, newspaper accounts, conversations with parties involved in the various studies, and personal visits to Cedar Grove Cemetery.

Anthropology, Grave Robbing, Historical Remains

LW2 An American Atheist at Rest: The Abduction, Murder, Recovery, and Identification of Madalyn Murray O'Hair

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The goals of this research project are to demonstrate the importance of multidisciplinary collaboration in skeletal recovery and identification cases.

This case study describes the mysterious disappearance of Madalyn Murray O'Hair, America's most well-known atheist, along with her son and granddaughter, in August 1995. The final chapter of her story concluded January 27, 2001 with the discovery of her skeletalized remains in a mass grave on a remote Texas ranch. The objective of the presentation is to demonstrate the importance of multidisciplinary collaboration in skeletal recovery and identification cases.

In August 1995, American atheist leader Madalyn Murray O'Hair, her son Jon Garth Murray, and granddaughter Robin Murray O'Hair were reported missing from their home in Austin, Texas. Madalyn Murray O'Hair, America's most well-known atheist, was responsible for the landmark and controversial 1963 lawsuit resulting in the banning of bible reading and prayer in public schools. Since that time, O'Hair founded several organizations devoted to atheist philosophy. She garnered many enemies as a result of her activism and was said to have considered herself the most hated woman in America.

At the time of her disappearance, O'Hair was 76 and of poor health, suffering from severe osteoarthritis, diabetes, and heart disease. Several scenarios were proffered to explain her whereabouts, including living comfortably in New Zealand after embezzling \$600,000 from her own organizations, moving away so that she could die in a place where Christians could not pray over her, and foul play at the hand of one of the many enemies she had acquired. The last time that any of the three O'Hair members was seen occurred in September 1995 when Jon Murray took receipt of \$600,000 dollars in gold coins from one of O'Hair's organizations.

Investigations of the O'Hair family disappearance centered upon the missing money, which finally led to Gary Paul Karr and subsequently David Roland Waters and Danny Fry. Karr and Waters were charged with extortion. The body of Fry, missing his head and hands, was found in Dallas shortly after the O'Hair family disappearance in 1995. On the eve of his trial, Water's struck a deal with prosecutors that included his leading investigators to the location of a single clandestine grave, which allegedly held the O'Hair family remains.

On January 27, 2001, investigators from the FBI, IRS, Texas Department of Public Safety, and Real County Sheriff's Department, along with a forensic anthropology team from Southwest Texas State University, convened at a remote South Texas ranch. The search, excavation, and recovery of the skeletalized remains were a collaborative effort by all agencies. A total of 21 excavation hours were necessary to complete the systematic recovery of three sets of remains and an additional fourth skull accompanied by hand bones only.

All skeletal remains were transferred to the forensic anthropology laboratory at Southwest Texas State University for analysis and identification. Anthropomorphic and osteometric analyses revealed a consistent match between the unknown skeletons and records of Jon Murray, Robin Murray O'Hair, and Madalyn Murray O'Hair. The skulls were then transferred to Drs. Alder and Senn at the Dental School of the University of Texas Health Science Center at San Antonio. Comparisons of dental

antemortem radiographs with radiographs of the unknown dentitions resulted in a positive identification for all three individuals. The fourth skull and hands, thought to be those of the accomplice Danny Fry, currently await DNA testing for positive identification. Cause of death for the O’Hair family will be discussed during the presentation.

Skeletal Recovery, Forensic Anthropology, Dental Identification

LW3 “I Was Lost, But Now I’m Found”: The Amazing Case of Boston Billy

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The goals of this research project are to present an interesting case that illustrates the multi-disciplinary approach to skeletal identification stemming from a Vietnam-era loss.

On February 28, 2001, Jerry Lawrence Degnan was identified, thus ending a journey that began over 30 years ago in the jungles of Vietnam, detoured through Thailand, Boston, and Honolulu, before ending on May 5 in a home-made coffin in a plot of ground outside Youngstown, Ohio. In the course of the journey, Jerry Degnan’s path crossed that of an Army deserter, an ill-fated helicopter crew, the President of the United States, and the Vietnam Unknown Soldier.

In the summer of 1967, Jerry Degnan was a civilian contractor working for the Saigon office of Decca Navigator Systems. A dutiful son, Degnan routinely wrote his mother and brother in Youngstown, Ohio; however, in late July 1967, the letters stopped. Not initially concerned, the family telephoned Decca’s office in Saigon, and was told that, while Jerry wasn’t around at that moment, everything was fine. Two weeks later, unable to find their employee, the Decca office notified the American Embassy that Jerry Degnan had not reported for work in An Khe where he was assigned and was assumed to be missing. A reconstruction of events by Decca Systems suggested that Mr. Degnan was last seen at the company headquarters in Saigon on August 26 or 28 trying to catch a flight to An Khe. A Decca employee came forth to say that he had met Degnan and another Decca employee, Joseph O’Brien, (both of whom he indicated as knowing well) in Saigon on August 25, 1967. However, in a letter to the Degnan family attorney, Mr. O’Brien indicated that not only did he not recall knowing the cooperative Decca employee, but that his flight records indicate that he was no where near Saigon on August 25-27, 1967. Furthermore, O’Brien affirmed that he last saw Jerry Degnan in Bear Cat, South Vietnam on August 8, 1967.

Obviously, there was some confusion as to Mr. Degnan’s whereabouts in August 1967. Due to the nature of his work as a helicopter pilot instructor, he often traveled throughout South Vietnam as an unmanifested passenger on various aircraft, but a search of military bases frequented by Degnan proved negative. Sometime around September 10, Degnan’s luggage and flight helmet were discovered in a company van at the Decca office in Saigon. Jerry Degnan, however, was never seen again.

On August 9, 1967, Private William J. McRae, who had just been released from the Long Binh Jail near Saigon, boarded a Huey helicopter manifesting four other personnel. Minutes later, the ill-fated Huey collided in mid-air with an RF-101C aircraft. Remains of the five personnel recovered from the helicopter wreckage were taken to the U.S. Army Mortuary in Saigon where the four flight crew were quickly identified. The fifth body was clothed in jungle fatigues but lacked unit insignia or name tape. Fingerprints were not obtainable and the dental remains were inconclusive; however, since McRae was the only individual manifested on board the helicopter who was unaccounted for, and since the body matched his race, build, and stature and had the same hair color, the remains were presumptively identified as William J. McRae and buried at his family’s request in Boston.

Almost five months later, an American patrol happening upon the Huey crash site found the remains of a sixth individual. Since all of the personnel manifested on the helicopter had been previously accounted for, no identification was made, and the sixth body remained unidentified when the mortuary was closed at the end of the war. Transferred first to a laboratory in Thailand, the unidentified remains were finally received at the U.S. Army Central Identification Laboratory, Hawaii (CILHI) in 1976.

Enter President Ronald Reagan. In the early 1980s the Reagan administration began championing the cause of a Vietnam Unknown Soldier for Arlington. Among the first remains that came under consideration were those of the sixth individual recovered from the 1967 Huey crash. With this impetus, the CILHI reopened the case and succeeded in 1982 in correctly identifying the remains as those of Private McRae. At that time, the remains erroneously identified as McRae in 1967 were exhumed from the grave in Boston and were transferred to the CILHI where they became affectionately known to a generation of CILHI employees as “Boston Billy.”

But who was Boston Billy? No American serviceman was listed as unaccounted for from near Saigon on August 9, 1967.

Through a combination of detective work, DNA analysis, and Forensic Anthropology, which would take almost 25 years, the CILHI finally put all of the puzzle pieces together. On February 28, 2001, Boston Billy was identified as Jerry Lawrence Degnan. Returned to his family in Ohio, Degnan’s remains were buried in a home-made coffin by his brother. Thus ended the journey of Boston Billy—the man who died on August 9, 1967, was mysteriously seen two weeks later, was erroneously buried in Boston, was later exhumed and supplanted by a candidate for the Tomb of the Unknown Soldier, and was then stored on a shelf in Hawaii for nearly 20 years until his eventual identification.

He was lost, but now is found.

Anthropology, Vietnam, CILHI

LW4 Rudolph Virchow and World War I: Did a Missed Diagnosis Shape the Course of 20th Century History?

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The goals of this research project are to understand how events in the history of medicine and pathology had an impact on world history.

Beginning with the assassination of Archduke Francis Ferdinand on July 28, 1914, an Austro-Serbian war escalated into a European war that soon became a world war. In the end, over 10 million died, 20 million were wounded, and over 7 million were missing. The aftermath of World War I in Germany laid the foundation for the rise of Adolph Hitler and World War II.

Of the various factors that led to World War I, many historians consider the aggressive German foreign policy pursued by Kaiser Wilhelm II to be of major significance. Some believe that the first World War may have been prevented altogether had not the father of Wilhelm II, Kaiser Frederick III, died after a reign of only 99 days. Frederick III died of cancer of the larynx—a diagnosis that was missed. Had Frederick III lived longer and been able to institute liberal changes in German government and foreign policy, perhaps World War I may never have occurred.

Frederick III was considered liberal by German standards. He was open to change and his wife, Queen Victoria’s oldest daughter, helped shape his moderate inclinations. Their marriage promised improved relations between England and Germany.

In his brief reign Frederick III instituted one change that foreshadowed the liberal policies he hoped to implement. He forced the resignation of Puttakmer, Minister of the Interior, and the second most powerful cabinet minister after Chancellor Bismarck. But with Frederick’s death in June 1888, the hope for a more liberal Germany also died.

The blame for the death of Frederick III from laryngeal cancer has frequently been placed on the English laryngologist, Dr. Morell Mackenzie. Dr. Mackenzie was called for a consultation by the Emperor's German physicians because he was well known to some of the doctors, spoke German, and because his textbook on diseases of the throat was widely used in German medical schools.

Throughout Frederick's illness and in the personal attacks and accusations of incompetence that followed, Mackenzie kept emphasizing the decisive part played in the diagnosis by the opinions of Dr. Virchow, to whom he sent the biopsy specimens. Virchow never accepted any share in the responsibility.

Nine days before the Kaiser's death Virchow still denied that the disease was cancer. Interestingly, Dr. Virchow's assistant, Dr. Waldeyer, interpreted expectorated material when Virchow was abroad in March 1888. Waldeyer made it known to the physicians caring for the Kaiser that what he saw was cancer. Virchow examined the material upon his return and concluded there was no cancer present.

The British Medical Journal in its June 9, 1888 issue reported that the microscopic evidence was contradictory, or more accurately, that equally competent authorities interpreted the material differently. Why one eminent pathologist saw cancer and another did not stemmed from the differences in opinion as to what constituted cancer. Dr. Waldeyer believed that the appearance of nests of epithelial cells arranged like an onion constituted cancer wherever they were found. Dr. Virchow was of the opinion that nests of epithelial cells could only be considered cancer if they were found in the mucous tissue itself. The article concluded by stating that time would show which of these eminent pathologists was correct. Seven days later Frederick III was dead.

Virchow and his assistants performed a partial autopsy. The examination revealed "cancerous destruction of the larynx," and cancer involving a lymph node on the left side of the neck. The examination also revealed inflammatory destruction of the upper portion of the trachea and neighboring parts, bronchiectasis and "gangrenous bronchopneumonia." In spite of his postmortem findings, Virchow continued to deny any responsibility for his failure to diagnose a malignancy.

The controversy surrounding the failure to diagnose Kaiser Frederick's cancer had a negative impact on the field of surgical pathology. As a result of the missed diagnosis on biopsy material, laryngologists for the next fifty years routinely declined to obtain a tissue diagnosis prior to surgery. In one series of 788 laryngectomies from the 1920's, the laryngologists reported they never performed a radical laryngeal operation before a tumor was proven to be cancer.

The chief criticism of Dr. Morell Mackenzie may be that he relied too much upon the results of the microscopic examination made by the most famous pathologist of the time. If Mackenzie hoped that Frederick III did not have cancer, Dr. Virchow's reports gave him ample reason for hope. Mackenzie also insisted that the course of the disease was not typical of laryngeal cancer. Part of his insistence may be due to his illustrious patient's almost daily examinations by physicians whose names are part of the history of nineteenth century medicine: Virchow, Kussmaul, Waldeyer, and Langerhans, to name a few. Mackenzie's insistence on biopsy was also considered unusual for the time. This is perhaps surprising because in 1888 a patient was more likely to die from the surgery than from the disease.

"Is the world what it is today because a liberal German emperor died ... because a pathologist missed the diagnosis, or because a surgeon was understandably cautious?" To this hypothetical historical question there can never be a certain answer. What is certain is that Morell Mackenzie, by insisting on making the diagnosis of cancer through the use of biopsies, was ahead of his time.

Virchow, World War I, Biopsy

LW5 "Where Death Delights to Serve the Living": Who First Said It?

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The goals of this research project are to discover highlights from the history of pathology, as related to the origin of the Latin motto that translates as "Where Death Delights to serve the Living"; to become familiar with forgotten heroes and characters out of the history of forensic pathology, and to know more about the role and the limitations of the Internet in research (usegroups, digital research, search engines), as used by an expert to follow this quotation toward its source.

The most famous autopsy theater maxim in our field has no known author. By making research simpler and contact between professionals worldwide more direct, the Internet can assist an expert researcher in a complex project, such as attempting to track down the original source of this celebrated quotation.

On the day I started my forensic pathology fellowship at the Office of the Chief Medical Examiner of the City of New York, I paused to look at a motto emblazoned in letters of bronze across the marble wall of the lobby. It read, "*Taceant colloquia. Effugiat risus. Hic locus est ubi mors gaudet succurrere vitae*: Let conversation cease. Let laughter flee. This is the place where death delights to serve the living."

This motto is not restricted to Manhattan. It can be found adorning the walls of autopsy suites and forensic institutions across the United States. Most derived it from New York City, which means that they derived it, wittingly or not, from Dr. Milton Helpern, the giant of forensic pathology who built the medical examiner's office in New York City, and who caused it to be emblazoned across the marble wall. But where did Dr. Helpern get it?

Dr. Helpern wrote in his memoirs, "Its origin is lost in the mists of time." But is it? That casually posed question led an Internet expert on a year-long virtual journey, from New York City, to Czechoslovakia, Canada, Italy, Bulgaria, England, and France. Along the way, resources tapped included Sir Bernard Knight; the Latin newsgroup of experts in medieval and classic languages; Dr. Axel Bauer, the historian of medicine and pathology in Heidelberg; the website of the Jesuits; kind colleagues in six countries who answered e-mail; other colleagues in ancient seats of learning in Europe, who went and looked at their anatomy theatre walls for us; and the Library of Congress.

We searched the works of Galen and Hippocrates. We learned the meaning of the "dactylic" hexameter style of Latin poetry, in which this quote is written, and why the "parameters of hexameters" show that the quote cannot be original, but must be composed in two parts. We came to understand why the quote cannot date to the ancients, but must have been either assembled or written in the centuries between Vesalius and the modern age. As we left the ancients behind, returning to our own century, we moved the earliest known citation back in time, over and over. Eventually we started to narrow the search to the 19th century classically trained physician in Paris or Italy, who must have been the first to use the phrase.

It has taken more than a year to follow this quote back towards its source. Had it not been for this Internet journey to strive to track down the source of a saying, I would never have heard of Dr. Isadore "Okkie" Gordon of South Africa, who gave Dr. Helpern the quote to bring to his architect in New York City; Giuseppe Moscati of Naples, Italy, the only autopsy pathologist to be canonized a saint by the Catholic Church; Luciano Armanni, his mentor and teacher, genius of dissection, for whom the Armanni-Ebstein lesion is named; Joseph Hyrtl, nineteenth century anatomist of Vienna; and, his aristocratic morgue assistant, Alfonso Corti, discoverer of the organ of Corti. Nor would I have heard of the forensic anthropology connection between Charles University in Hradec Kralove and the Smithsonian Institution in Washington, D.C. The number and the diversity of our predecessors in the centuries before our own are both astonishing and delightful.

As I summarize the yearlong search, I will demonstrate not only the turns and twists of the journey, but what kind of investigative tool the Internet is in expert hands, and where it still falls short. What can the Internet do to help a pathologist answer unanswerable questions? Is an Internet expert required to navigate the bends of the river of information, or can you paddle your own inquiries? And when should a busy medical examiner abandon the Net as a waste of time, to return to older methods of investigation?

The mists of time that baffled Dr. Helpm are parting in the face of Internet research, and they reveal heroes and characters in the centuries that saw the founding of our field, as well as the possible, uncertain, but likely origin of the great motto, "*Taceant colloquia. Effugiat risus. Hic locus est ubi mors gaudet succurrere vitae*: Where death delights to serve the living."

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