

THEREUPON, the defendant, further to maintain the issues on his part to be maintained, called as a witness DR. PAUL L. KIRK, who, having been first duly sworn, was examined and testified as follows:

DIRECT EXAMINATION OF DR. PAUL L. KIRK

By Mr. Bailey:

Q Sir, will you state your name?

A Paul L. Kirk, K-i-r-k.

Q Where do you live?

A 1064 Creston Road, Berkeley, California.

Q What is your occupation?

A I am Professor of Criminalistics, School of Criminology, University of California, Berkeley.

I am also a private consultant in matters concerning both civil and criminal cases.

Q And how long have you held your teaching position?

A I have taught at the University of California since 1925, in various capacities. I taught previously to that as a teaching assistant only at the University of Pittsburgh in 1924 and '25. At the University of California I was made instructor in 1929; I was an associate prior to that, and teaching assistant.

I was made assistant professor in 1933. I was made

chris
Coleman



CAC President

As practitioners of forensic science, we were concerned. We didn't want the government to start making policies that were going to have wide-ranging effects on our profession without having input!

Alphabet Soup

I am half way through my term as president. Just like watching your children grow up, the time flies by way too fast! Before I know it, I will be handing the mantle over to Brooke in May! Before I do that though I want to discuss one of my more interesting, albeit time consuming and sometimes frustrating, duties as the official representative of the CAC, that of handling all the correspondence that our great association receives. Even though I was warned, I was not prepared for the onslaught of emails I get. I won't go into details about all the emails I get from companies trying to sell products or services of one type or another to our organization, or who wants us to endorse or test their wares. Most of you have dealt with spam mail before so I am sure you are well aware of the mountain of emails that can await you daily. I'm not even going to discuss in length the numerous professional associations that write me asking me to come speak at their conferences and seminars. Many of which are not even forensic in nature! Most of them don't even know me from Adam (or Greg, or Eric, Todd, Kevin, or even Bob. Bob? The last possible Bob to run this association was in 1980!) Seriously, I have gotten emails addressed to all the above listed past presidents!

No, what I want to discuss is the alphabet soup of "groups" that are purported to be supporting forensic sciences and that are supposed to be our voice and champion our cause in this ever-changing political landscape, and the fact that I have to respond to them. You may notice the sarcastic tone with how I stated that. As you read on I think it will be clearer to you why I have chosen this tone and why I feel the way I do, having tried very hard to stay on top of this situation, so bear with me.

To start with, of course, is our own CAC (California Association of Criminalists). We all know why this association was formed and what we do. Then there is the AAFS (American Academy of Forensic Sciences) a professional society dedicated to the application of science to law. I don't think we need further discussion on these groups. They are pretty well established. Then there is ASCLD (The American Society of Crime Laboratory Directors), a non-profit professional society that is dedicated to providing excellence in forensic science through leadership and innovation. The CACLD (California Association of Crime Laboratory Directors) has the same goal as ASCLD, to advance forensic science through effective management. The CACLD was founded by many of the same people who founded the CAC. ASCLD and CACLD exist in the same manner as the AAFS and CAC do, national versus regional groups.

Next up we have ASCLD/LAB (The American Society of Crime Laboratory Directors / Laboratory Accreditation Board) who is a not-for-profit corporation specializing in accreditation of public and private crime laboratories. I should mention ISO (The International Organization for Standardization) here as well. They develop and publish international standards for almost everything, including Standard 17025:2005 which are the general requirements for the competence of testing and calibration laboratories, which forensic labs fall under, and ASCLD/LAB manages for a lot of us. I know there are other groups out there that accredit crime labs, but I'm only mentioning ASCLD/LAB, so this doesn't get completely out of hand. Since I mentioned accreditation it is only fair if I discuss the ABC (American Board of Criminalistics) an organization dedicated to providing the path for individuals, rather than organizations, to be recognized for their dedication to our profession via certification. I would also like to mention CTS (Collaborative Testing Services, Inc.) the company who many of us get our proficiency tests from so our labs

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FIRST QUARTER 2016



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Submissions should be made in the form of Windows compatible files on CD or by e-mail. Alternatively, text files may be saved as plain ASCII files without formatting codes, e.g. bold, italic, etc. Graphics, sketches, photographs, etc. may also be placed into articles. Please contact the editorial secretary for details.

The deadlines for submissions are: December 1, March 1, June 1 and September 1.



The Other "Trial of the Century"

On the cover: The first page of Paul Kirk's testimony in the murder trial of Sam Sheppard from November, 1966. One of the CAC's most well-known founders, Dr. Kirk was called by the defense as an expert to refute the prosecution's theory of the case.

Source: Cleveland State University archives. (Thanks to Bob Blackledge.)

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CAC Has a Facebook Presence

Don't forget to check out our facebook page. The URL is long, so just google "facebook", "CAC", "criminalists." (There are lots of "CAC's" out there...)

Lab Retriever White Paper Accepted

Lab Retriever, a software tool for calculating likelihood ratios incorporating a probability of drop-out for forensic DNA profiles, was originally supported by McLaughlin funds. A paper authored by Keith Inman, Norah Rudin, Ken Cheng, Chris Robinson, Adam Kirschner, Luke Inman-Semeran and Kirk E. Lohmueller has been accepted for publication at www.biomedcentral.com/1471-2105/16/298.

Abstract: Technological advances have enabled the analysis of very small amounts of DNA in forensic cases. However, the DNA profiles from such evidence are frequently incomplete and can contain contributions from multiple individuals. The complexity of such samples confounds the assessment of the statistical weight of such evidence. One approach to account for this uncertainty is to use a likelihood ratio framework to compare the probability of the evidence profile under different scenarios. While researchers favor the likelihood ratio framework, few open-source software solutions with a graphical user interface implementing these calculations are available for practicing forensic scientists.

Nominating/Application Deadlines

Awards Chair Vincent Villena reminds members that there are two important dates for nominations: June 30 for the Anthony Longhetti Distinguished Member Award and the Paul Kirk and Presidents Award (even years). Then there is December 31 for the ABC Examination Award and Edward F. Rhodes Memorial Award. Visit www.cacnews.org/awards/awards_dates.shtml

Calendar Check—Future Meetings

Spring 2016 (LAPD), Fall 2016 (DOJ Riverside), Spring 2017 (San Francisco), Fall 2017 (Orange County).



Alice Hilker and her toothy friend (the one on the left) receive a Service Award for chairing the Fall 2015 seminar in San Mateo.

Awards Announced

Congratulations is in order to Brian Burritt, winner of the Anthony Longhetti Distinguished Member Award, Kevin Andera, who won the W. Jack Cadman Award (Spring 2015), and Dean Gialamas, whose talk on "How the NCFS will Impact Our Work" received the Alfred A. Biasotti Most Outstanding Presentation Award (Spring 2015). The Poster Presentation Award went to Amanda Davis and Katherine Roberts for their presentation of "Detection of Bullet and Non-Bullet Damage to Textile Fabrics."

For her outstanding work as Seminar Chair (Fall 2015) Alice Hilker was presented with a Service Award. (photo)

Houde Gets Life

CAC President Chris Coleman presented John Houde with life member status, commenting, "John has been a member of the CAC since 1988 and has done much to support of our great organization. Besides all of the great work he has performed in his career, his greatest contribution to our field would have to be the decades of the CACNews that he has arranged and published. To get an idea of his handiwork, check out



our CACNews archive and notice how the quality and professionalism changed around Winter of 1992. Thank you for all you've done!"

Video of Dr. Henry Erlich's Founders Lecture

The members and guests in attendance at the Fall 2015 seminar were treated to a Founders Lecture by Dr. Henry Erlich. Thanks to the staff of the San Mateo County Crime Laboratory, those of us who were not in attendance can now watch streaming video of this great lecture. To watch the video, follow this link: www.cacnews.org/training/lectures/lectures.shtml

On-line Microscopy Courses at McCrone Research Institute

Microscopy courses taught at McCrone Research Institute range from basic, introductory courses, emphasizing the proper use of the microscope, to specialized courses focusing on a particular technique, a particular material, or a particular industrial, forensic or environmental field of application. In addition to Polarizing Light Microscopy and Forensic Microscopy Courses, McCrone offers classes in SEM, IR, Fluorescence, Raman, Sample Prep and other micromethods including

Asbestos, Fungal Spore, Pollen, Dust and Indoor Air Quality Microscopy.



Call for Papers Inter/Micro 2016

Next year's Inter/Micro will be June 6-10 at McCrone Research Institute. The deadline to submit titles and abstracts is April 15, 2016. Inter/Micro is considered the premier international microscopy conference and CAC members are encouraged to present their research.

Papers are being solicited in micro-analytical techniques and instrumentation, environmental and industrial microscopy, and chemical and forensic microscopy.

For more information email McCrone at: intermicro@mcric.org

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Polos and more!**



chris Coleman

can meet ASCLD/LAB and ISO standards for accreditation as well as maintain our individual ABC Certification.

Ok, now that I have laid that forensic foundation, I will discuss the NAS (National Academy of Science). The NAS was established by an Act of Congress in 1863 and is composed of distinguished scholars and scientists who are elected to the NAS by their peers. The NAS is tasked with providing independent, objective advice to the nation on matters related to science and technology. The NRC (National Research Council) was organized by the NAS to be the mechanism that the NAS uses to help the government improve decisions about science and technology through their expert reports. This allows the government to shape policies and actions for the "greater good". The NRC report "Strengthening Forensic Science in the United States: A Path Forward" released in August of 2009 has had a huge impact on how things are being done in our crime labs today. The report also set in motion a movement to establish a group responsible for representing our collective interests as forensic practitioners. This is where most of my angst is being generated.

Because of the attention the NAS (NRC) report garnered, members of congress got involved and started introducing bills on forensic science reform, Senator Leahy being the most outspoken and prominent. He has sponsored at least two bills to my knowledge (in 2011 and 2014) both of which were not enacted. As practitioners of forensic science, we were concerned. We didn't want the government to start making policies that were going to have wide ranging effects on our profession without having input! Many of the professional organizations and societies we belonged to did formally prepare responses to the NAS report as well as try to get information to the various government "committees" working on these bills. I know, I helped edit and review several responses that AFTE (Association of Firearms and Toolmark Examiners) formally prepared.

Though are efforts were valiant, it seems that they are varied and disorganized as each professional group sends out their individual groups' response. It seemed we needed a more coordinated plan. Enter the CFSO (The Consortium of Forensic Science Organizations) formed in 2000 to be a single voice to represent the thousands of forensic science professionals in the country and influence public policy and generate more federal funding for crime laboratories. The CFSO is comprised of six professional forensic science organizations spanning a wide range of interests (including two I have already mentioned, the AAFS and ASCLD). Then there is the ACFSL (American Congress of Forensic Science Laboratories) an assembly of US forensic science laboratory professionals supported by the FFG (Forensic Foundations Group). A relative new group formed in June of 2015 to advocate for forensic science concerns over the reforms congress is considering. Now wait a moment...

NIJ (The National Institute of Justice) created the FTCoe (Forensic Technology Center of Excellence) to improve the practice of forensic science and strengthen its impact...by comprehensive dissemination of best practices and guidelines. The FTCoe provides funds to research new technologies and put

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meiling
ROBINSON



CAC Editorial Secretary

For the record, I think that *CSI* is an imperfect predictor of future forensic techniques. But what's important to glean from this example, is that we must recognize that the rigidity of science sometimes suffers from lack of imagination.

The Error in the Situation

Marty McFly: Where are we? When are we?

Doc: We're descending toward Hill Valley, California, at 4:29 pm, on Wednesday, October 21st, 2015.

Marty McFly: 2015? You mean we're in the future?

Jennifer: Future? Marty, what do you mean? How can we be in the future?²

On October 21, 2015 we experienced the collective media celebrate "Back to the Future" Day. On that day, comparisons were drawn between our current 2015 and how it stacked against the imaginary year 2015 that was portrayed in the 1989 movie *Back to the Future II*. Not only was this highly entertaining to me (being born in the 80s), but it was interesting to reflect on what technological advances we thought would be developed 30 years out from the original movie release. Surprisingly, the movie was correct in predicting more than a dozen things including handheld tablets, our obsession with 3D movies and personal electronics, video conferencing, and wall mounted wide screen televisions. Other things, such as hoverboards, flying cars and the Cubs winning the World Series, missed the mark. Nonetheless, we find ourselves in the year 2015, 30 years have passed since the original movie's release, and we are actually utilizing some of the technology that was featured. Great Scott! Could that mean that current forensic television shows are possibly highlighting future technologies that may actually be utilized by criminalists in the future?

Many original forensic techniques, which emerged with the early development of the field of criminalistics, gave way to more reliable methods. For example, the anthropometric measurement system—the Bertillon System of Criminal Identification was introduced in the United States in 1887, but by 1903, a more reliable fingerprint identification system and fingerprint analysis had emerged. Some current techniques are merely more refined versions of their predecessors, and many other methods that were utilized a century ago are still being utilized today. Technological advances have also breathed new life into old methods, allowing them to reemerge, as a phoenix from the ashes. For instance, from galvanoplasty and rudimentary sketching and three-dimensional plaster casting, arose laser scanning technologies. Now, with laser scanning we can produce accurate 360° 3D laser scans of crime scenes, allowing incident scene reconstruction and measurements to be determined between any objects within the captured scene.

These forensic advancements were borne out of the natural progression of science and not of movie predictions of futuristic crime fighting. But have there been examples of science fiction providing inspiration for the advancement of technology? The answer is most definitely, a resounding yes. Specifically, many crime fighting sci-fi movies feature technologies that the government and the public are already utilizing, including airborne drones that have automated intellectual ability, autonomous military ground robots (UGVs), display technology, genetic profiling, predictive policing models, and advanced facial recognition software. So perhaps there can be other material by-products from the *CSI* television series (and other crime drama series) other than the "CSI Effect"? Let us examine one infamous example in which *CSI* exercised far-fetched scripted science—fingerprints found on blades of grass. It's common knowledge that fingerprints deposited on porous surfaces like paper or skin are particularly difficult to process. Blades of grass are not only porous, but are small and also often times a wet surface. In reality we scoff at the idea of obtaining fingerprints from grass, but in actuality, *CSI* may have unknowingly predicted it. Researchers have utilized advanced microscopy and nanotechnology to detect fingerprints by measuring the chemical traces they leave on a surface. Scanning electrochemical microscopy (SECM) has been used to image latent fingerprints enhanced by adsorption of gold nanoparticles onto which silver is chemically deposited, a process known as "multi-metal-deposition" (MMD)². Using this SECM method to detect invisible traces of sweat and oils, it is proven possible to create a chemical picture of a fingerprint. This method has the potential to develop fingerprints on surfaces, which are known to generate poor results with current techniques, such as textured, highly illustrated or wet surfaces. In essence, what was not previously possible is made possible by using this method.



Just as the Back to the Future franchise thought they were just wildly speculating about a futuristic world, crime drama shows and crime fighting sci-fi movies, may be showing us that there is no real boundary but the one we impose on ourselves by not imagining the possibilities.

For the record, I think that *CSI* is an imperfect predictor of future forensic techniques. But what's important to glean from this example, is that we must recognize that the rigidity of science sometimes suffers from lack of imagination. *CSI* did not have *anything* to do with the development of this SECM/ MMD technique, but they did highlight something that, in reality, is impossible and made it possible. They imagined a world in which actually obtaining fingerprints from a blade of grass was possible. Perhaps just by blurring the line between reality and Hollywood magic, shows like *CSI* are actually pushing us to consider what's actually in the realm of possibility. Just as the *Back to the Future* franchise thought they were just wildly speculating about a futuristic world, crime drama shows and crime fighting sci-fi movies, may be showing us that there is no real boundary but the one we impose on ourselves by not imagining the possibilities. Maybe, next time we won't just watch with an incredulous smile, but consider instead, that perhaps one day it may be possible. Or better yet, contemplate how we can make it realizable. Although, I'm not hopeful that we'll ever be able to make a plaster mold of a wound to determine the murder weapon, as *CSI* suggests we can, but at least the imaginative spirit is in the right place.

Just as shows like *CSI* and science fiction movies are pushing the boundaries of what's possible today, back in 1921, the canon of Sherlock Holmes was arguably the *CSI* of the turn of the twentieth century. In 1921, the June issue of *Popular Science Monthly*, featured an article entitled "How Science Tracks the Criminal". The 1921 article eerily echoes a similar sentiment towards forensic science as today's public perception influenced by the *CSI* series. The author stated that "Europe is far in advance of the United States in crime detection" and that "in the whole United States there is no Sherlock Holmes". Never mind that Holmes was a fictional character, the general conviction expressed in the article, was that of deep appreciation for the cutting edge technology and methodology employed by Holmes. Furthermore, that the spirit of Sherlock Holmes was embodied in Professor Hans Gross of the University of Graz. The article praises Gross' ability to find "the error in the situation—the little forgotten thing or act that betrays" through scientific study of the crime scene. The author encourages U.S. laboratories to look to the European laboratories and universities as the new paragons of modern forensics.

It's hard not to appreciate the humor in the unintentional wordplay of the author of this *Popular Science* article. The error of the author's situation is simply that he grossly underestimated the development of criminalistics in the U.S. (Insert rimshot here). By the time this article was published, August Vollmer was chief of police in Berkeley, CA and was already applying forensic science to investigations, and working in conjunction with scientists at UC Berkeley, was operating a pseudo crime laboratory since 1910. In 1923, Vollmer was appointed chief of police of the Los Angeles Police Department and created the Scientific Investigation Division—the first physical crime laboratory in the United States. No Sherlock Holmes, indeed! And although Dr. Edmond Locard became known as the "Sherlock Holmes of France," Paul L. Kirk deserves an honorable mention as perhaps the American archetype. Kirk so eloquently depicts these little forgotten things in describing Locard's Theory:

"Wherever he steps, whatever he touches, whatever he leaves, even unconsciously, will serve as a silent witness against him. Not only his fingerprints or his footprints, but his hair, the fibers from his clothes, the glass he breaks, the tool mark he leaves, the paint he scratches, the blood or semen he deposits or collects. All of these and more, bear mute witness against him. This is evidence that does not forget. It is not confused by the excitement of the moment. It is not absent because human witnesses are. It is factual evidence. Physical evidence cannot be wrong, it cannot perjure itself, it cannot be wholly absent. Only human failure to find it, study and understand it, can diminish its value."⁴

This world renowned quote captures the imaginative spirit required by the criminalist. The search and discovery of the "error in the situation" is not merely the aim, but is indeed the entire essence of criminalistics. This blast through the past has reminded me to keep an open mind and to be imaginative. As we say good bye to 2015 and welcome in the New Year, I hope that the spirit of Sherlock Holmes may be rekindled in all of you. May 2016 give you a renewed sense of wonder regarding the work that we do.

Happy New Year!

Mai

Doc: I foresee two possibilities. One, coming face to face with herself 30 years older would put her into shock and she'd simply pass out. Or two, the encounter could create a time paradox, the results of which could cause a chain reaction that would unravel the very fabric of the space time continuum, and destroy the entire universe! Granted, that's a worse case scenario. The destruction might in fact be very localized, limited to merely our own galaxy.

Marty McFly: Well, that's a relief.²

References:

1. *Popular Science Monthly* June, 1921; Volume 98, No. 6. "How Science Tracks the Criminal"
2. *Back to the Future, Part II*. Dir. Robert Zemeckis. 1989. Film.
3. Zhang, M., et al. "SECM Imaging of MMD-enhanced Latent Fingerprints." *Chemical Communications Chem. Commun.* 38 (2007): 3948
4. *Crime Investigation: Physical Evidence and the Police Laboratory*. Paul L. Kirk. New York-London: Interscience, 1953.

COVER FEATURE

To whet your appetite we present a few more pages from Dr. Kirk's testimony...

	1058
	associate professor in 1939. I was made a full professor in 1945. This was all in biochemistry.
	In 1949 or '50 -- '49, I believe, I was made associate, full professor of biochemistry and criminalistics. And in 1954 I gave up the biochemistry work and went into criminalistics as full professor criminalistics, full time.
Q	What does criminalistics involve, doctor?
A	Criminalistics is the subject that is concerned with physical evidence, that is, the examination and identification, individualisation, and interpretation of physical evidence of all types.
Q	Doctor, would you give us a resume of your educational background other than that which you just described?
A	I first went to Ohio State University in Columbus for four years; following graduation from Randolph Macon Academy, Macon, Virginia. I took the Bachelor of Science degree in chemistry.
	I went from there to the University of Pittsburgh where I took the Masters degree in chemistry.
	I went from there to the University of Berkeley where I took the Doctors degree in biochemistry, PhD, in the Biochemistry Department.
Q	Now, how long have you been working as distinguished from teaching, on the subject of criminalistics, that is, physical evidence?

	1059
A	The first case I worked on was in 1935, and I have been doing it ever since then. Of course, I had to interrupt it for three years during the war, from 1942 to '45, because I was on the Manhattan Project at that time. That interrupted both teaching and investigative work.
Q	When your work at the Manhattan Project was concluded did you return to criminalistics, both teaching and actually doing the work?
A	I did, yes.
Q	Have you been involved in legal cases prior to this one?
A	I have been involved in over two thousand.
Q	Civil and criminal?
A	Civil and criminal, prosecution and defense, and plaintiff and defense. I worked for both sides, on both civil and criminal matters.
Q	Doctor, have you authored any written material in the various fields in which you have taught and been educated?
A	I have published about 240 publications of one type or another, which includes four books. It includes four encyclopedia articles. Most of it is the reports of original research.
	There are, of course, a few things like book reviews, and so forth, included in that list.

	1060
Q	Doctor, we learned from a prior witness that the Cleveland Police Department has a book called Criminal Investigation, by Paul Kirk, in its library; are you the author of that book?
A	I am.
Q	Doctor, do you belong to any --
A	Pardon me. It is Crime Investigation, rather than Criminal Investigation.
Q	I am sorry, Crime Investigation. When was that book initially published?
A	It was published in 1950. It is being revised at the present time to make two volumes.
Q	Do you belong to any professional organizations or societies?
A	I do, yes. I belong to the American Chemical Society, of course, since 1923.
	I am a member of the American Association for the Advancement of Science; the American Society of Biological Chemists; the American Society of Criminology.
	I am a founding member and president-elect of the California Association of Criminalists. I am a member of the British Forensic Science Society.
	I am a fellow of the American Institute of Chemists.
	I am a fellow of the New York Academy of Science.
	I am a fellow of the Belgian Royal Academy. I am a

	1061
	member of the International Association of Forensic Toxicologists, and the newly formed International Association of Forensic Sciences. We just had it in Copenhagen a few months ago. There are still a few others.
Q	Let's have them all, please.
A	I am trying to think of all of them. Association of Consulting Chemists and Consulting Engineers. That is one of them.
	I can't think of any others at the moment, other than honor societies.
Q	Doctor, other than the teaching you have done at the University of Pittsburgh and the University of California in Berkeley, have you had occasion to lecture?
A	I have lectured all over the United States, actually.
Q	And of the many civil and criminal cases that you indicate you have been involved in in the past, are these all cases that arose in California?
A	No. As a matter of fact, they have arisen pretty much all over the world. There have been two originated in Okinawa, and I have testified in Okinawa.
	I have testified more than once in --
	MR. SPELLACY: I object. There is no question before the witness.
Q	Tell us the jurisdictions in which you have testified?
A	Well, I have testified in New York, New Jersey,

	1062
	Louisiana, Idaho, Washington, Oregon, California, Nevada, Arizona, and Oklahoma.
	I have investigated in addition in some additional places. I have one case currently from Jamaica. I have had cases from England. I have had several from Canada. I have them from Hawaii, from Alaska.
	I think that is probably the geographical distribution completely.
Q	Have you ever done any studies or experiments with dry blood?
A	I have.
Q	How long have you been working with dry blood?
A	I would estimate since about 1937.
Q	And have you published any papers on the subject of dry blood?
A	I have published a number of papers in that general area, yes.
Q	Do you know Mary Cowan?
A	I do.
Q	When did you first meet her?
A	I am not quite sure. I met her several years ago and I have known her quite well in recent times.
Q	Doctor, whether or not in late 1954 or early 1955 you had some occasion to have something to do with the case of the State of Ohio against Samuel H. Sheppard?

	1063
A	I did, yes.
Q	By whom were you first contacted in this case?
A	William Corrigan.
Q	Had you had some conversation with him initially?
A	Yes, I was called by him by phone.
Q	As a result of that conversation did you do something?
A	Yes. I came to Cleveland.
Q	And when you got to Cleveland when did you meet?
A	I met Mr. Corrigan.
	THE COURT: Fix the time, counselor, please.
Q	When did you arrive in Cleveland?
A	I arrived on January 22, 1955.
Q	You were met as you arrived in Cleveland by Mr. Corrigan?
A	I met Mr. Corrigan in the hotel, the old Hollenden Hotel.
Q	And did you see anyone else connected with the Sheppard case while you were in Cleveland on that first occasion?
A	I did, yes.
Q	Who?
A	Well, of course, I saw the two Sheppard brothers, Richard and Stephen. I saw their families, of course, as well.

	1064
	I saw Mr. Farrino, especially, one of the prosecutors, at that time. I believe he is a judge at the present time. He made available to me for inspection the evidence held by the district attorney at that time.
	I don't know offhand exactly who else I met. I met a number of other people, but I think the connection with the Sheppard case was probably somewhat remote.
Q	Did you meet this fellow right here (indicating)?
A	Yes, I did.
Q	Where did you see him?
A	In Cleveland jail.
Q	Did you have some conversation with him?
A	I did.
Q	Did you do anything beside talk with him?
A	Yes, I did.
Q	What did you do?
A	I obtained from him some blood.
Q	How did you do that?
A	I took with me a bottle, which I have today, and a lancet, and I allowed him to stick the lancet into his own finger and let the blood flow or drip into the bottle.
Q	After you obtained this sample of blood did you at some later time group it?
A	Yes.
Q	In what group did you find Doctor Sam Sheppard to be?

	1065
A	He belongs to A group.
Q	Any sub-factors of importance?
A	He was a weak A, and therefore probably an A-2. But I didn't determine specifically that he was an A-2. In those days means for doing so were very primitive as compared to the present.
Q	Between 1955 when you entered this case and 1966 have there been any notable advances in the field of blood grouping?
A	Oh, yes, a great many.
Q	Doctor, we have been told that there are four basic groups of blood, A, B, O, and A-B.
	Are you able to tell us from your experience or scientific knowledge generally the breakdown by percentage, that is, the likelihood that any given person will fall into a certain group?
A	In the American Caucasian population, the percentage is about 43 percent for O. This is the most common group; in other words, almost half of the population.
	It is 40 percent for A. So that A and O together constitute most of the population.
	14 percent for B; and 3 percent for A-B. It is a little higher in the colored race, it is about 6 percent for A-B, in the colored race.
Q	Doctor, within a group of blood, whether it be O, A, B,



Ethical Dilemmas

DISCUSSION CORNER WITH CAROLYN GANNETT

Preliminary Reports

Policies on the release of preliminary results...must be thoughtfully conceived, precisely written, and clearly communicated to lab personnel in order to be effective.

The Scenario

You are walking by a co-worker's office when you overhear her giving test results over the phone to an investigator. She tells him that she will not be able to provide a written report until her results have been reviewed and a written report signed. You believe she has just verbally released results that have not been finalized.

What would you do? Do any ethics concepts apply?

Discussion

This is possibly the most common topic of the scenarios submitted to me by students prior to each of my ethics classes. There are various permutations:

- An investigator hounds you to provide verbal results before he becomes forced to release an "obviously-guilty" suspect.
- A coroner investigator complains she can't proceed with her high-profile case without your thumbs-up on a fingerprint comparison, but you have no one available to verify your work.
- The inquiring investigator understands you want to comply with lab policy that prohibits release of results prior to technical review, but pressures you for a hint, say, a weather forecast—is it going to be cloudy or sunny?

While there may be ethics concepts that apply to the dilemma presented in these scenarios, the first line of query might best be: What are the lab's policies on the release of preliminary results? Such policies are necessary, and they must be thoughtfully conceived, precisely written, and clearly communicated to lab personnel in order to be effective.

In my opinion, the primary purpose for such policies should be to fulfill the ethical concept of serving justice. Laboratory policies provide a fundamental stop-gap for helping to ensure that bad results do not get injected into the justice system. These policies also help the lab, its agency, and its employees avoid embarrassment that could arise from the release of bad results, should those results become a topic of public debate. Additionally, lab management owes it to their employees to protect them as individuals from making any erroneous reports, regardless of whether the media become

aware and drag the individual's name through public scorn. Conscientious analysts may think they are doing their jobs well by complying with policies, but if the policies are poorly conceived, written, or communicated by management, then analysts can wind up paying the price for management's shortcomings, because the proverbial flow tends to be down-hill.

A discussion on what those policies might contain depends on the area of expertise and is beyond the scope of this article. It may be worth mentioning here, however, that often they include the release of preliminary results only after technical review or verification, but prior to administrative review.

Practitioners' Ethics

As I mentioned above, serving justice may be the primary purpose for having solid policies in place regarding preliminary reports. That concept is expressed in the CAC Code of Ethics Preamble, which states, "It is the duty of any person practicing the profession of criminalistics to serve the interests of justice to the best of his or her ability at all times." This concept is also expressed in the ethics documents from AFTE, NWAFS, and others.

Another concept that applies is: verify and review results. This can be found in several ethics documents, including the following:

- CAC Code of Ethics, II.D: "Where possible, the conclusions reached as a result of analytical tests are properly verified by re-testing or by the application of additional techniques."
- ASCLD/LAB Guiding Principles, 10: "Honestly, fairly and objectively administer and complete regularly scheduled: ...comprehensive technical reviews of examiners' work; verifications of conclusions."

Other concepts that may apply include objectivity and honesty in reporting results, making conservative statements, and communicating clearly.

In my opinion, the primary purpose for such policies should be to fulfill the ethical concept of serving justice. Laboratory policies provide a fundamental stop-gap for helping to ensure that bad results do not get injected into the justice system.

Share your thoughts and dilemmas at
www.ethicsforum.cacnews.org

Managers' Ethics

I would like to call attention to an often-overlooked but important document: ASCLD's *Guidelines for Forensic Laboratory Management Practices* ("ASCLD's Guidelines," for short). It is an important adjunct to ASCLD/LAB's *Guiding Principles of Professional Responsibilities for Crime Laboratories and Forensic Scientists* ("ASCLD/LAB's Guiding Principles," for short). For clarity, there are two documents:

- ASCLD/LAB's *Guiding Principles*, the document accredited labs are typically familiar with and annually review, and
- ASCLD's *Guidelines*, with which, in my experience, practitioners are less familiar. You can find it here: www.asclcd-lab.org/wp-content/uploads/2013/04/labmgtguide.pdf.

If you pull out your copy of ASCLD/LAB's *Guiding Principles*, you can see that paragraph three of the Preamble mentions the second document, ASCLD's *Guidelines*:

ASCLD/LAB has adopted the ASCLD Guidelines for Forensic Laboratory Management Practices, many of which have been incorporated into the ASCLD/LAB accreditation standards. Those practices provide for management support of the guiding principles set forth below and are intended to create a culture of ethical behavior and professional responsibility within the laboratory. The ASCLD practices should be implemented and followed to give practical meaning to the Guiding Principles of Professional Responsibility for Crime Laboratories and Forensic Scientists.

To be clear, ASCLD/LAB *Guiding Principles* states that content of another document, ASCLD's *Guidelines*, should be implemented and followed. But, how many accredited labs require compliance with and an annual review of ASCLD/LAB's *Guiding Principles*, while remaining silent regarding ASCLD's *Guidelines*? Based on paragraph three quoted above, they go hand-in-hand. Anything that applies to the application of the *Guiding Principles* automatically includes ASCLD's *Guidelines*.

Here are some concepts in ASCLD's *Guidelines* that may apply to the scenario.

1. Under "Responsibility to the Public" paragraph "Work Quality:"

A quality assurance program must be established. Laboratory managers and supervisors must accept responsibility for evidence integrity and security; validated, reliable methods; casework documentation and reporting; case review; testimony monitoring; and proficiency testing.

As it applies to this scenario, this clearly states that managers are responsible for casework reporting. As such, it behooves management to develop, clearly communicate, and enforce well thought-out policies that address the reporting of preliminary results.

2. Under "Responsibility to the Employer" paragraph "Quality:"

Laboratory managers are responsible for implementing quality assurance procedures which effectively monitor and verify the quality of the work product of their laboratories.

ASCLD's *Guidelines* squarely place the responsibility of the work product on the shoulders of management. This would presumably include the reporting of the work product—when and how it can be reported, including preliminary reports.

3. Under "Responsibility to the Employee" paragraph "Communication:"

Laboratory managers should take steps to ensure that the employees understand and support the objectives and values of the laboratory. Pathways of communication should exist within the organization so that the ideas of the employees are considered when policies and procedures of the laboratory are developed or revised. Communication should include staff meetings as well as written and oral dialogue.

As it applies to the above scenario, management is responsible for ensuring that all employees, including the co-worker reporting preliminary results and the person overhearing the conversation, are clear on what, if anything, constitutes acceptable preliminary reporting. Also, when developing policies, management is responsible for considering the ideas of employees.

There may be other concepts in ASCLD's *Guidelines* that apply to this scenario. Those listed above are the ones I found most salient.

Summary

With all of this in mind, what would I do given the above scenario?

The initial questions I would ask are: What are the lab's policies on the release of preliminary results, and, were they followed? Do the policies allow release of verbal results after a technical review, but before an administrative one? When the co-worker said she couldn't "provide a written report until it is reviewed," did she mean technical review or administrative?

If I had found any discrepancies between the coworker's conduct and policy, then I would report the matter to a supervisor. If I didn't know enough about the situation, I might consider asking the coworker for more information so that I could determine whether a supervisor needed to become involved.

If I found the policies to be incomplete, ill-conceived, or poorly communicated, then I would report to management what I believed to be shortcomings of the policies, and I would offer to assist, if wanted, in the development of policies that are effective and clear.

And, as for that weather forecast—I'd steer clear. It would still be a violation of policy, even if the topic is, on the surface, only the "weather."

Have an ethical dilemma you'd like evaluated?
Submit a sanitized version to
GannettForensics@aol.com

The California Supreme Court Discusses Forensic Science

By Michael Chamberlain, Deputy Attorney General,
California Department of Justice

A decision by the California Supreme Court is a big deal, because it becomes the ultimate law of the state.¹ But our Supreme Court is very picky about the cases it accepts, rejecting most petitions for review. By law, however, all death penalty cases skip the court of appeal and get automatically reviewed by the California Supreme Court. So, if you testify in a death penalty case resulting in a death judgment, your name and a description of your testimony will become a permanent part of state law. (Do a good job!) Capital cases can also generate a California Supreme Court decision on more mundane forensic science issues that ordinarily would not be deemed worthy of consideration by the state's high court, but that are important to the forensic science community. In late October 2015, the California Supreme Court issued one of these opinions: *People v. Cordova*.²

The facts of the case are predictably grim. In August 1979, eight-year-old Cannie Bullock was left home alone one night while her single mother went out to the local San Pablo bars. Sometime before Cannie's mother arrived home between 2:00 and 3:00 a.m., a man named Joseph Cordova showed up at the small house. He had seen Cannie before, because one Friday he picked up her mother at a bar and went to the Bullock house for sex when Cannie was there. On that night in August, however, Cordova found Cannie alone. He brutally and violently raped her. Then he strangled her to death with his hands. Then he dragged Cannie's naked body into the weed-choked back yard and dumped her there, in the prosecutor's words, "to be eaten by the ants."

Cordova's name never came up in the initial investigation, and he moved to Canada shortly afterwards. He got away with his monstrous crime for 23 years. In 2002, the Contra Costa Sheriff's Crime Laboratory developed a DNA profile for the killer from vaginal swabs collected during Cannie's autopsy. The profile was uploaded into SDIS and NDIS databases, and immediately hit Cordova. He had been in CODIS since 2001, after being convicted of child molest offenses in Colorado. Cordova was arrested and charged with murdering Cannie. A jury convicted him in late 2006, and voted for death in early 2007.

The California Supreme Court affirmed. For criminalists and other forensic science professionals, several aspects of its opinion are worth noting. Here they are:

It's never too late to conduct forensic science testing in a murder case. Murder has no statute of limitations. But when defendants are charged with murder many years after the crime, they often argue that the delay so impairs their ability to defend against the charges that a trial would be fundamentally unfair. Our courts resolve this kind of claim by balancing any showing of harm to the defendant against the government's justification for the delay. In *Cordova*, the Supreme Court found that Cordova's assertion of prejudice based on delay was, at best, speculative. More significantly,

the court found that the 23-year delay in bringing charges was justified because the police simply could not identify Cordova before the 2002 cold hit, and investigators were not negligent in their efforts. "Sometimes," the court wrote, "a crime simply is not solved immediately but must await some break in the case . . ."

So, if there is new scientific testing that can be done on an old unsolved case in your jurisdiction, and may yield new clues, that testing should take place as soon as possible, regardless of the age of the crime.

There may be practical reasons, like a defense ability to retest evidence, why laboratory records need not be provided to the defense as Brady material. Forensic Science Associates (FSA) did some of the DNA testing in this case. At trial, the defense sought discovery of laboratory contamination events in other, unrelated, casework. The trial court denied the request, and the California Supreme Court agreed with that ruling. It held that the records did not fall under *Brady v. Maryland* (1963) 383 U.S. 83, which requires the prosecution in every case to give the defense all information that is both favorable to the accused (i.e., could help the defense or hurt the prosecution) and material to the outcome of the case (there is a reasonable probability it would make a difference). The court cited some practical, common-sense reasons for its conclusion.

First, FSA tested the evidence samples, and reported the results, more than a year before it received Cordova's reference blood sample for analysis. Contamination in this case was thus impossible, regardless of what happened at other times in other cases.

Second, and this deserves a quotation, "defendant had available a far more probative means to challenge [FSA's] results if, in fact, those results were unreliable. He could simply have retested the evidence himself." The court's point here is worthy of repeating to trial courts strongly and often. Namely, what makes lab records *Brady* material is their potential to cast doubt on the reliability of the test results. This question should be the focus of every trial court inquiry along these lines. And when the requested records would have dubious value in that regard, the fact that new testing could take place can push the records entirely out of the realm of evidence "favorable to the accused." In fact, Cordova's defense did conduct retesting, which only confirmed that it was his sperm in Cannie's body. If retesting shows different results, stated the court, the defense can present that evidence at trial.

The lesson here should be a welcome one to crime labs. All too often, lawyers demand disclosure of information from labs that the scientists know is absolutely irrelevant to the reliability of the reported test results—and this applies to any forensic science discipline, not just DNA. Our Supreme Court has now endorsed a pragmatic calculus for trial courts: Considering everything we know about how the testing occurred,³ including the possibility that the defense could conduct retesting, is there really an argument to be made that the records would be both helpful to the defense and material to the outcome of the case? The question appropriately suggests the answer.

¹ Unless the court overrules itself later, or the United States Supreme Court overrules it, or the state Legislature acts to make the ruling moot.

² *People v. Cordova* (Oct. 26, 2015, S152737) ___ Cal.4th ___.

³ Here I would add considerations like QA/QC protocols, technical review, instrument validation and calibration, and laboratory accreditation.

The Supreme Court opined that, “when the odds are as astronomical as those here, and except for identical twins or close relatives, it may be appropriate for the expert to testify that, to a reasonable scientific certainty, the evidence sample and the defendant’s sample came from the same person.”

Kelly⁴ *general acceptance hearings are not required for new DNA test kits, or other incrementally improved forensic testing techniques built on the same established technological platform as their predecessors.* Cordova claimed that the Identifiler® DNA test kit should have been assessed by the trial court under Kelly’s prong one general acceptance standard. The Supreme Court disagreed, and held that “more sophisticated “ applications of generally accepted PCR and STR testing methods, like Identifiler®, are not new scientific techniques. Only the latter require a first prong Kelly hearing. Of course, observed the court, a party may still cross-examine the other side’s expert about problems with the technology they utilized, but that merely goes to the weight the evidence should be accorded, not its admissibility in the first instance.

Source attribution statements from DNA experts are admissible. Cordova provided an interesting contrast in laboratories’ approaches to source attribution statements from the witness stand as part of DNA testimony. One witness (from a county lab) had no qualms about it:

[Prosecutor]: And I want to talk about those statistics in relation to the blood sample of Joseph Cordova versus the evidence sample and talk about whether or not you can form an opinion to a reasonable scientific certainty as to the source of the evidence sample based on the knowledge you have, assuming the lack of an identical twin and assuming a population of nonrelated individuals.

[Witness]: With those assumptions in place, yes.

[Prosecutor]: And what would your opinion be?

[Witness]: I would attribute the source of the sperm to Joseph Cordova.

Another witness (from a private lab) declined to answer the question:

[Prosecutor]: And in your opinion from a scientific standpoint or reasonable degree of certainty is he the source of the sperm found in the evidence samples in this case?

[Witness]: Here’s where I have a problem. I think that the role of the scientist here is to get you up to the point where you can make the logical leap, but the logical leap then needs to be made by jurors.

[Prosecutor]: Okay.

[Witness]: So the—I—the correct way for the scientist to express this information is that Joseph Cordova and the sperm source share

⁴ *People v. Kelly* (1976) 17 Cal.3d 24. Remember, it’s no longer “Kelly-Frye.” The United States Supreme Court overruled *Frye* in 1993 in *Daubert v. Merrell Dow Pharmaceuticals* (1993) 509 U.S. 579.

the same genetic profile and that genetic profile is expected to be unique in the human population. The next step is a step for the jurors to take.

The Supreme Court opined that, “when the odds are as astronomical as those here, and except for identical twins or close relatives, it may be appropriate for the expert to testify that, to a reasonable scientific certainty, the evidence sample and the defendant’s sample came from the same person.”⁵

The Melendez-Diaz⁶ confrontation clause question is still in play. In Cordova, the trial court permitted testimony from a Cellmark Diagnostics supervising DNA analyst about work done by another analyst who did not testify at trial. The trial witness had performed the technical review in the case—at which time she reviewed the raw data—and had co-signed the lab’s reports. Cordova claimed on appeal, however, that her testimony violated his Sixth Amendment right to confront a witness against him. He argued that he was entitled the opportunity to cross-examine the original analyst. Given the facts presented, and the California Supreme Court’s confrontation clause jurisprudence in *People v. Duno* (2012) 55 Cal.4th 608 and *People v. Lopez* (2012) 55 Cal.4th 569, it should have been straightforward for the court to address the merits of the question and affirm the constitutionality of the evidence. But the court avoided the issue.

Instead, the California Supreme Court decided that, if the testimony was permitted in error, that error was harmless. In other words, it could not have affected the outcome, so the legal issue didn’t matter. Given the redundancy and corroborating effect of DNA test result evidence in Cordova, the court was absolutely right on this point. But why not dig in and decide the confrontation clause question? While one can only speculate, it is possible that our Supreme Court recognizes that the United States Supreme Court has yet to reconcile deep divisions among its Justices and issue a definitive ruling on the issue. The three United States Supreme Court decisions on the confrontation clause implications of expert testimony have been decided by 5-4, 5-4, and 4-1-4 splits between the nine Justices. Not knowing how the United States Supreme Court will view the problem in the future, but knowing that it will grant review of another expert testimony confrontation clause case at some point, it is a safer course for a state supreme court to decide the claim on other grounds. Bottom line: we haven’t heard the last word in the Melendez-Diaz line of case authority. Stay tuned.

⁵ The random match probability statistics offered at trial ranged from one in 670 quadrillion and “one out of a trillion trillion,” or, a septillion. As an aside, the phrase “reasonable scientific certainty” has been critiqued by some courts, as well as the National Commission on Forensic Science. Indeed, the terminology raises several questions: What is “scientific certainty,” really? And if someone is actually certain of something, aren’t they more than reasonably certain of it? And, by whose measure should the jury evaluate the reasonableness of an ostensibly true statement, since “reasonable” implies subjective judgment?

⁶ *Melendez-Diaz v. Massachusetts* (2009) 557 U.S. 305.

Last Word from the Past-President

When I began my term as president of the CAC, I vowed in my first message to the membership that I put my support behind certification offered by the American Board of Criminalistics. During my term, we at the board made it a mission to strongly support our members to not only to become certified but for those already certified to continue to retain their certification. One of my promises made as president that I myself would undergo the process of becoming certified. Despite scheduling conflicts and other distractions during my year as your president, I applied for and sat for the exam at the meeting in Ventura this past May. Besides me, only one other individual sat for an ABC exam. It was a most challenging exam as most anyone who has taken it will tell you. I left the examination room wondering how many questions I got right as opposed to how many I may have missed. Well, to minimize the suspense, I can proudly exclaim that I did pass. I am now a Diplomate in Comprehensive Criminalistics and certified as such with the American Board of Criminalistics.

With the recent news coming from Washington that the Department of Justice has formed the National Commission on Forensic Science and that the National Institute of Standards and Technology has formed the Organizations of Scientific Area Committees, the probability that mandatory certification of forensic practitioners is all but certain. Certification will be not be a recommendation; it will be a mandate. Laboratory accreditation is already virtually required. Therefore, I encourage all CAC members who are not now certified to begin the process. The CAC has the means to assist you financially in terms of the application process, and for some paying for the sitting fee. By becoming certified through the ABC or another body that oversees your area of specialty, you will not only have the satisfaction of knowing that you are well versed in the subject of your discipline, that you are the member of an accredited certification body, but that you have demonstrated a commitment to further gaining knowledge not to just yourself but to your lab, and your profession. Now, let's get out there and get certified!

—Gregory E. Laskowski

Six Thousand and Counting

On October 27, 2015, the Serology DNA Unit (SDU) of the LAPD Forensic Science Division (Scientific Investigation Division) marked a milestone of its 6000th offender hit. Since 2001, the SDU has been submitting DNA profiles from crime scenes to the California Department of Justice and the Federal Bureau of Investigation, resulting in thousands of investigative leads.

—Larry Blanton

Centers of "Excellence"

When I hear or read some institution described as a "center of excellence," simultaneously my blood pressure goes up and I have to fight my gag reflex. Today, more and more institutions have this designation. Don't believe me? Just perform a Google search and enter the term, "center of excellence." It has been used so much that the term "excellent" has just about lost its impact as a positive descriptor.

I don't care much about use of the term in other fields, but it particularly irks me to see it used in forensic science and its subdiscipline, criminalistics. Paraphrasing from a NIST website www.nist.gov/coe/forensics/index.cfm "NIST announced today that it has selected a consortium led by ___ to establish a new NIST-sponsored center of excellence for _____. The ___ new Center will be funded in part by a \$25 million award from NIST over five years."

Instead of this title being created, awarded, and funded by some governing government organization, wouldn't it be fair if said institution had to first conclusively show that according to *Daubert* criteria they were entitled to this descriptor? For example:

1. What performance tests have been carried out by disinterested parties that clearly show their work product meets the standard of "excellent" (must first be defined).
2. What is the known or potential rate of error for their work product?
3. Have the methods used in producing their work product been subject to peer review?
4. Are there established standards controlling the techniques they use?
5. Have they shown that the methods they use are generally accepted by the forensic science community?

If one's place of employment does not have the "center of excellence" descriptor, then it must be something less. Hmm, what are some antonyms for "excellence"? I find "mediocrity; unimportance; failure; imperfection; inferiority." I find the term "center of excellence" to be an example of "puffery." That is, although not used in the world of advertising, it is a promotional statement or claim that is in no way supported by objective data.

So, if you feel as I do, what can we do? My solution (and I hope it will be followed by others) is that whenever attending a conference, seminar, symposium, study group, etc. and I hear or see used the term, "center of excellence", I will loudly shout out, "Puffery!"

—Bob Blackledge
ROF & Forensic Science Gadget

Spring 2016 Seminar for Free?



Full Member Seminar Lottery Now Open

That's right! If you're a Full member of the CAC, throw your name in the hat to be awarded \$1000 to attend the Spring seminar, hosted by the Los Angeles PD Laboratory. They already are hard at work planning what is sure to be a great conference, and you can attend for free! Just follow these easy steps to enter (Full Members only): Log into your CAC account, Click the "Edit" button, Scroll down to "Enter Spring 2016 Seminar Lottery" & check the box...and may the odds be ever, well, you know...

chris Coleman

together training programs that are broadcast as webinars. I'm sure quite a few of you have attended one of their webcasts. I have viewed many, and they were all really good.

In 2013, DOJ (Department of Justice) established the NCFS (National Commission on Forensic Science) in partnership with NIST (National Institute of Standards and Technology) to enhance the practice and improve the reliability of forensic science. The very thing the NAS report was calling for. The NCFS is composed of individuals from all aspects of science and justice (including forensic science) and its objective is to provide recommendations and advice to DOJ on how to strengthen the validity and reliability of forensic science. NIST for its part established OSAC (Organization of Scientific Area Committees) to coordinate development of standards and guidelines for the forensic science community to improve quality and consistency of work in our fields. OSAC essentially replaces the SWG's (Scientific Working Groups) that previously performed this function. The NCFS and OSAC will cooperate and collaborate in these endeavors and is, in my opinion, a great thing. The NCFS is composed of almost 50 members while the OSAC and its numerous sub-committees have well over 500 people involved, and both include forensic scientists.

Which brings me to the PCAST (President's Council of Advisors on Science and Technology) an arm of the OSTP (Office of Science and Technology Policy) who convened a group of scientists (none in forensic sciences) on October 22nd to explore how best to ensure the quality of forensic science. The PCAST group sent inquiries to many of the aforementioned professional associations, which in turn were distributed out to members. This is an effort to hear from the "broad stakeholder community" and "in an effort to better understand the landscape of this topic. I was the recipient of their inquiry, not once, not twice, but three separate times! It set off a firestorm of emails that I was a party to about who should respond and what should we say. I was even asked several times if I would be responding as the voice of the CAC. The AAFS is formulating a response, as are several other associations. I mean its only seven questions right? Except when you really delve into

it, they are asking nineteen specific questions, many of which have very complex answers that require lengthy discussion to properly answer. Oh yeah, they need the responses in three weeks.

Luckily while I was contemplating taking an extended vacation somewhere with no cell coverage or internet, I received a forwarded email from the chair of one of the OSAC sub-committees discussing how they were going to respond to this inquiry so there were no duplication of efforts. Thank you! Finally we are making some sense out of this quandary. I can't imagine the twenty PCAST committee members reviewing 15,000 individual replies or even the several hundred they are sure to get with even the very limited timeline they allowed. But responding with a group effort from an entity that is representing us (the forensic scientists) and our best interests sure made me feel better. Especially since I thought we already responded to these inquiries a few times since the NAS report was released in 2009. Oh how quickly we forget...

Now before anyone gets up in arms about what I have just said, take my sarcasm with a grain of salt. While venting my own frustrations I am not only trying to entertain you, so you keep reading, but also educate you. Knowledge is power folks. We have been duplicating our efforts over and over for as long as I can remember and we do need a unifying voice to represent us. So go research the alphabet soup of groups I have mentioned and come to your own conclusions. Then get involved! Join some of these groups and make sure your voice is heard. I'm just happy that since I don't have to respond to this inquiry, I can use my time wisely on another email I received recently. It seems a foreign interest with lots of capital in off shore accounts needs my assistance investing that money here in the United States and will pay me a percentage for my efforts! So even though my term as President will end soon, I will be just fine. ;-) Until next time, take care.



LA Confidential: A Crime to Remember

Los Angeles Police Department
Forensic Science Division

2016 Spring Seminar
May 2-6th, 2016



The Garland Hotel
4222 Vineland Ave
North Hollywood, CA 91602
Room rates \$155/ night
(+taxes/ fees, based on availability)

<http://www.cacnews.org> for
more details



welcome to san mateo



A true pioneer in the field of PCR, Dr. Henry Erlich delivered the Founders Lecture. After an introduction by Jennifer Mihalovich (above, r) he took his attentive audience through the history of forensic DNA analysis, beginning in 1985 and continuing right up to the present.



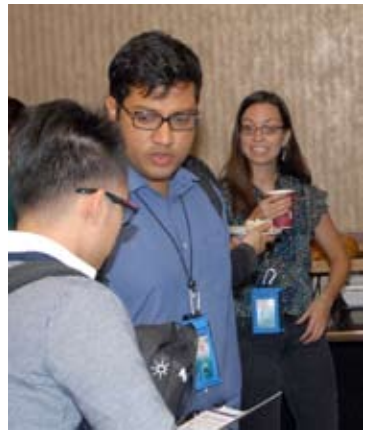
126th CAC Seminar started off with a biting commentary as the San Mateo County Sheriff's Office Forensic Laboratory hosted the fall 2015 meeting. With a theme like sharks, how could you go wrong? From the Pacific Shark Research Center came David A. Ebert and Victoria Vasquez, experts who answered questions and corrected misapprehensions in a most entertaining fashion.

Workshops

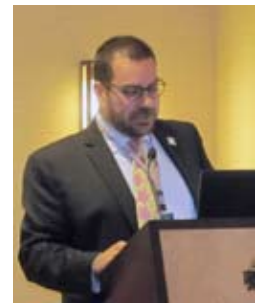


welcome to san mateo





welcome to san mateo





California Association of Criminalists

CALL FOR PROPOSALS

2016-17 McLaughlin Endowment Funding

The A. Reed and Virginia McLaughlin Endowment of the California Association of Criminalists is beginning its annual cycle of grant funding. During 2015-2016, grants for training, scholarships and research totaled over \$30,000. Applications and requests are now being accepted for 2016-2017 funding.

The Training and Resources (T&R) Committee Chair must receive applications for training funds by **Friday, February 19, 2016**. (See Section I below for specific application information).

The Endowment Committee Chair must receive requests for all scholarships or research funds by **Friday, March 18, 2016** for consideration. (See Sections II & III below for specific information).

Specific Requirements for Proposals

I. Training

A. General

Requests to sponsor training must be submitted earlier than other requests so that the Training and Resources Committee can review them and coordinate with other CAC training efforts. The T&R Committee shall prioritize these requests where necessary and shall consider how the requested training fits into the overall training needs/desires of CAC members. The T&R Committee shall forward ALL requests to sponsor training together with their recommendations to the Endowment Committee for their consideration.

B. Request Format

The two-page Application for Training Funding should be completed. This application is available on the CAC website (www.cacnews.org) and requests the following:

1. Class title, outline and description of ownership (public or privately owned).
2. Information (curriculum vitae) on instructors.
3. Class logistics: minimum and maximum size, limitations and location.
4. Class coordinator/contact person.
5. Student interest/demand supported by T&R Survey and/or the number of applications on file.
6. Course budget including supplies, texts or handouts, instructor fees, travel/per diem, and site costs. Amortize material fees for # of CAC

member/class.

7. Student fees.

Send completed Application for Training Funding forms to the T&R Committee Chair by **Friday, February 19, 2016**.

II. Scholarships

A. General

The A. Reed and Virginia McLaughlin Endowment offers scholarships through academic institutions rather than directly to students. Proposals from academic institutions shall set forth their general criteria for student scholarship selection. The academic institution shall be responsible for selection of student recipients of such scholarships and shall report award-ees and amounts to the Endowment. Students receiving funds must be members of, or applicants to, the CAC. Students who are interested should request application information directly from their academic program coordinator.

B. Request Format

Proposals for scholarships must contain both a summary and detail section containing a general description of the academic program, its goals, and information on how the proposed funds would be used. For example, will funds be used for tuition and fee relief, stipendiary support, to underwrite student research, etc? The detailed description should include information on recipient selection criteria and who will perform the selection. Scholarship fund administrators must be named, including who will be responsible for submitting the mandatory annual report of activities to the CAC.

C. Reporting of Distributions

The Academic Program Coordinator must provide a full accounting of the recipients and how they meet the minimum criteria.

D. Refund of Unused Endowment Funds

Any remaining unused portion of the endowment funding shall be returned to the Endowment fund via the CAC Treasurer.

III. Technical Development and Research

A. General

The implementation of new and more efficient technical procedures related to forensic science requires the investment of time, ingenuity, and resources by those working in the field. The development of new techniques and technology can benefit the profession by one or more of the following:

1. Permitting the development of new or additional information from the analysis of certain types

2016-17 Call for Proposals

of evidence.

2. Implementing a mechanism for the analysis of new forms of evidence.
3. Improving the reliability of methods already in use.
4. Increasing sample throughput by improving efficiency.

Resources permitting, the CAC encourages technical development or research for the benefit of the profession. The A. Reed and Virginia McLaughlin Endowment does not generally fund professional level salary for researchers. Incidental funds for students assisting in research projects will be considered. However, neither the CAC nor the Endowment shall act as an employer.

B. Request Format

Requests for funding for technical development or research should contain the following:

1. Project name and purpose.
2. Name(s) and curriculum vitae for each researcher.
3. A brief description or outline of the project.
4. Information on the project facilities, equipment and supplies needed.
5. Information on the project site, including permission to use the site for this purpose where applicable.
6. Information on the adequacy of available space, safety planning, equipment and supplies.
7. Agreement for responsibility for disposal of products of research, including but not limited to chemicals, biochemicals, biologicals, and hazardous waste.
8. Project budget.
9. Time line and projected completion date of project.

C. Progress Reports

Progress reports will be required in writing, the frequency to be determined by the Endowment Committee. The recipient must prepare a final project report, including a summary of results and conclusions. As a condition of funding, products of research must be submitted to:

1. CAC Seminar Technical Program Chairperson with intent to present research at a CAC seminar; or
2. CAC Editorial Secretary for publication in a journal or newsletter as appropriate.

When problems occur or results are not as expected, funding recipients are expected to use good judgement in reevaluating the course and goals of the project, and in modifying the project approach as necessary to maximize the project results. The project should be terminated when it is determined that the value of the project is minimal. In addition, funding may be terminated by the Endowment Committee if progress is inadequate.

The T&R Chair must receive all proposals for **training** by **Friday, February 19, 2016.**

Send proposals to:

Trevor Gillis
Santa Clara County DA Crime Lab
250 W. Hedding St.
San Jose, CA 95110
Tel: (408) 808-5900; Fax: (408) 297-6532
tgillis@crimelab.scgov.org

The Endowment Committee Chair must receive all proposals for **scholarships or research** by **Friday, March 18, 2016.**

Send proposals to:

Nessa Rosenbaum
San Bernardino County Sheriff's Dept.,
Scientific Investigations Division
200 South Lena Road
San Bernardino, CA 92415-0056
Tel: (909) 387-2200; Fax: (909) 387-2688
nrosenbaum@sbcscd.org

PLEASE NOTE:

Preference will be given to CAC members and California Universities/Colleges with Forensic Science programs.

Applications that miss the deadline dates will not qualify for consideration.

If you submit a proposal and do not receive confirmation from the Endowment Committee that it has been received, call the Chairperson before March 18th, 2016.

ADVANCED MICROSCOPY

CLASS DATE: MARCH 7-11, 2016

CLASS CODE/CLASS: M205 ADVANCED MICROSCOPY

SUBJECT AREA: M-Microscopy and Trace Program

CLASS LOCATION: California Criminalistics Institute
11181 Sun Center Drive, Rancho Cordova, CA 95670

CLASS DESCRIPTION:

This one-week (40-hour) course will provide the students the ability to use optical properties to identify or characterize trace evidence, learn advanced microscopy techniques such as central stop dispersion staining, microchemical and fusion methods, and learn particle analysis techniques for the identification of unknown materials.

This course:

- is next in the series course after Basic Practical Microscopy (M101)
- will complement hair, fiber, building materials, soils and minerals, sexual assault evidence, explosives, and drug identification as well as paint comparison courses taught at CCI
- is intended for criminalists involved in microscopy, drugs, and trace evidence work

Upon completion, students should be capable of utilizing advanced techniques in the analysis of materials using various microscopical methods.

Each class is limited to 12 students. This course is POST certified.

INSTRUCTORS: William Schneck and Wayne Moorehead

TEACHING METHODS: Classroom lectures, video demonstrations, and practical exercises.

OBJECTIVES: Students will be required to demonstrate their proficiency in practical and written tests.

PREREQUISITES: Basic Practical Microscopy (M101) or its equivalent. The student is expected to be familiar with microscope alignment, Kohler illumination, and polarized light.

PREPARATION: A pre-reading package may be assigned.

MATERIALS FEE: \$35.00 materials fee will be charged to all non-BFS students. This charge is due at the beginning of the class. Make check(s) payable to the California Department of Justice.

TUITION: No cost to POST supported or State of California based law enforcement agencies. A \$600.00 tuition fee will be required of all other public agency, private sector, or out-of-state applicants.

CONTACT COURSE COORDINATOR:

Neda.Khoshkebari@doj.ca.gov

(916) 464-5599 for additional information.

FAX (916) 464-5818

Applications are available through: <http://ag.ca.gov/ccil/>



ABSTRACTS

FROM THE

FALL 2015 SEMINAR

The Effects of Lean Six Sigma: Hard Numbers and the Intangibles

Maria Cowman, San Francisco Police Department

Lean Six Sigma is an efficiency methodology focused on improving throughput and quality by systematically removing waste and promoting standardization, while fostering a culture of teamwork and data-fueled change.

Our goals in creating an LSS team were to produce a predictable turn-around time (TAT) within the required 120 day limits of AB 1517, to create a culture of visibility and accountability among analysts and management, and to completely eliminate a need for outsourcing casework.

We began the LSS project in February 2015, with a team of 5 analysts, 1 supervisor and 2 off-site leaders. Over the last 6 months, the team has gone through the five steps of LSS - Define, Measure, Analyze, Improve and Control.

During the Define phase we pinpointed 3 major areas for growth by seeing where a case sat for the longest amount of time and held up workflow. The areas were standardization of screening examination, data interpretation, and tech review. In Measure, we provided mock screening cases to analysts, made step-by-step logs of data interpretation, and tracked and categorized every error found during technical review. In Analyze, we evaluated the data. We determined Loss of Memory cases needed more instruction during screening to ensure standard work and that tech review errors were largely administrative in nature. We also found that while LSS typically sees intralab variation in data interpretation and must account for and eliminate that variance, our lab data interpretation was standardized across the board and there was simply a need for uniform documentation.

We presented the results to the unit, and brainstormed together for solutions to try during the Improve phase. These solutions included a defined 3-day DNA lab schedule and constructing a presumptive test guide addressing Loss of Memory cases, as well as longer term goals of creating a comprehensive DNA-specific technical review checklist to correct for administrative areas before review. Currently we are in the Control phase where we are continuing to implement improvements and track our productivity numbers daily, weekly and monthly as we work towards a steady state of <120 days TAT for every case by our stated goal of Sept, 2015.

A summary of each LSS phase will be discussed as well as the impact LSS has had on TAT, production, and lab culture.

Utility of Novel qPCR and PCR Systems for the Analysis of Challenging Samples

Jonathan Tabak, InnoGenomics Technologies

There is currently a need for more robust, highly sensitive, reproducible methods for DNA quantitation and typing when profiling difficult forensic samples. Downstream processing decisions, such as targeting amplification DNA amount based on quantitation results and the typing system best suited for a sample based on the quality of the DNA, are

crucial in obtaining a typing result from these challenging samples.

This presentation discusses the use of a combination of two recently developed technologies to improve the success rate for obtaining informative results from forensic samples, including highly compromised, degraded and trace samples. First, quantitation of extracted DNA is critical, and a quality/quantity sample assessment can be effective in determining which typing system to use, as well as how much DNA to take forward to the typing stage with the highest chance of first pass success rates, eliminating the need for repeat analysis. New DNA quantitation kits, InnoQuant® and InnoQuant® HY are designed to generate more accurate and reproducible information about casework samples. These next generation DNA quantitation kits allow accurate quantitation at picogram levels (~1 pg) of two autosomal targets: a short Alu based target of 80 bp in size, and a long target from a separate retrotransposon of 207 bp in size. The InnoQuant® HY kit also includes a male specific multi-copy target. The large copy number of the selected autosomal targets (>1000 copies/genome) provides high sensitivity while minimizing the effect of variation between individuals, enabling high reproducibility for low level samples. Studies presented will demonstrate the ability of the InnoQuant® kit to enable confident screening of negative samples and guide selection of optimal downstream typing methods and input DNA target amount, based on the samples quantitation and degradation index (DI) values. Additionally, the correlation between quantitation values, DI and profile recovery with property crime samples will be presented.

Once the determination is made for how much DNA to take forward to the typing stage with the highest chance of first pass success rate, several systems are now available to enhance a laboratory's ability to obtain a usable, interpretable DNA profile. One of these systems, the InnoTyper® 21 kit, is a small amplicon DNA typing system for challenging forensic samples that is compatible with currently used PCR/CE instrument platforms. The system contains 20 Alu retrotransposon element bi-allelic markers, ranging in size from 60-125 bp, making the assay highly sensitive for extremely degraded and/or low-level forensic samples, and enabling recovery of discriminating results from samples that would typically require mtDNA sequencing. The application of the InnoTyper® 21 system to challenging samples such as rootless hair shafts and degraded skeletal remain samples, will be presented.

Using data generated from multiple studies with real casework samples, this presentation will demonstrate the utility and efficacy of the InnoQuant® and InnoTyper® 21 systems to improve processing decisions, prevent the consumption of limited samples, and increase workflow efficiency while increasing success rates with extremely challenging forensic samples.

Integrating PowerQuant Into a Forensic Lab that Utilizes Y-Screening

Presenter: Craig Nolde, Sorenson Forensics

The PowerQuant System from Promega Corporation is one of the latest versions of qPCR chemistry designed to quantify samples generated during genetic identity processing. In addition to quantifying samples, some laboratories use a technique, often referred to as Y-

screening, to determine whether questioned forensic samples have the presence of male DNA before DNA typing is attempted. By taking advantage of current assays to detect DNA, Y-screening can successfully identify samples that would result in probative male profiles even when serological techniques such as microscopic sperm search produce negative results.

A full validation of this chemistry was performed evaluating studies and criteria consistent with SWGDAM guidelines and FBI QAS. In addition to these specific guidelines, threshold assessments were conducted for both Y-screening quantification and quantification occurring after extraction to aid in processing decisions that would maximize the ability to obtain a comparable DNA profile and minimize the need to send samples forward for DNA typing. Key results to consider were related to sensitivity, variability when normalizing samples and whether undetected or zero values are accurately represented to be consistent with downstream results.

The results found during the full validation demonstrated that this new sensitive qPCR chemistry is an improvement over its predecessors in regards to sensitivity, reproducibility, person to person variability, and autosomal to male ratios. New thresholds for Y-screening and quantification performed after extraction need to be applied as well as consideration to added features such as degradation index.

Comparison of Three 6-dye STR DNA Typing Kits

Abby Burg, San Francisco Police Department

Effective January 2017, all forensic DNA laboratories submitting samples to the Combined DNA Index System (CODIS) must use STR DNA typing kits that encompass the new 20 core CODIS loci.

Currently there are three commercially available 6-dye STR DNA typing kits that will produce DNA profiles containing the required 20 core CODIS loci. In an effort to identify the optimal kit for use at the San Francisco Police Department Criminalistics Laboratory, a comparison of all three kits was performed to select a single kit for validation.

Kits and required reagents (spectral standard, size standard, etc.) were donated by three companies for use in the comparison tests. Lab donor saliva swab samples were extracted using a Qiagen EZ1 XL advanced robot with the DNA Investigator Kit and quantified in triplicate using Quantifiler Duo on an ABI 7500.

The initial comparison was a sensitivity study using two samples each of a single source sample, two person 1:1 mixture, and three person 1:1:1 mixture. The input of DNA ranged from 3 ng to 0.008 ng, cycling parameters were per manufacturer's recommendations on an ABI 9700, separation was with an ABI 3130xl, and analysis used Genemapper IDX v1.4. Based on this study, the optimal input was determined for each kit and used for subsequent comparisons.

The next comparison was to evaluate performance in mixtures using two and three person mixtures in triplicate in the following ratios: 1:20, 1:10, 1:5, 1:2, 1:1, 2:1, 5:1, 10:1, 20:1 and 1:1:10, 1:2:10, 1:5:10, 1:1:1, 1:10:2, 1:10:5, 1:2:5.

Kit performance in the presence of inhibitors was assessed by maintaining DNA input at 1/4 optimal amount for single source samples with inhibitor amount increased until failure.

Finally, impact of DNA degradation was investigated for each kit by subjecting 1 ng/ul of single source DNA samples to 30 minutes of maximum vortex speed, UV exposure for 30 minutes and 20 minutes of autoclaving.

Results for each study will be presented and the final decision of the laboratory detailing what kit was chosen for final validation for use in casework will be discussed.

Combined Autosomal STR and Y-STR Multiplex System

Sara Laber, Promega Corporation

The PowerPlex® Fusion 6C System is a 6-color STR system for simultaneously amplifying 23 autosomal loci, three Y-STR loci, and Amelogenin. The twenty required (Amelogenin, D18S51, FGA, D21S11, D8S1179, vWA, D13S317, D16S539, D7S820, TH01, D3S1358, D5S818, CSF1PO, D2S1338, D19S433, D1S1656, D12S391, D2S441, D10S1248, DYS391) and three recommended (TPOX, D22S1045, SE33) proposed expanded CODIS core loci are combined with Penta D, Penta E, DYS570, and DYS576 to give this system a discriminatory power ($PI = 1.80 \times 10^{-32}$) that is over 108-fold higher than that for the twenty required expanded CODIS core loci ($PI = 9.35 \times 10^{-24}$). With DYS391 and nine autosomal loci being less than 250bp, the additional genetic information obtained with this 27-loci STR system will be extremely useful for analyzing degraded samples, where even a partial profile would be informative.

The DYS391 locus is included in the proposed expanded CODIS core loci for verification of gender in amelogenin null samples. However, it has one of the lowest locus variability values and does not significantly increase discriminatory power. In contrast, DYS570 and DYS576 have two of the highest locus variability values within American subpopulations and contribute more to the system's discriminatory power than DYS391. Additionally, because they are rapidly mutating Y-STRs, DYS570 and DYS576 provide the potential for separating close male relatives and further improving useful information from a single STR analysis. These three Y-STR loci will allow more confident determination of the number of male contributors in complex mixtures without the need for a separate Y-STR analysis, thus saving time and money.

This system is designed for 1ng of optimal input DNA template. The average peak height ratio is over 90% with 1ng DNA template and remains high (80%) with as low as 100pg DNA template. It is very sensitive and is capable of calling $98 \pm 21\%$ (average \pm SD) of alleles with 100pg DNA template. Even with as low as 50pg DNA template, $77 \pm 17\%$ (average \pm SD) of alleles are called. The system is also resistant to very high concentrations of PCR inhibitors. One-hundred percent of alleles are called in reactions containing up to 0.5mM hematin with this system. Improved resistance to humic acid and tannic acid is also observed.

To improve laboratory workflow efficiency, this system is designed for use with both casework samples as well with reference and database samples. Direct amplification of blood or buccal samples on multiple substrate types such as FTA® card, nonFTA cards, and swabs eliminates the extraction process, which saves time and money. To further save time and improve efficiency, automation methods are available for multiple liquid handling platforms which result in over 95% first-pass success rate and minimizes potential cross-contamination.

Implementation of a Fully Continuous Approach to DNA Profile Interpretation – It's Actually Possible...

Lisa Hobgood and Christie Johnson, Defense Forensic Science Center

Interpretation of complex DNA mixtures is one of the main challenges for forensic DNA laboratories. New SWGDAM guidelines, as well as the forensic DNA community, are advocating for a better and more consistent way to interpret these types of mixtures. The move toward probabilistic genotyping using likelihood ratios is a way to make full use of mixture data during interpretation. Several software programs are currently available to assist in this analysis. This presentation will focus on the Defense Forensic Science Center's (DFSC) implementation of one such program to include the validation of software, training of analysts as well as a quick overview of the basics of how the program works. Casework examples will also be shown to illustrate how mixtures that were once considered uninterpretable can now be used to aid in the investigation of a crime. This brief overview will give a perspective from a casework laboratory's point of view, providing a better understanding of this tool and how powerful it can be when compared to conventional CPI/RMP methods.

A False Confession and a CODIS Hit Entwine Two Capital Cases

Gary Harmor, Serological Research Institute

On Mothers Day in 2005, two young girls, Laura Hobbs (age 8) and Krystal Tobias (age 9) were both brutally stabbed to death in a park in Zion, Illinois. Jerry Hobbs, an ex-convict and father to Laura Hobbs was arrested shortly after finding his daughters body. After over 24 hours of interrogation, Hobbs confessed, recorded on video, to the murders and signed a confession. SERI was hired by the Public Defenders Office of Lake County in 2007. Brian Wraaxall and Heather Parsons developed a genetic profile from semen stains found on Laura Hobbs, semen stains missed by NIRCL. The genetic profile eliminated Jerry Hobbs, but he remained in custody and charged with capital murder for three more years. The semen donors profile eventually hit in CODIS in June of 2010 to a Jorge Torrez. Torrez had been previously charged with abduction and a number of sexual assaults in Alexandria, VA. He was convicted and was serving five life sentences plus 168 years for the Northern Virginia attacks. Jorge Torrez, 16 years old at the time of the Illinois murders, was a friend of

Kristal Tobias older step brother. Jerry Hobbs was released and all charges were dropped in August of 2010. Jerry Hobbs sued for his arrest and imprisonment and received approximately \$8 million settlement in 2013. Jorge Torres profile also hit the semen profile in the rape/strangulation homicide case of U.S. Navy service member, Amanda Snell. He was tried and convicted in the Amanda Snell Federal Court case. During the penalty phase of the trial, the jury heard of the other cases including the double homicide in Illinois. In June of 2014, at the age of 25, Jorge Torrez was sentenced to death in U.S. District Federal Court in Alexandria, Virginia for the killing of Amanda Snell. A Capital Homicide Trial is pending in Illinois.

The Six Year Itch

Tony Nguyen, Contra Costa County Sheriff's Office

An interesting cold case, and the techniques and approach that was necessary in linking it to another cold case.

Evaluation Results of QIAGEN's Investigator® 24plex QS and GO! STR Multiplex PCR Assays

John Haley, Qiagen

In response to the FBI expanded CODIS core loci, QIAGEN developed and validated two Multiplex PCR kits for reliable genotyping of human DNA. The two kits, Investigator® 24plex QS Kit and Investigator® 24plex GO! Kit, were developed for forensic DNA casework and database type samples, respectively. Both kits contain 22 polymorphic STR markers (21 autosomal markers and 1 Y chromosome marker), Amelogenin, and a patent pending and novel Quality Sensor. The Quality Sensor allows for more effective troubleshooting of inhibited and degraded samples, as well as identification of failed amplifications. The Investigator® 24plex multiplex kits were available in the United States as of June 17, 2015 and since their US release the kits have been evaluated in many forensic laboratories. This presentation will provide a glimpse into the preliminary data that laboratories are obtaining when utilizing the Investigator® 24plex multiplex kits themselves.

Internal Validation of a Yfiler Plus Casework Protocol for the Bureau of Forensic Services

Gunther Scharnhorst, California Department Of Justice - Bureau of Forensic Services

This presentation covers the internal validation of a casework protocol utilizing the Life Technologies Yfiler Plus amplification kit. The validation was performed in accordance with the SWGDAM Validation Guidelines for DNA Analysis Methods (approved December 2012) and the SWGDAM Interpretation Guidelines for Y-Chromosome STR Typing by Forensic DNA Laboratories (approved January 2014). Notable aspects of this Y-STR kit will be discussed including the potential impact of the addition of several rapidly mutating Y-STRs and their effects on casework and familial searching.

Digging for the Truth

Alice Hilker, San Mateo County Sheriff's Office

A 2001 slaying of a 15 year old boy, a backyard dig, and the lovers' connection.

Development and Validation of a Targeted Next Generation Sequencing Solution for Forensic Genomics

Kameron Wong, Illumina

Sequencing (NGS) by Synthesis (SBS) enables the entire human genome to be sequenced in one day. As a simpler yet highly effective alternative, forensic scientists can choose to perform targeted sequencing of PCR products. By sequencing a dense set of forensic loci, casework and database efforts are directed toward the genomic regions that best answer fo-

rensic questions, relieving privacy concerns and simplifying analysis. Because it does not depend on allele separation by size, the number of targets interrogated is not limited, allowing a more comprehensive result to be generated.

We describe the development and validation of a targeted amplicon panel for forensic genomics that combines a core of global short tandem repeat markers used routinely today, along with additional forensic loci that can provide information when standard markers would fail to sufficiently resolve a case. Maximizing the number and types of markers that are analyzed for each sample provides more comprehensive and discriminating information for standard samples, as well as challenging samples that contain low quantities of DNA, degraded and/or inhibited DNA, and complex mixtures. The targeted amplicon panel will enable more complex kinship analysis to be performed, and can also reveal phenotypic and biogeographical ancestry information about a perpetrator to assist with criminal investigations. This capability is expected to dramatically improve the ability to investigate dead end cases, where a suspect reference sample or database hit are not available. We will describe the complete workflow, system, and data analysis tools, and present data from validation and collaborator studies including reproducibility, sensitivity, actual forensic samples, and concordance with standard capillary electrophoresis methods.

(Founder's Lecture)

Thirty Years of Forensic DNA Analysis: A Perspective

Henry Erlich, Ph.D., Children's Hospital Oakland Research Institute

In 1985, two papers reported technical developments that revolutionized the field of forensics genetics. The analysis by Southern Blotting of Variable Number Tandem Repeat (VNTR) regions of human genomic DNA, known as "DNA Fingerprinting," was used for individual identification and in vitro method of enzymatic amplification, termed Polymerase Chain Reaction or PCR, was used to amplify and genotype a single gene (beta-globin) from human genomic DNA. PCR amplification of the polymorphic HLA-DQA1 gene with a thermostable DNA polymerase provided evidence in the first U.S. DNA case in 1986 (*Pennsylvania vs Pestinikis*) as well as the first exoneration (*Illinois vs Dotson*) in 1987. This assay, based on genotyping with immobilized hybridization probes, became the basis for the first commercial PCR test in 1991 and, along with the SNP-based test, Polymarker, introduced shortly thereafter, was widely used in forensics analysis. The introduction of commercial PCR-based kits to analyze a specific set of short tandem repeats (STRs) using capillary electrophoresis provided greatly enhanced discrimination potential. These STR systems are the basis of current casework and database genotyping and, in a sense, represent the "fusion" of the two technical developments reported 30 years ago. The history of forensic DNA analysis in criminal cases and missing person identification, including a discussion of the so-called "DNA Wars" period during which the admissibility of DNA evidence was hotly debated, will be reviewed. Finally, recent developments in the application of "Next Generation Sequencing" technology using mitochondrial DNA to the analysis of particularly challenging forensic specimens, such as mixed samples, will be discussed.

Looking for "Lost Sharks": A Journey of Discovery

David A. Ebert, Ph.D., Program Director. Pacific Shark Research Center and Victoria Vasquez, Pacific Shark Research Center

The public's perception of sharks often conjures up images of a large, fearsome, toothy predator, with its large dorsal fin cutting its way through the waters' surface. However, the reality is that sharks come in a variety of sizes and shapes, from the whale shark (*Rhincodon typus*), the world's largest fish, to the dwarf pygmy sharks (*Squaliolus spp.*), these enigmatic fishes occupy most marine, and some freshwater, habitats. In addition, the batoids and chimaeras, along with the sharks, form a distinctive group of fishes collectively referred to as the Chondrichthyans. There are more than 500 species of sharks, along with nearly 650 batoid and 50 chimaera species, bringing the overall total to about 1200 species of sharks and shark-like fishes. The diversity of sharks and their relatives has increased exponentially over the past decade with more than 230 new species having been described over the past decade. This represents nearly 20% of all shark species that have been described. Most of these new discoveries have come from the Indo-Australian region, followed by the Western Indian Ocean and western North Pacific regions. However, despite such a rich and diverse fauna, the majority of sharks and their relatives have largely been "lost" in a hyper-driven media age whereby a few large charismatic shark mega-stars overshadow the majority of shark species. While these mega-stars, such as the Great White Shark (*Carcharodon carcharias*), receive much media adulation and are the focus of numerous conservation and "scientific" efforts the "Lost Sharks" remains largely unknown not only to the public, but also to the scientific and conservation communities. A review of the Red List status of Chondrichthyans indicates that 17.4% are threatened and nearly half (46.8%) are Data Deficient or have not been assessed. It is these "Lost Sharks" sharks that will be the focus of my presentation.

Familial DNA Links Suspect in the North County Creeper Case

Jennifer Mertz, Bureau of Forensic Services Richmond DNA Laboratory, Jason Rouse, Escondido Police Department, Jeffrey Udvarhelyi, Escondido Police Department, and Shelly Webster, San Diego County Sheriff's Department

In the summer of 2013, San Diego County was having a heat wave in the North County. Many homes had their windows open at night for relief; thus making it easy for hot prowls to occur. One individual (North County Creeper) was climbing in open windows. He was molesting innocent children, while they were sleeping. This happened in multiple jurisdiction with numerous houses. A team approach was taken to catch this molester. After a year and half with no suspect, a familial hit occurred. This led to an arrest of the North County Creeper in Feb. 2015.

This presentation will take you back to summer of 2013. We will follow the cases from the perspectives of the lead detectives, the casework DNA analyst, and the familial DNA analyst. It will show the importance of teamwork among investigators and forensic scientists.

Crime Scene Bravos and Blunders

Kirsten Fraser, Los Angeles County Sheriff's Department

Crime scene investigation is a delicate process and one that is just as reliant on human diligence as it is susceptible to human error. This presentation will discuss some important successes over the years as well as some funny, albeit embarrassing, blunders that have occurred at crime scenes.

Comments on the Responses to the Proposed National Code of Ethics and Professional Responsibility for the Forensic Sciences

Donald Jones, San Bernardino Sheriff's Department (Retired)

Under the auspices of the National Institute of Standards and Technology the Interim Solutions Subcommittee of the National Commission of Forensic Science drafted a proposed National Code of Ethics and Professional Responsibility for the Forensic Sciences (Code). In April 2015 this draft was made available for one month for the solicitation of comments and feedback. In all, twenty seven responses were posted. They contained specific concerns relating to protection of defense analysts, lab managers, and whistle-blowers to whether certification should be required to properly defining terms to grammatical corrections. In general, it appears the majority of input was from attorneys, professors, and lab management personnel. It seemed there were very few comments from actual forensic laboratory practitioners. While this was only a starting point for a Code, many commented on the need for an enforcement process, a fact already recognized by the subcommittee up front. A close look at some of the Code requirements for forensic service providers (both analysts and managers) should cause some concern regarding the scope of intentions for a National Code of Ethics.

Hillsdale High School Attack

Jeff Gilbert, Lead Principal, Hillsdale High School, Kevin Raeffaelli, Inspector, County of San Mateo District Attorney's Office, Christina Richardson, Criminalist, County of San Mateo Sheriff's Office, Brian Hester, Special Agent, Bureau of Alcohol, Tobacco, Firearms and Explosives, Karen Guidotti, Chief Deputy, County of San Mateo District Attorney's Office

On August 24 of 2009, a 17 year old former student of Hillsdale High School in San Mateo, CA walked onto the campus with the intent to kill his teachers. He had a well designed and practiced plan of attack and was heavily and uniquely armed for the assault. Alert and courageous school staff and first responders, coupled with the assailant's poor plan execution, thwarted the attack and averted potential tragedy.

A panel, consisting of the school principal, law enforcement incident commander, explosives expert, forensic laboratory / CSI team member, and prosecuting attorney will discuss the unusual event circumstances and lessons learned. This is a unique opportunity to hear from those directly involved in the detection and intervention of the unsuccessful attack and its subsequent investigation and prosecution.

Asiana Airlines Flight 214 Plane Crash

Robert Foucrault, Coroner - County of San Mateo Coroner's Office

On July 6, 2013 at 11:30 a.m. the San Mateo County Coroner's Office was notified of a plane crash at San Francisco International Airport. The airport is located in the north end of the county and is one of the busiest airports in the United States.

This presentation will take you through the process and procedures followed in responding to this disaster. The aircraft was a Boeing 777 and was reported to have 307 passengers on board. As the investigation progressed we were able to confirm 2 deaths at the scene. One additional victim was seriously injured and subsequently died at San Francisco General Hospital 6 days later.

During our investigation, we were able to confirm one of the deaths occurred from fatal injuries that were unfortunately caused by a responding San Francisco fire truck.

I will discuss how our investigation began and some of the details that led us to our conclusions regarding the decedents as well as the complications associated with a multi-agency involvement and parallel investigations.

Confirmation Bias: A Large Scale Evaluation of Past Firearms Comparison Casework

Todd Weller, Oakland Police Department

The concept of confirmation bias and its influence on forensic science is not new. Past studies indicate that confirmation bias is real has the potential to influence forensic science outcomes. In a nutshell, the fear is that close proximity to police personnel and access to case

information will result in a higher portion of identifications (or misidentifications). However, it has been our experience at the Oakland Police Department Criminalistics Firearms and Toolmark Unit that a significant portion of our casework results in eliminations. We examined several years of past firearms casework and tabulated the numbers of identifications and eliminations being performed at the Oakland Police Criminalistics Laboratory. We purposely focused on casework where confirmation bias would be influential: requests for direct comparisons of firearms to recovered evidence. We found that we are reporting more eliminations than identifications. Furthermore we realized it was important to present this data since the justice system may not be aware of the frequency of these eliminations.

IAI / NIST Stipend for Abstract Submission to make Oral Presentation at 2016 IAI Conference

Gregory Laskowski, Criminalistics Services International, LLC

Interested parties in the fields of criminalistics (crime scenes, bloodstain pattern analysis, and footwear/tire track analysis being excluded) are invited to submit abstracts to the International Association for Identification for oral presentation at next years annual educational conference in Las Vegas, NV. Two presenters will be selected to have their registration, travel, and lodging paid by NIST. The deadline to submit abstracts is December 31. Information will be given on how to submit abstracts for oral presentation.

Driving Under the Influence of Cannabis vs. Driving and Dying Under the Influence of Cannabis

Nikolas P. Lemos, San Francisco Office of Chief Medical Examiner

Cannabis intoxication in living and deceased drivers is an important medicolegal topic, but a limited number of studies review cannabinoid concentrations in both living and deceased humans.

California is currently one of 25 U.S. states and territories to have existing or pending legislation permitting the use of cannabis for medicinal purposes, the State having enacted this legislation since 1996.

The present study examines and compares cannabinoid concentrations measured in two groups of vehicle operators in San Francisco: (1) arrested operators of vehicles who allegedly operated their vehicles in San Francisco while impaired by cannabis, and (2) deceased operators of vehicles involved in fatal traffic accidents whose postmortem bloods were found to contain cannabinoids.

The goals of the study were to determine blood cannabinoid concentrations and to better characterize any differences between these two groups of drivers, who theoretically have access and use similar cannabis preparations available in the City and County of San Francisco, thus removing any bias based on geo-location and cannabis product availability, and whose bloods were analyzed by the same ABFT-accredited laboratory, thus removing any bias based on analytical capability differences.

In addition, the Huestis Predictive Models I II were applied and evaluated in a subgroup of living drivers DUID suspects for whom we were able to identify the time interval between the driving incident (and therefore the last time they had the opportunity to be exposed to cannabis) and the time of blood draw. This portion of the study was designed to determine the consistency between the predicted times of cannabis exposure provided by the Huestis' models and the true (time of alleged driving incident to time of blood draw) obtained from police reports and chain of custody records, in order to assess the usefulness of these research-derived, plasma-based predictive models in a forensic toxicology, whole blood setting after converting whole blood concentrations to plasma equivalent concentrations using various plasma to whole blood ratios and including the 95% Confidence Intervals (CIs) for each of these cases.

From 2010-2013, there were 318 cannabis-positive DUID cases (mean, median THC: 4.9, 3); 88 had cannabis-only in their bloods (mean, median THC: 5.8, 4). In 23 DUID cases, Huestis' Predictive Models with 95% confidence intervals were applied and evaluated, demonstrating that the actual case time points in all 23 cases fell within the predicted time ranges. Among deceased drivers, 19 had cannabis-positive toxicology (mean, median THC: 11.7, 4.5) and 8 had cannabis-only (mean, median THC: 20.3, 19.5). Motorcyclists and bicyclists comprised the majority of deceased vehicle operators, with bicyclists averaging the highest mean and median THC concentrations overall. The ANOVA, between living and deceased drivers' cannabinoid concentrations demonstrated that THC-OH and THC-COOH concentrations are not statistically different between the two groups, but that THC concentrations are, making it difficult to correlate or compare postmortem to antemortem THC concentrations in living and deceased drivers.

Current Trends in Medical Cannabis from the Viewpoint of a Cannabis Testing Lab

Joshua Wurzer, SC Laboratories Inc.

Medical cannabis is quickly gaining legitimacy in the medical and scientific community. With many states also legalizing recreational cannabis, and California poised to do the same, many issues are raised. How do medical cannabis and recreational cannabis coexist in California? This presentation would discuss the current products in the medical cannabis market, their uses, and recent medical research regarding cannabis and cannabinoids. It will also touch on numerous issues surrounding the current medical cannabis system and those that will arise in the near future from the vantage point of a testing laboratory.

We will also discuss what our laboratory does and the history of cannabis testing worldwide which has its roots in forensic testing for law enforcement but has taken on a new meaning since independent labs began opening in the San Francisco Bay Area. Now, quality and safety testing have become mandatory in most states which have legalized medical or recreational cannabis.

Lastly, we will cover the most common tests offered by cannabis labs, as well as, methodology and techniques and discuss the challenges the industry is facing in adopting contaminant tolerances in the absence of federal guidance.

A Comparison of Collection Methods for Touch DNA Samples on Steering Wheels of Vehicles

Irina Kirgiz, UC Davis Forensic Science Graduate Program

The purpose of this research was to directly compare alternative methods for collecting touch DNA from steering wheels. Tape lifting and FTA paper scraping methods were compared to a traditional double swabbing DNA collection method. 35 cars were used in the double swabbing vs. tape lifting study. One half of a steering wheel of each car was sampled using two sterile cotton swabs, while the other side of a steering wheel was sampled using 3M™ Water-Soluble Wave Solder Tape 5414. Another 35 cars were used in the double swabbing vs. FTA paper scraping study. Cotton swabs were used to sample one side of a steering wheel, and the Whatman WB120205 FTA Classic Cards were used to sample the other side. The sides were frequently alternated in both studies.

QIAGEN® QIAamp DNA Kit was used to extract DNA from all samples. Promega® PlexorHY Human Quantitation kit was used to quantitate each sample. Statistical analysis of data showed no significant difference in yields between double swabbing and tape lifting techniques. It has also shown that the difference in yield between FTA scraping and double swabbing is statistically significant, with FTA paper collecting more touch DNA. AmpFLSTR Identifiler™ kit was used to generate a driver's profile from 20 randomly selected samples. STR analysis has shown that most of the samples contained two persons' mixtures, where the owner (the most recent driver) is the major donor. The results of this research indicated that FTA paper scraping method has high potential and should be further studied.

A Brief History of Forensic Sciences from Genesis to Today

Gregory Laskowski, Criminalistics Services International, LLC

The history of forensic science and its sub discipline criminalistics will be explored from the time of genesis as described in the Old Testament of the Bible to today. The audience will be introduced to early pioneers in the field, including Locard, Bertillon, Gross, and Orphilia as well as new pioneers, Goddard, Landsteiner, McDonnell, Wraxell, Culliford, Jeffreys, and Mullis in the form of biographical sketches. This presentation will also examine the many specialty areas in forensic science such as crime scene analysis toxicology, firearms, fire debris analysis, trace evidence, impression evidence, serology, and DNA highlighting the milestones and the technology employed in the course of history. In addition, the effects of television in the genres of crime dramas, documentaries and documentaries will be explored.

Characterizing the Frequency of Heteroplasmy in mtDNA of Tissues Using Next-Generation Sequencing

Janice Lin, Erin Laurie, George Sensabaugh, Cassandra Callowa, UC Davis Forensic Science Graduate Program

Mitochondrial DNA (mtDNA) is often used for analysis in forensic and mass disaster cases involving small and degraded tissue samples. Tissues can degrade from exposure to various weather and environmental conditions. High temperatures and level of destruction can also cause tissues to fuse together or commingle with other remains, resulting in mixtures that can make analysis and interpretation difficult. While the quality and level of nuclear DNA is low in these cases, mtDNA has a high copy number, increasing the possibility of obtaining enough DNA from compromised samples for fragment-size analysis of short tandem repeats. In addition, the control region of mtDNA contains highly polymorphic hypervariable regions I/II (HVI/HVII) where heteroplasmic mutations have been observed. It is important to understand the nature of heteroplasmy across various tissue types because the presence of heteroplasmy in mtDNA can affect interpretation and analysis.

While Sanger sequencing is a standard approach for mtDNA analysis, it has a number of limitations that prevent a comprehensive analysis of mtDNA in forensic samples and mixtures.

Sanger sequencing electropherograms display peak heights that do not always reflect the ratio of mixture components, making it difficult to determine individual mtDNA haplotypes in a mixed sample. Moreover, minor components that make up less than 10% of a DNA mixture are not detected with Sanger sequencing. This research project aims to address these common issues in forensic mtDNA analysis by using a sensitive Next Generation Sequencing (NGS) method to characterize low levels of heteroplasmy in brain, heart, muscle, and blood tissues.

The Roche 454 NGS technology overcomes limitations of Sanger sequencing in forensic mtDNA analysis with its high and massively-parallel throughput, clonal amplification, and pyrosequencing chemistry. Through these features, the 454 GS Junior can separate individual components of a mixture, provide a quantifiable estimate of the ratio of mixture components, and analyze low frequency of heteroplasmy in mtDNA. In comparison to Sanger sequencing data on the same tissue samples, data from this research project has detected hetero-

plasmly occurring at frequencies as low as 1%. These results support the high sensitivity of 454 GS Junior to not only detect low levels of heteroplasmy but also reveal additional heteroplasmic sites in the HVI/HVII regions. In addition to confirming heteroplasmy previously detected by Sanger sequencing, the more sensitive NGS has detected additional heteroplasmy that were not previously observed in Sanger sequencing. For example, preliminary NGS data shows that heteroplasmy was observed at a low level in the muscle tissue at hot spot HVII position 189 in at least one individual. Furthermore, NGS provides a quantitative assessment of heteroplasmy by establishing frequencies of the two bases that occur at one site. This research will help establish NGS sensitivity thresholds for varying levels of heteroplasmy in different sample types. Moreover, the results demonstrate the potential of NGS to improve interpretation guidelines and increase the efficiency of forensic mtDNA analysis, especially with limited and degraded DNA samples.

Whole Mitochondrial Genome Sequencing Method for Limited and Highly Degraded Bone Samples for Use in Forensic Casework

Rachel Gordon, Sarah Copeland, George Sensabaugh, D. Crim, Henry Erlich and Cassandra D. Calloway, PhD, Children's Hospital Oakland Research Center

DNA samples of limited quantity and quality are often encountered in forensic casework and are at times difficult to analyze with standard STR markers. Mitochondrial DNA analysis is most useful in these cases because of its high copy number per cell (200 copies/cell). Currently, the standard approach is to analyze the hypervariable regions (HVI/HVII) of the mitochondrial genome using Sanger sequencing. However, Sanger sequencing has limited sensitivity and often fails when the DNA is highly degraded (<250bp). Given the limitations associated with the current standard method, there is a need for the development of an improved system for limited and degraded DNA analysis in the forensic field.

We have developed an optimized whole mitochondrial genome probe capture enrichment method coupled with Next Generation Sequencing (NGS) on the Illumina platform to overcome these limitations. Mitochondrial DNA whole genome analysis is an alternative approach and can be used for increased genotyping success particularly with forensic samples where nuclear DNA is limited or degraded. We present here results demonstrating the potential application of this optimized NGS whole mitochondrial genome enrichment method for sequence analysis of difficult forensic samples. This robust method was successfully used for sequencing the entire mitochondrial genome of highly degraded bone samples, limited DNA samples, as well as samples from different population groups.

We tested the sensitivity of the assay by reducing the starting amount of a control DNA from 1 ng to 10 pg. All limiting dilution samples led to full (100%) coverage of the whole mitochondrial genome with a specificity of 96% average on target rate using the optimized protocols. We also tested DNA samples (n=20) from 4 different population groups (Caucasian, African-American, Hispanic, and Japanese), which led to 100% coverage of the whole Mitochondrial Genome with a specificity of 95% average on target rate. DNA from <50 year old femur was also processed and sequenced success-

fully with 100% coverage. A mock degradation experiment was also performed where DNA was mechanically sheared to 150 bp on average and then processed using the 250 bp protocol and compared to a DNA control processed only at 250 bp shearing protocol. The samples were successfully captured and sequenced showing the method is independent of quality. We have also applied this method to DNA from >1000 year old bones. Preliminary results show ~99% mitochondrial genome coverage demonstrating the application of this method to highly degraded DNA samples.

Our results show our optimized method for whole mitochondrial genome analysis to be robust with increased specificity and sensitivity. Standard NGS methods require starting DNA amounts higher than a typical forensic sample, however, we have successfully captured and sequenced with significantly less starting material (10pg). Our optimized whole mitochondrial genome NGS method has the potential to greatly improve the discrimination power compared to current mitochondrial HVI/HVII sequence analysis as well as to increase the number of limited and degraded samples successfully genotyped.

Increasing the Detection of a Minor Contributor in Mixtures using QIAGENs Investigator 24plex QS STR Multiplex PCR Assay

Dukes, M.J.; D. Muller; A. Prochnow; M. Scherer; R. Perist; John Haley, Pamela Jarman, Qiagen

In response to the FBI expanded CODIS core loci, QIAGEN developed and validated two Multiplex PCR kits for reliable genotyping of human DNA. The two kits, Investigator® 24plex QS Kit and Investigator® GO! Kit, were developed for forensic DNA casework and database type samples, respectively. Both kits contain a patent pending and novel Quality Sensor.

The Quality Sensor is unique, and patent pending, in that the Quality Sensor resultant alleles, "Q" and "S", allows differentiation between:

- Robust amplification
- Degradation
- Inhibition
- Lack of amplification of DNA
- Failed PCR amplification

The QIAGEN Investigator® 24plex kit was evaluated at the U.S. Army Criminal Investigation Laboratory (USACIL) Defense Forensic Science Center (DFSC) and ultimately requested for NDIS approval. The 24plex QS kit was approved as an accepted kit by National DNA Index System (NDIS) on June 29, 2015. Analysis of DNA samples from forensic casework must contain the ability to differentiate mixtures of DNA from more than one contributor. It has often been the task to increase the total amount of DNA input in the PCR to boost the detection of the minor contributor. This study addresses same ratios of DNA, but variable total templates (0.5ng vs. 1.0ng) in the PCR. This presentation will provide a glimpse into the mixture studies designed and performed, and the resultant data obtained and submitted for NDIS approval.

The Case

by Liz Porter

British armed robber Andrew Pearson probably never imagined he'd end up as the star of an anti-dandruff advertisement. He also probably never dreamed he'd get caught for the 1993 holdup in which he and two accomplices stole £38,000 from a caravan company in the Yorkshire city of Hull. After all, the masked and armed trio left an impressively clean crime scene behind them.

All that the police found afterwards was a stolen Vauxhall Cavalier, abandoned near the scene. Inside it were a few fingerprints, none of which produced a match to any prints already on file, and one small segment of black stocking – discarded, investigators assumed, after one of the robbers had used it as a mask. How could Pearson ever have thought that, 11 years on, DNA analysis of specks of dandruff on this mask would lead police straight to his door and earn him a 15-year prison sentence? The storyline was so irresistible that the advertising copywriters for Head & Shoulders anti-dandruff shampoo didn't even need to sex it up. The half-page advertisement that appeared in papers across the UK simply reproduced a tear-out of an article about the 2004 court case, adding the slogan "Don't get caught with dandruff."

The robbery was brutal but effective. On a pay day in July 1993, the 29-year-old roofer was one of a gang of three masked men, two armed with guns and one with a baseball bat, who stormed into the Hull headquarters of Atlas Caravans. The trio expected to make off with the £250,000 due to be paid to the company's staff. They missed the main wages delivery, but still got away with £38,000.

During the robbery, office workers were told to lie on the floor, or someone's head would be blown off, while one man was left with head injuries caused by flying glass – the consequence of one of the robbers firing his gun through a window.

Eleven years later, the victims found themselves reliving the trauma of that experience when they gave evidence at Pearson's trial. But they were all reportedly thrilled by the advertisement, declaring it the perfect light relief after the stress of the witness box.

By the time Pearson faced court, his accomplices had still not been found, and there was no way that he was ever going to rat on them. Detective Mike Reed, who was in charge of the re-opened investigation, believed that Pearson was the

The "Head & Shoulders" Case, originally published in Crimemagazine.com, Jul 15, 2013, reprinted by author's permission. "Head & Shoulders" is a registered trademark of Procter & Gamble.

man holding the baseball bat, rather than one of the guns. But even that conclusion came from witnesses' descriptions, not from the criminal's own admission.

Pearson had previously been a temporary employee of the company and was a habitual offender, with 76 convictions dating back to the 1970s for offences including burglary, robbery and assault. Despite the many times he had been arrested, however, it seems that he had had few fears – until his arrest in 2003 – of being caught for the armed robbery. In fact, he had been so confident that he had been living in a mobile caravan on an estate five minutes' drive from the caravan company's headquarters.

He could have been forgiven for assuming that the 1993 robbery had been forgotten.

In 2001, there had been blanket media coverage of another armed robbery at the same site. On that occasion, another equally violent but less competent threesome had been caught within a day of its overnight raid on the company's office, during which a security guard had been killed. Newspaper reports on that break-in did not mention the unsolved 1993 incident.

The storyline was so irresistible that the advertising copywriters for Head & Shoulders anti-dandruff shampoo didn't even need to sex it up. The half-page advertisement that appeared in papers across the UK simply reproduced a tear-out of an article about the 2004 court case, adding the slogan "Don't get caught with dandruff."

But Pearson hadn't counted on the diligence of the crime scene police investigating the first robbery. They had collected the section of stocking, which contained only the toe and part of the leg, in the hope of finding blood, saliva or hair roots suitable for the DNA profiling that was available at the time. They found none. But, running a roller covered in special forensic sticky tape over the stocking, they recovered 25 skin flakes which, when examined under a microscope, were confirmed as dandruff. These samples were too small for 1993's DNA technology, so the tape containing the flakes was placed on a clean sheet of plastic acetate and stored.

The 1998 invention of "low copy number DNA," a technique enabling a genetic profile to be obtained from samples as small as 15 or 20 cells, was first used on long-unsolved murders. By 2003, police were keen to see if the new technology could help them find the perpetrators of other unsolved cases. The carefully preserved dandruff flakes from the 1993 armed robbery arrived at scientist Dr. Jonathan Whitaker's Birmingham laboratory in July 2003. The DNA profile that the scientist extracted from them was run against the 2-million profiles on the UK national database. As a man with a string of convictions, Pearson's profile had been on the database for some years. The profile from the dandruff matched it.

After arresting Pearson, police took a buccal swab of skin cells from the inside of his cheek. Whitaker extracted Pearson's DNA profile from the sample; it was an exact match for the profile from the dandruff flakes.

In November 2004, Whitaker was in a witness box in the Hull Crown Court, explaining to the jury that the match he

had found between Andrew Pearson's DNA profile and the one extracted from the dandruff meant one of two things: either the skin flakes came from Pearson, or they came from a person with exactly the same profile as Pearson. The chance of obtaining that profile from a person chosen at random in the UK was about 1 in 1 billion.

Pearson worked hard to explain to the jury why his DNA might have ended up on the stocking. He admitted that he might have been in the robbers' car. He could have been given a lift, leaving his DNA on the back seat. He might have used the piece of stocking as a rag to mop his head. Or he could even have touched the stocking without being in the car.

Unimpressed with any of these alternatives, the jury spent only 75 minutes deliberating before finding him guilty of the robbery. Sentencing Pearson to 12 years for the robbery and three years for the possession of a firearm, the judge, Michael Murphy QC, warned other criminals that they should learn a lesson from this case. "As detection methods become more effective and sophisticated, even criminal behavior for which they feel they have evaded responsibility is likely to catch up with them. Justice will be done in the end."

Pearson's conviction did not close the case, but it is unlikely that either of his co-offenders will be prosecuted for this crime. As Pearson was facing court, detective Mike Reed was still on the track of one of his gun-wielding accomplices. Advances in fingerprint technology had enabled police to find a match for one of the sets of prints found on the stolen Vauxhall: a notorious and formerly Liverpool-based armed robber. By the time Reed went looking for him, the man had been released from prison after serving time for another armed robbery, and had vanished. The UK's National Criminal Intelligence Service, which targets organized crime, was also looking for the suspect, who had moved on from armed robbery to a career as a cocaine dealer.

Reed finally interviewed the man in prison after he had been convicted of serious drug importation charges and given an 11-year sentence. He admitted that his "business" in 1993 had been car stealing, which made it plausible that his prints might be on one of the many cars he stole from the Liverpool area and then sold on. But he denied having taken part in the armed robbery.

Reed was more inclined to believe that the inmate was the robber who had fired his gun during the incident, but he couldn't prove it. Meanwhile, without a trace of forensic evidence to help police find him, it seems that the third robber will never be even identified, let alone convicted.

*Liz Porter is an award-winning journalist and specialist forensic science writer based in Melbourne, Australia. Her book, *Written On The Skin; An Australian Forensic Casebook* shared the 2007 Ned Kelly prize for best true crime book and contains 55 cases illustrating the use of different forensic specialities to solve crimes. In 2011 she published *Cold Case Files: Past Crimes Solved By New Forensic Science*, featuring cases from the United Kingdom, the United States and Australia. She has written a novel and is now working on another true crime book. She can be contacted at trager@netspace.net.au*

Bullet Impact, Kinetic Energy, Momentum and What Will Move You

Lucien C. Haag

Abstract

Movies and television have instilled a deep belief in the minds of the ballistically naïve public that the impact of a bullet striking a gunshot victim will result in the victim being driven or even hurled in the direction of the bullet's flight path. This is *not* possible and easily disproved using basic Newtonian physics, but testimony accompanied by the supporting mathematical calculations are not likely to change the lay person's mind and an adherence to this false notion. These same people are likely to serve on a jury in cases here the movements of a gunshot victim are the subject of debate and contention. This paper reviews the matters of kinetic energy, momentum, the conservation of momentum after which some simple means will be provided to demonstrate momentum transfer by bullets impacting and lodging in selected targets.

Introduction

That the impact of a bullet will knock a gunshot victim back or over from a standing position would seem to have a common sense logic. But this is largely, if not exclusively, from movies and television, extending back to the very beginnings of these media. The entertainment value of an evil-doer getting driven back through a nearby window by a shotgun blast from our movie hero, or hurled against a wall by a short burst from a sub-machine gun, or driven over a balcony railing by a shot from some sort of magnum handgun, cannot be denied. A technically and realistically correct depiction of a gunshot victim simply collapsing or staggering away after being shot by any of the previously cited firearm types would surely disappoint the audience. The end result of decades of movie and television depictions of shootings is that jurors are likely to accept this notion of bullets knocking or hurling gunshot victims this way or that. This very idea was the center piece in a recent case in which this writer was involved. In this fatal shooting case two otherwise well-educated expert witnesses testified that a gunshot victim was driven backwards by the first of two shots resulting in a change in location of, what they opined was the second gunshot wound. One of these two experts had extensive training in physics and automobile accident reconstruction, but apparently little or knowledge or understanding of momentum transfer insofar as bullets and gunshot victims are concerned. Confronted by this situation, this writer assembled several short video productions to demonstrate the fallacy of the opposing experts' claims.

In the Beginning-The Ballistic Pendulum

A historical starting place is the work of Benjamin Robins (1707-1751), a Newtonian mathematician and military engineer who, among other things, related to the early science

of ballistics, developed and described the use of the ballistic pendulum in his famous 1742 treatise, *New Principles in Gunnery*.¹ Prior to Robins' work, the velocity of bullets and cannonballs was unknown. His invention forever changed that. To this day, the principle of his ballistic pendulum remains valid, and if modeled in such a way as to be relevant to the firearm and ammunition involved in casework, it can serve as one means to aid a jury in understanding momentum transfer, and at the same time, dispelling their likely preconceived notion regarding the consequence of bullet impacts with gunshot victims.

Momentum vs. Kinetic Energy

Objects, including projectiles in motion, carry with them two important and inter-related properties: momentum and kinetic energy. The latter is consistently given, along with velocity and bullet weight values, in ammunition manufacturers' advertising brochures. In the case of American ammunition manufacturers, kinetic energy (K.E.) values are given in foot-pounds and velocity in feet per second. The K.E. values are typically large, impressive numbers, particularly at high velocities with relatively heavy bullets. This is immediately understandable when one examines the formula for kinetic energy,

$K.E. = \frac{1}{2}mv^2$ where m is the mass of the projectile and v is the velocity.

Of particular importance is the fact that kinetic energy increases by the square of velocity. By comparison, the equation for momentum, denoted by the letter p in physics, is simply $p=mv$ (mass x velocity) which means that momentum only increases linearly with increasing impact velocity. These equations have each been reduced to a form that makes them easy to use in calculating kinetic energy and momentum values in English units of foot pounds and pound-seconds and bullet weights in grains.

$$K.E. (ft-lbs) = gr(v^2)/450,440$$

$$\text{Momentum (pound-seconds)} = gr(v)/225220$$

where gr is the weight of the bullet in grains and v is in feet per second

By way of example, manufacturers' listings or calculations for the .308 Winchester cartridge with a 150 grain bullet (equivalent to the military 7.62 NATO cartridge) with a muzzle velocity of 2820 feet per second give a K.E. value of 2648 ft-lbs. One will *not* find momentum values in these same manufacturers' performance tables. When one either calculates the momentum value for this same bullet, or pulls it from an exterior ballistics program such as *Sierra Bullets Infinity-6*, the result is a very unimpressive number, 1.88 pound-seconds. The marketing value of 2648 ft-lbs compared to 1.88 lb-sec should be obvious. The K.E. values are, however, of some forensic value and importance. Think of a bullet's K.E. value as an expression of the bullet's ability to perform work on a target, and if that target is a human being, "work" can be related to wound production and/or any accompanying expansion/fragmentation of the bullet. However, it is the *momentum* value which is important and operative when it comes to how much movement a bullet could induce in the body of a gunshot victim. This relationship comes to use from Isaac Newton's 3rd Law of Motion dealing with the conservation of momentum. Newton's Laws of Motion to include numerous discussions and videos related to the conservation of momentum can be

found on the Internet. Perhaps one of the most useful is a YouTube video by Physicist Paul G. Hewitt at www.youtube.com/watch?v=1-s8NZ8xKW0

There is little question that jurors, and possibly many readers, would have little or no concept of what 1.88 pound-seconds (or any other momentum value) corresponds to in some meaningful way. Using the previous 7.62NATO round as an example and the 150gr bullet striking and coming to rest in a 180 pound victim, the ability to move this victim can be thought of as pushing against the hypothetical entry wound site with a force of 1.88 pounds for 1 second. This concept of a given force multiplied by the time the force is applied is known in physics as *impulse*. Even after such a verbal explanation from the witness stand, jurors are likely to remain skeptical and continue to cling to their fallacious belief in the awesome knock down power of energetic bullets. If this explanation of momentum is used, one would be well advised to remind them that the much larger kinetic energy value of this same bullet is what punches a hole in the victim, destroys tissue and organs and causes the bullet to deform or fragment. Something that they can see stands a better chance of overcoming long-held beliefs about how gunshot victims should respond when struck by such bullets. This was and is the purpose of this article: to provide the reader with several means of preparing two or more choices for visual trial aids to demonstrate momentum transfer and the fallacy of kinetic energy as having anything to do with the post-impact movement of gunshot victims.*

Figure 1 provides a useful and usable example of a ballistic pendulum. A bullet of mass m and impact velocity V strikes and comes to rest in a free-hanging block of wood of mass M . This previously motionless block of wood with a new mass of $M+m$, and in accordance to Newton's Law regarding the conservation of momentum, will have a velocity (v) of $(M+m)/mV$. The wood block, now in motion with velocity v , will have a kinetic energy of $\frac{1}{2}(M+m)v^2$.

As a result of the design of this experiment, this kinetic energy will be converted to potential energy when the block reaches its highest point, shown here as h . In the usual method of using a ballistic pendulum, the researcher is attempting to determine the original velocity, V , of the projectile where the researcher knows and has measured m , M and h . The mathematical relationship for the derivation of the kinetic energy velocity, v , from newly stored potential energy is $v=\sqrt{2gh}$ where g is gravitational acceleration. Once v has been derived, it is an easy matter to work backwards to calculate V , the impact velocity of the bullet. For the purpose of a court demonstration, I placed a properly functioning ballistic chronograph immediately in front of a suspended block of wood of measured weight and fired a bullet of known weight into the wood block. A tape measure was suspended adjacent to the wood block and in the same plane as the wood block. A high speed video-camera was set at a relatively low frame rate of 300 frames per second and was positioned orthogonally to the wood block. A shot was fired, the impact velocity recorded and the maximum height to which the wood block rose was derived from a frame-by-frame inspection of the video. From this simple demonstration, one can then point out that a block of wood weighing far less than the decedent, struck by the same brand and weight of bullet as that of the fatal bullet and traveling at a measured velocity did not propel the wood block off screen, but rather only caused it to swing through an arc of about 7 degrees and rise to a height of less

than an inch above its initial position of rest. **Figure 2a** and **2b** illustrate such a demonstration prepared for the trial. Of course, the actual video was also shown, which included the use of an exemplar firearm comparable to the officer's firearm, the specific ammunition, the chronograph reading and the behavior of the suspended wood block upon impact by the bullet. In this simple demonstration an 18 pound block of wood was struck by a .40-caliber, 180 grain bullet with an impact velocity of 1001f/s. The kinetic energy of this bullet at this velocity was 400 ft-lbs. The bullet's momentum at impact was 0.800 lb-sec. and the calculated velocity imparted to the 18 pound block of wood was 1.43f/s. Using the this velocity and the potential energy equation, $v=\sqrt{2gh}$ (the square root of $2gh$ where g is gravitational acceleration and h is the height in the same units of feet per second and feet), the calculated value for h is 0.38 inches (0.0317 feet), not particularly far off from the 0.5 inch estimate taken from the frame-grab depicted in **Figure 2b**.

At the trial in question, the opposing experts tried to make a point in their momentum transfer claim, that because the 145 pound subject was in a seated position when shot, an effective body weight of approximately 72 pounds should be considered when the 'first bullet' struck the subject in the upper chest and drove him back prior to the arrival of the second shot. Although the 18 pound wood block demonstration should have exposed the fallacy of their claims, a slightly modified experimental design was chosen to address this testimony. An inexpensive nylon duffle bag was filled with 72 pounds of dry sand and suspended from a strong tree branch. A plumb line was also suspended from this same branch and at a position near the duffle bag. Its purpose was to serve as a vertical reference line which would ultimately allow the maximum amount of movement of the duffle bag to be determined. **Figure 3a** depicts the video frame immediately prior to the impact of a 147-gr bullet having an impact velocity of 1009f/s, a kinetic energy of 332 ft-lbs and a momentum of 0.66 lb-sec. The bullet was stopped by the dry sand (no exit on the opposite side) and the subsequent, unexciting movement of the duffle is shown in **Figure 3b**. The Newtonian conservation of momentum calculation yields a velocity for the previously stationary, free-hanging duffle bag of 0.29f/s.

But in an American courtroom, you should never underestimate your critics and a well-prepared cross-examiner. They might easily claim that, *This experiment is flawed and not representative of the actual situation in this shooting. The upper half of the victim's body was not free-hanging! In the seated position, it was essentially free to rotate backwards at the waist line when he was shot in the upper anterior chest, and this is exactly what happened in this case.* While I would disagree with the "flawed and not representative" assertion, a judge might not. In anticipation of these criticisms, a second demonstration was set up, using the same 72 pound duffle bag of sand. This time it was placed on a small and rather unstable table so that a small force applied to the duffle bag would cause it to topple over. This was very apparent in the video prepared during this test, but not so in the frame-grabs, particularly since the duffle bag and table

*Note: The momentum-kinetic energy discussion presented here was part of a presentation by Alexander Jason and this writer at the Spring 2015 California Association of Criminalistics seminar in Ventura, California under the title "A Momentous and Moving Case."

It is always useful and important to examine any alternate explanation or reconstruction of an event. Simply defending one's own analysis is not sufficient.

did not fall over when shot. Nonetheless, the setup is shown in **Figure 4a**. The terminal ballistic properties of the shot into the duffle bag of sand and the video frame showing the maximum movement of the duffle bag, are provided in **Figure 4b**.

It should also be realized that a conscious human subject could be leaning forward, moving forward at the waist, in a state of rigid muscular tension, or at the other extreme, already in a rearward, avoidance motion when faced by a subject, (in this case a police officer) about to discharge his firearm. The points of the hanging bag and the bag-on-the-table shots were to once again, point out the fallacy of the Hollywood depiction of bullets knocking gunshot victims over or driving them back in the direction of the bullet's travel.

Two final and inter-related terminal ballistic demonstrations were carried out during my preparations for a trial appearance in this officer involved shooting case. The nominal 18 pound block of wood was placed on a leveled table and the force necessary to move the block slowly across the surface of the table was measured with a digital force gauge. A chronograph was once again positioned immediately in front of the block to measure the impact velocity of a bullet fired directly into the center of the wood block. The test setup shown in **Figure 5** was carried out in replicate with a .40S&W Glock and 180-gr bullets. The initial position of the block was marked on the table top before each shot. The impact velocities were 993f/s and 1004f/s, both of which only moved the wood block 1.25-inches. Although they are meaningless in this situation, the associated kinetic energy values were 394 ft.lbs and 403 ft-lbs.

The momentum values for these two shots were 0.79 lb-sec, and 0.80 lb-sec.

The final demonstration and setup (shown in **Figure 6**) involved placing the 18 pound wood block on a 2 pound dolly used for moving decorative plants. Although this increased the overall weight of the target to 20 pounds, it substantially lowered the force necessary to move the block and dolly across the table from the previous 3.58 pounds to 1.33 pounds. The impact velocities for these replicated shots were 1001f/s and 1013f/s which moved the block and dolly 4.5-inches and 4.6-inches respectively. The calculated momentum values for these two shots were 0.80 lb-sec. and 0.81 lb-sec. respectively.

Case Example

Many years ago this writer worked on a case in which a pre-adolescent boy sitting on an overturned bucket and fishing was struck in the left side of his head by a 225-gr jacketed soft point bullet fired from a .338Winchester Magnum rifle at a distance of 183 yards. This is a very powerful firearm intended for hunting large and dangerous game. Its power far exceeds that of any handgun and most centerfire rifles.

The bullet perforated the victim's head and produced a large exit wound with the ejection of considerable bio-mat-

ter. The calculated impact velocity of this bullet was 2550f/s, giving it a kinetic energy of 3248 ft-lbs and a momentum of 2.55 lb-sec. **Figure 7** shows this horrific scene. The victim is still holding his fishing pole, but it is the direction he fell that should forever lay to rest the notion that the impact of bullets propel the victim in the direction of the bullet's flight. This young victim fell towards the source of the fatal bullet. This may have been due to him having been slightly left of his center of gravity when struck, or for the same reason that President Kennedy's head snapped rearward when he sustained his fatal head wound^{2,3}, but he was not driven to his right by the impact of this high velocity, high energy bullet.

Other Considerations

It is always useful and important to examine any alternate explanation or reconstruction of an event. Simply defending one's own analysis is not sufficient. This was especially true in the instant case. In the shooting case that precipitated this article, and the shooting demonstrations illustrated here, a subject seated on the ground was ultimately shot twice in rapid succession by a police officer. Both bullets struck the subject in the upper anterior chest. One perforated the body and the other came to rest in the chest. After being shot, the subject collapsed onto his back. The foregoing matters were not in dispute. The proponents of, "the impact of the first shot drove the victim's upper torso back," used this claim to explain why one entry wound was below the other entry wound. This was of critical importance to the plaintiff's case, if they could convince the jury that the upper gunshot wound was sustained first. According to their reconstruction, this first shot produced the upper wound and drove the victim's upper body rearward resulting in the second gunshot wound occurring approximately 3 inches below the upper wound. This proposition required that the shooting officer's pistol remained in the very same position for both shots. This was an immediate problem for their reconstruction, because there was neither a likelihood that this occurred, nor was there a way to establish the position of the gun at the moment of each shot. But the real revelation came when one examined the wound paths of the two gunshot wounds and considered their reconstruction. This, the plaintiff and his experts had apparently never done. Had they done so, they would have seen that their "reconstruction" was fatally flawed. **Figure 8a** and **8b** provide profile views of the wound paths of the two pistol bullets fired by the police officer. **Figure 8a** presents the wound paths of the two gunshot wounds with the body in the usual anatomical position. The general path of the upper wound was described by the pathologist as "slightly downward", and the lower wound as "downward." In **Figure 8b**, I have rotated the previous anatomical drawing approximately 10 degrees backward to test the plaintiff's hypothesis. The red lines, per the requirements of the plaintiff's experts' reconstruction, assume *no* change in the height and position of the officer's pistol. It quickly becomes apparent, if one studies the dashed red line for the lower gunshot wound, that this wound would become less downward as the subject rotated rearward. Indeed, in this view with only 10 degrees of rearward rotation, wound 'B' becomes essentially horizontal when the body is returned to the normal anatomical position. With further rearward rotation, things only get more problematic for the plaintiff's experts, as the wound path for 'B' would take an *upward* track. If either momentum or kinetic energy had anything to do with the seated subject's rearward movement,

a review of **Figure 8a** would have shown the plaintiff's experts that gunshot wound B was *first*, and gunshot wound A was *second*; the very proposition the plaintiff needed to disprove. The fallacy of the plaintiff's reconstruction becomes even more apparent when one examines the three **Figures, 9a, 9b and 9c** prepared by Alexander Jason in which he has integrated the wound path information derived from the autopsy report with the critical elements from the scene. In these figures, the shooting officer can be seen standing on an area somewhat lower than the subject seated on an elevated area. Both are facing each other when the two shots are fired. The first two of these figures takes the reader through the plaintiff's claim regarding momentum transfer, from the impact of the bullet associated with gunshot wound 'A', followed by the inevitable (and fatal to the plaintiff's theory) consequences when one back extrapolates the path of gunshot wound 'B' in the final figure.

Summary

The central propositions in this article were to provide the reader with—1) an improved understanding of the difference between kinetic energy and momentum, 2) the application of the Newton's 3rd Law regarding the conservation of momentum in shooting cases, and, 3) several simple means for demonstrating projectile momentum transfer using a real case example where allegations of substantial body movement of a gunshot victim were induced by the impact of a single pistol bullet.

From the calculations presented here and the demonstrative tests, it should be abundantly clear that typical small arms projectiles impacting gunshot victims do not, and cannot, cause any major or significant body movement in the victim.

On the other hand, gunshot victims may display substantial, dramatic, even gross movements upon being shot, but such movements are *not* the consequence of any physical effect associated with kinetic energy or momentum. They may be a pain response, an avoidance response, a response to the extreme loudness of a close range gunshot, or the continuation of a voluntary movement already initiated when the gunshot wound was received.

As has often been pointed out, but seldom understood by individuals with little or no understanding of the laws of physics, a bullet launched from a firearm, which does not knock the shooter over upon exiting the muzzle (action-reaction more commonly known as recoil), cannot possibly knock over a person of comparable weight as the shooter if struck by the bullet at its maximum velocity. Any velocity less than that, can only produce less of an effect. Moreover, a bullet that *perforates* a gunshot victim gives up even less of its energy and transfers less of its momentum, than if it came to rest in the victim.

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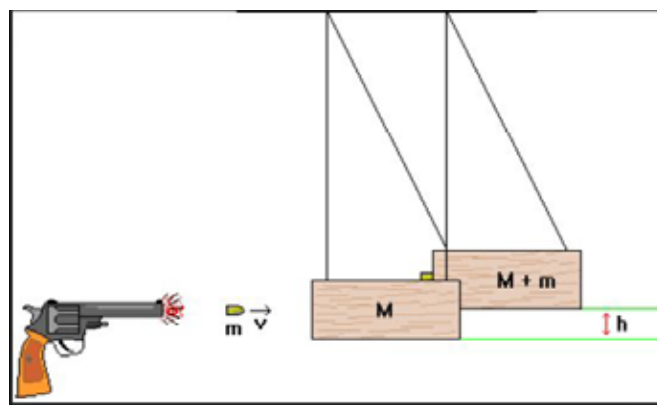


Figure 1
A Simple Ballistic Pendulum

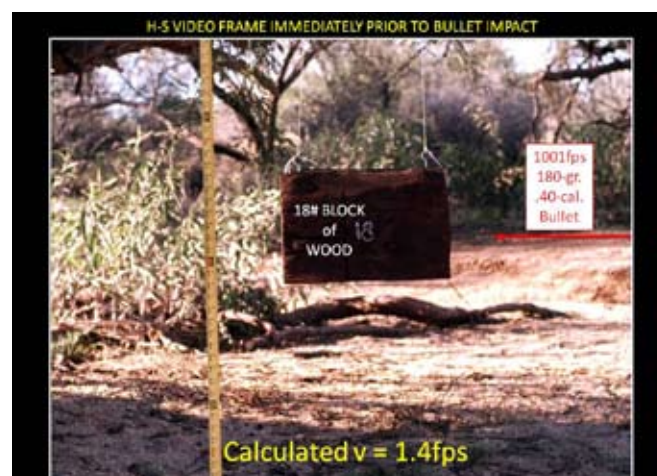


Figure 2a
A Practical Example Of A Ballistic Pendulum

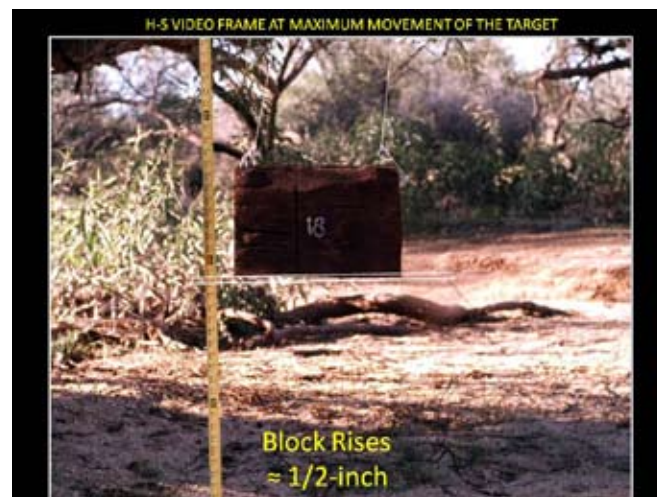


Figure 2b
A Practical Example Of A Ballistic Pendulum

VIDEO FRAME IMMEDIATELY BEFORE BULLET IMPACT

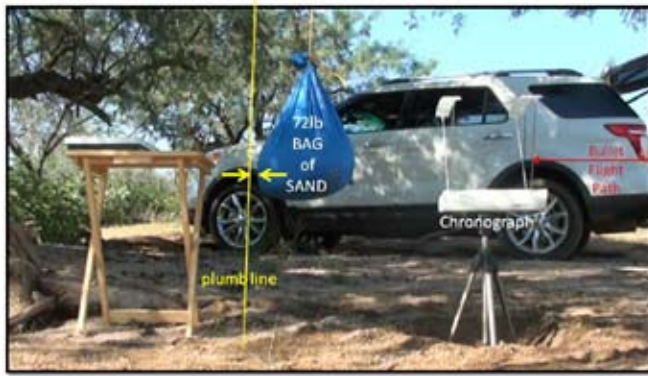


Figure 3a
147-gr. Jhp Bullet At 1009f/s

VIDEO FRAME after BULLET IMPACT- MAXIMUM TARGET MOVEMENT



Figure 4b

VIDEO FRAME - MAXIMUM MOVEMENT AFTER BULLET IMPACT

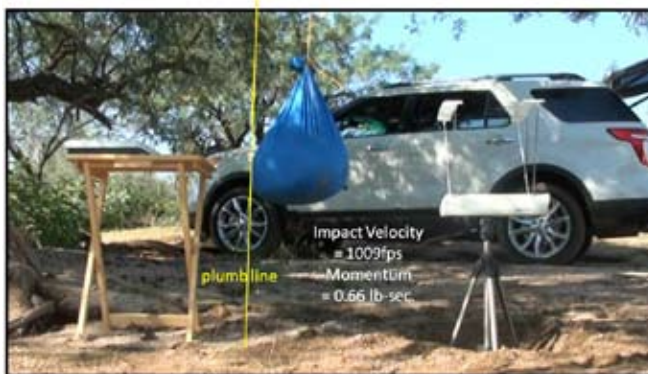


Figure 3b



Figure 5

VIDEO FRAME before BULLET IMPACT



Figure 4a

FINAL DEMONSTRATION of MOMENTUM TRANSFER
18 lb Block on a 2 lb Trolley



Figure 6

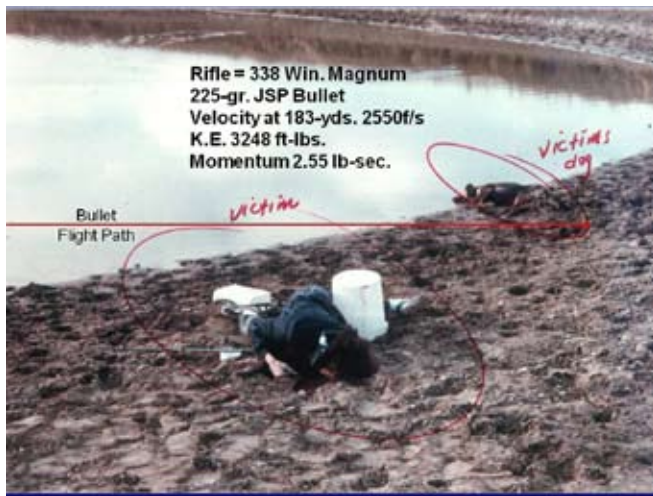


Figure 7
Law Enforcement Photograph of the Victims as Found



Figure 9a

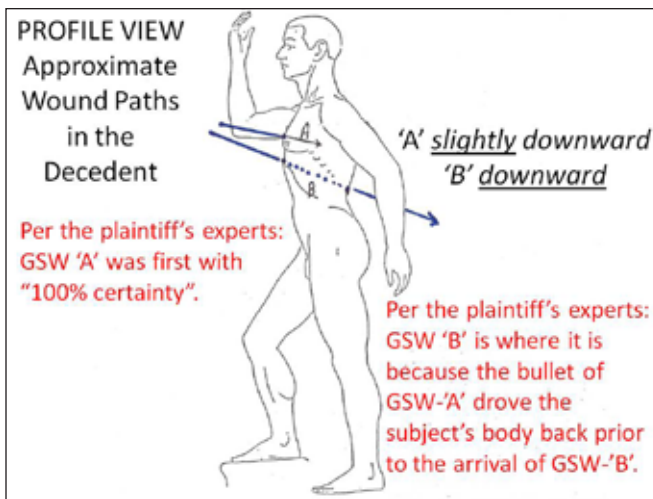


Figure 8a

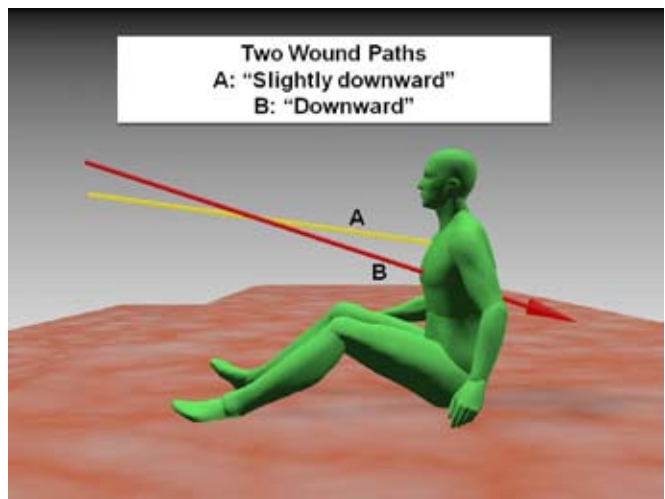


Figure 9b

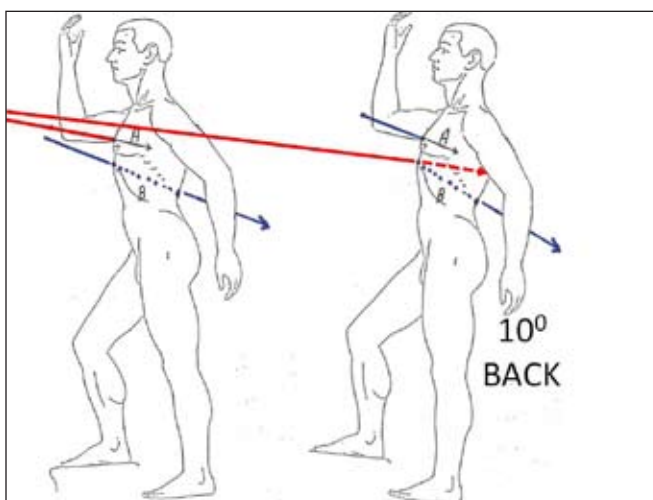


Figure 8b

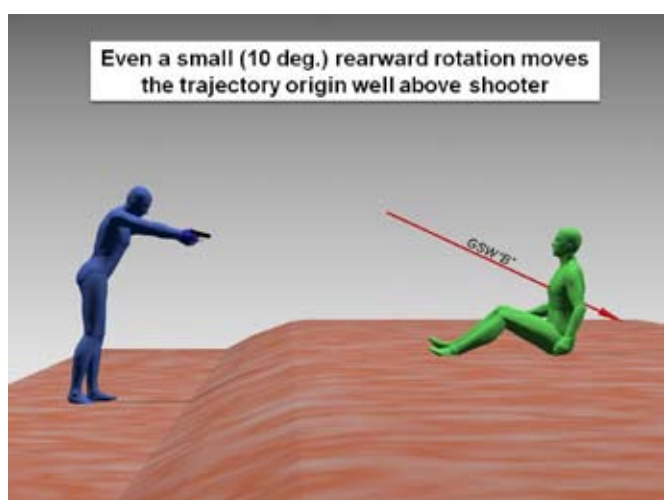


Figure 9c

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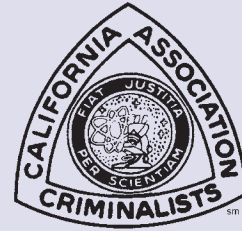


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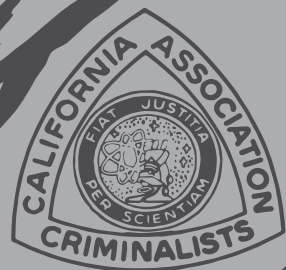


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