The CACNews

News of the California Association of Criminalists • Fourth Quarter 2016

Making Things Happen

brooke
BARLOEWEN

CAC President

People can't "make things happen" without working together, and I've found that CAC members work well with one another.

When I was a kid, I had a poster of three baby raccoons in my room with the following quote. It is a quote that I always liked and still try to live by today. "There are people who make things happen, there are people who watch things happen, and there are people who wonder what happened." It's a cliché saying, but it's also very applicable to those of us who work in forensic science.

I've been CAC President for a few months now, so I looked back at my last address to evaluate whether I am "making things happen," or in other words, whether I am achieving the goals I set forth at the beginning of my term. One of the goals I set forth was increasing CAC membership. Living in California is expensive, and sometimes criminalists have so many living expenses that they struggle to pay annual dues for a number of professional memberships. I found that this keeps criminalists from becoming CAC members. Therefore, I convinced my Laboratory Director to pay for an additional professional membership fee for each of our criminalists. This has encouraged many more of my colleagues to join the CAC. Thank you, Ian Fitch! Now I will work to get more of these new members to attend study group meetings and seminars. Maybe I can even get one or two of them to present some of their fine work. Are any other laboratories able to dig a little deeper to find some funding to financially assist their criminalists in participating in professional activities?

Another goal was to get more people to serve so that our association as a whole can "make things happen." I have asked a lot of people to step up and serve and have only been met with enthusiasm. This is encouraging. Criminalists from California want to participate. All CAC vacant positions have been filled, and those criminalists are working diligently to improve the CAC and criminalistics in general in California.

People can't "make things happen" without working together, and I've found that CAC members work well with one another. We have a sense of community. We can and should help and support one another because we are all facing similar challenges. Do you have deputy district attorneys who make unreasonable requests? Have newspaper reporters been hounding your lab for information through public records requests? Do you have a local defense attorney or expert pushing the boundary? Have you called your neighboring lab for advice or help? Northern CA Tech Lead study group has become a forum at study group meetings through which tech leads can talk about issues facing them. "Making things happen" isn't something that has to be done in a vacuum; instead, we should utilize the vital resource of each other.

Relying on others is especially important today, when the level of stress has increased in our laboratories. These stressors can come from the outside as well as within. Change is inevitable, but the additional oversight and outside entities telling us how we must operate can be stressful. There are many articles on potential sources of bias affecting criminalists' decisions. The courts are asking for copies of corrective action requests or documentation of any mistake that we have ever made. Rush cases derail our efficiency. And don't forget that we see the worst that humanity has to offer on a daily basis, which adds an under layer of stress to all we do. With so much stress in our lives, we need to lean on each other in order for us to achieve our goal of "making things happen."

While writing this address, I looked up the quote that was on my raccoon poster and found out it was said by Jim Lovell, one of the Apollo 13 astronauts. The quote actually goes on to say, "To be successful, you need to be a person who makes things happen." Like all successful scientists, he knew how important it was not just to wonder or watch but to actually make things happen. We in forensic science, and especially in the CAC, need to follow his example. I'm happy to say, looking back on my first few months as President, that I am making progress on some of the goals I set for myself and am planning to continue to make things happen. As we put summer behind us, let us all think of Jim Lovell and ask ourselves, "What kind of people are we going to be?"

Brooke

The CACNews
www.cacnews.org

FOURTH QUARTER 2016

Vive la résistance!
A firefighter tosses a Molotov cocktail into a test cubicle to study burn patterns at the recent CAC fire debris workshop hosted by LAPD.

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Please direct editorial correspondence and requests for reprints to the editorial secretary.

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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.

INSIDE

CACBITS

Lindberg B. "Ed" Miller, 1927—2016

Ed Miller was born in Oakland on June 16, 1927 and passed away on April 3, 2013, survived by his wife Ellen, who he married in 1960, and three daughters and three grandchildren. At the age of 15 he "adjusted" his age and joined the Merchant Marines, spending the last years of WWII in the Pacific aboard merchant vessels in support of the allied forces in the Pacific theater of operations. He joined the Army Air Corp after the war and served as a ground control radar operator. After leaving the Army Air Corp he went to Riverside College where he earned an associates of arts degree and then went on to U.C.Berkeley where he graduated with a degree in Criminology. While a student at U.C. Ed was a personal driver for Dr. Edward Teller and joined the Berkeley Police Department.

After Berkeley Ed went back to Southern California where he rose to rank of Captain in the Riverside County Sheriff's Office, creating the first mobile crime laboratory for that department in the process. In the early sixties Ed joined the Los Angeles Police Department subsequently becoming the supervisor of the crime laboratory in the Van Nuys subdivision. Being in Los Angeles, Ed worked on many high profile cases including the murder of silent film star Ramone Navarro and the Manson family murders as well as the death of Marilyn Monroe. He was also a consultant on some of the early television crime shows.

In 1977 Ed left the public sector to join the Institute of Forensic Sciences in Oakland California which was an off-shoot of Western

Laboratories, a clinical and pathology laboratory that got its start in 1923. Western Laboratory was involved in contractual forensic pathology and toxicology for Alameda County Coroner's Office and the CHP for many years. In setting up the Institute of Forensic Sciences in the seventies, the pathologists recognized the need for criminalistic laboratory services and turned to Ed to lead their Criminalistics Division. Ed subsequently struck out on his own as a private consultant in Forensic Science until his retirement in 1994.

In addition to being on the Board of Directors and president of the CAC, Ed was actively involved in the activities of the organization as he was in anything he had passion for. He was active in the Lions Club of Oakland and became its President as well as being involved in the operation and expansion of the Lions Blind Center of Oakland. Ed, affectionately known as "Big Ed" since he was 6'4" and gregarious, generous and outgoing was active in various charities. If he became involved in a charitable endeavor you could be sure the donations would swell as he inspired and cajoled everyone into being more generous than they might have originally planned. In addition to being active in his community wherever he went he took the time to enjoy some of the good things in life, including sailing, good food and wine as well as his interest in animals and computers and especially his family and friends. It was rarely (probably never) boring if you were around Ed.

During his retirement years at Leisure World and Laguna Woods, Ed kept up his involvement in community, participating in many clubs and commissions and received many awards in the process. He helped lay the groundwork for the establishment of Laguna Woods as an independent municipality.

I know all of the membership of the CAC who knew Ed will always remember him and those of you in the organization who are too young to have known him, you missed out on one of the organizations memorable characters.

Chuck Morton

Rupert Page, 1970 —2016

Rupert joined the CAC right after joining the Santa Clara County DA's Crime Laboratory in June 2014. He quickly gained the respect and admiration of his peers and management. Rupert performed his work with the utmost enthusiasm and integrity, was an incredibly productive employee,

and was highly motivated to seek answers. His expert testimony was outstanding, and presented in an honest and comprehensible manner. His efficient approach to casework was effective in aiding investigations quickly.

He treated others with respect and courtesy, and became good friends with many of his colleagues. He was consistently happy and cheerful, and a genuine pleasure to work with and be around. Previously, he worked at the Indian River Crime Laboratory, the Miami-Dade Police Department, and Prince George's County Police Department.

Outside of work, Rupert had an adventurous spirit and loved to make new friends. His favorite hobbies included riding his motorcycle, attending festivals and concerts, traveling, scuba diving, wine tasting, and spending quality time with his friends and family.

Sadly, Rupert passed away on July 2, 2016 in a solo motorcycle accident, and will be sorely missed by many. He is survived by his brother Tim, and his beloved Absinthia.

The Staff of the Santa Clara Lab

"I thought this photo taken in front of Dr. Kirk's off-campus laboratory in August of 1964, would fit in." (l-r) Paul Kirk, Chuck Morton and Peter DeForest.

Peter DeForest Named AAFS Distinguished Fellow

Peter DeForest was recently named AAFS Distinguished Fellow and will receive the honor at the New Orleans meeting in February, 2017.

Dr. DeForest wanted to share the above photo and the story that goes with it with the *CACNews.*

"Dr. Kirk, Chuck and myself had just returned from conducting a fire experiment with a redwood firewall and a sustained gasoline fire within the confines of the lower level of a fire tower. OSHA would not have approved. We were covered with soot. When the secretary (an accomplished photographer) took one look at us she insisted that we pose in front of the office. The photograph was especially meaningful to me, because it was the same day that Dr. Kirk asked me to serve as his teaching assistant. I guess I didn't know it at the time, but this set me on the course for an academic career. "

CAC Award Opportunities

Don't forget about available award opportunities for CAC members! The **ABC Examination Award** nomination period is July 31-December 31 and the **Edward F. Rhodes Memorial Award** nomination period is July 31-December 31. For descriptions of these and other awards please visit:

www.cacnews.org/awards/awards_dates.shtml

Rancho Mirage is the Place to be

You are invited to attend and present at the CAC-AST-EE Semi-annual Seminar to be held in Rancho Mirage, California from Oct. 31—Nov. 4. Below is the tentative schedule. The planners have an exciting program lined up so far with a number of different planned workshops/tours and presenters.

Download a flyer here: www.cacnews.org/events/seminar/First%20Announcement.pdf

For more information, please visit:

www.cacnews.org/events/seminar/seminarcurrent.shtml

Workshops:
Fiber Dyes and Dyeing
Soil Recognition and Collection Field Exercise
DNA
Biology Workshop sponsored by Seratec
Controlled Substances
Firearms

Tours for Trace Evidence Examiners:
Hertiage Plastic Bag factory
Karma Automotive factory

(Tentative) Speakers: Jill Spriggs, Sacramento County DA's Crime Laboratory – updates on forensic science
Daniel DeLimon, Riverside County DA's Office – cases and testimony
Alissa Bjerkhoel, Innocence Project – notable cases

Stipends Offered Again

The IAI in conjunction with NIST will again be offering two stipends to anyone wishing to make an oral presentation or present a workshop at next year's IAI conference in Atlanta, GA. Two abstracts will be chosen from among those who submit and agree to make an oral presentation. The two winners will receive a reimbursed voucher from NIST that covers domestic travel, lodging, and registration. This invitation is open to all members of the CAC and non-members alike provided they are working in the field of forensic science. The invitation letter (sent out to all members) does spell out the disciplines more specifically. [*See page 9 for more details. Ed.*]

Greg Laskowski

Summer Recapitulation
or Life after a CAC Seminar

meiling
ROBINSON

CAC Editorial Secretary

Have a plan in place for tackling the post seminar "to do" list. You'll be exhausted and will want nothing more than to just have it all come to an end, but there will be plenty more things to complete.

With summer vacation winding down and the fall equinox upon us, many of us will be ramping back up and preparing to fire on all cylinders. For me, the summer can be summarized in 3 phases like a sonata, marked by the denouement of the CAC, new clarity, and a (re)commitment to new goals. On Friday, May 6th, I was beaming with pride to see so many people in attendance and overjoyed that our planning committee was just hours away from successfully executing our goal.

Here are my top three lessons learned:

People really, really want to help out. Your lab will rally around you. The thing to keep in mind is to make sure there are very specific jobs you can assign. You'll find that even though most tasks were assigned, more people will just show up the week of and will want to be useful. Be prepared to give them something to do.

Have a plan in place for tackling the post seminar "to do" list. You'll be exhausted and will want nothing more than to just have it all come to an end, but there will be plenty more things to complete. This includes sending thank you letters out to the vendors, the sponsors and businesses that donated raffle prizes and getting certificates out to all the workshop and general session attendees. It was extremely helpful to have thought this out in advance and had committee coordinators working on these tasks, freeing you up to deal with the final bill with the hotel.

Standard sound checks are not enough. Even when you prepare your sound equipment, set it up and run through the basic "check, check" on *all* microphones and from standing *all over the room*, it's still not a thorough enough performance check. It doesn't factor in the unique chaos introduced by a room full of people's cell phones or the speakers' random movements. I'm sorry for the constant "bzzzzzzz" sound, humming everyday of general session, but guess what?! Not our sound techs fault! I felt absolutely awful about this for *weeks* after the seminar. Ruminating over it, over and over, "why is this happening?!" and "we checked this, and it wasn't doing this the night before!" (sob, sob, sob). So I looked into this, and yeah, it's a thing: How to Stop Cell Phones From Interfering With Audio Equipment,*

Me and my awesome global ready T-Mobile phone and everyone else out there who had phones with T-Mobile or AT&T as their cell phone carrier (most likely suspects for GSM cell phones), we all contributed to this nuisance. For useful tips and helpful things to know, I suggest having whoever is your in-house AV coordinator read up on this: Resolving Interference Problems*

Also, give a gentle reminder to the speakers to place the lapel microphone high enough so that it can easily detect their voices and attach it in a suitable place such that their movement will not cause their hair or clothing to impede the microphone. You're welcome future seminar chairs. (mic drop)

Fire in the Sky

This past month, I finally decided to get Laser Assisted in-Situ Keratomileusis (LASIK) eye surgery. I had read about it and listened to many friends' firsthand accounts, but I really, truly had no idea what was in store for me. All accounts seem to leave out the finer, more traumatizing details of the experience, either intentionally as not to deter you, or inadvertently as a result of dissociative amnesia. LASIK is nothing short of a scientific marvel; however, let me tell you, it is an *intense* experience. Think about all alien abduction movies you have ever seen. Remember those scenes where the abductee is unable to move as blurry figures move about their head, periodically impeding the bright lights from above. The subject's eyes are held wide open, unable to look away from the foreign and menacing device that is inching steadily closer. These fictional accountings are very similar to my experience of the LASIK procedure, with the only major difference being, of course, that I had elected to subject myself to this procedure. Before I have you all thinking that LASIK is just unbearably awful, let me be clear, LASIK is a *surgery* not unlike any other surgery. You do *not* feel pain, however, you are conscious and aware during the whole procedure. The unique thing about it is the fear and stress you can experience since your vision and what you are physically able to see is changing as the surgery progresses. You literally *see* the surgery happening to your eyes. It's a much more profound reaction than merely (passively) watching surgery happen to another area of your body. Your eyes *experience* the surgery. First, the doctor makes a LASIK flap using a femtosecond laser. There's the discomfort from the "gentle device" holding your eyelids open, then pressure upon your eye, your vision dims, and you hear clicking and a background whirring sound from somewhere unknown. Then the doctor reshapes the cornea using pulses of light from an excimer laser. You can feel the doctor's gentle pressure on your jawline, taking a reassuring hold on your head to keep it in place, and then the assistant's calm assertive voice coaching you, "focus, stay focused." There's a weird smell and a warm breeze near your face and it's difficult to breathe. Your body wants to resist but you feel those reassuring hands tighten, you see dancing and flashing orbs of light, and blurriness like being under milky grey waters. It's intrusive and uncomfortable; overwhelming multiple senses all at once. It's hard to stay focused when you can't see anything discernible in the milky grey. It's difficult to keep your eyes still when you smell the smell and know, because you are a scientist, that it's not the gas used by the laser as they say. You know it's really because the molecular bonds holding together your corneal cells are being violently disrupted and the cells are rapidly released into a cloud that you can smell. Regardless, you remain perfectly still; you resist the urge to blink and fight to stay focused. It's over in mere minutes, but it feels arduous and long. The doctor is smoothing your cornea flap back in place, like ironing, removing all wrinkles. It's an odd uncomfortable feeling, like all the other odd uncomfortable feelings you've experienced for the last 20 minutes, except laced with relief—it's over now. The next day you wake up in your bed and find that science has blessed you with perfect vision. So perfect it makes you want to cry. All unpleasant memories fade as you relish in this new clarity. LASIK is a marvel.

**(See link in online edition.)*

The Midnight Oil

Transitioning from the seemingly slower pace of the summer, fall brings cooler temperatures and if you're lucky enough, a pageantry of changing leaves. The changing colors will be heralding in the final quarter of the year, and we will be undoubtedly challenged with increasing in productivity in order to face relentlessly rising demands. How do we maintain a balance between the things we should be doing and the things that we want and need to be doing in a world of infinite distractions? There's multiple sources competing for our attention and focus, between work demands and personal demands, many of us are juggling several tasks and depleting our energy reserve available to handle these demands. This tendency to work in survival mode is diminishing our capacity to maintain a sustainable high performance.

This quarter I will strive to focus on the *value* I am producing during the hours I work. I will commit to focus on renewal to balance the time spent working to meet the higher demand. The simplest solution is to develop the skills to work more efficiently. Here's a good reminder of how best to achieve this potential:

- Stop multitasking
- Delegate
- Use appropriate communication
- Apply structure to the schedule
- Give everything a proper place
- Time activities
- Commit to downtime
- Plan projects

By implementing and practicing these 8 Things Really Efficient People Do*, we can frame a strategy for balancing the aspects of our lives which pull our focus in opposing directions. In this last quarter, I ask you to reflect on how you work over the course of a typical day. How often are you incorporating recovery into your day? What one modification can you make to your day that would allow you to focus better on one task at a time? My own personal goal will be focusing on numbers 1, 3 and 7. I believe that by cultivating and investing in ourselves we can add value and purpose to performing our work with excellence. Not only can we strive towards the goals we set at our workplace, but collectively, we can influence the field of Criminalistics as an organization in meaningful and lasting ways.

Be good to yourself and be good to others.

Mei

Why Do We Need an SDO if We Have the OSAC?

*Brad Wing**

SDO is a term meaning *Standards Developing Organization*. OSAC stands for the Organization of Scientific Area Committees. The AAFS has established an SDO (called the AAFS Standards Board, abbreviated ASB) that works closely with OSAC to develop *voluntary consensus standards*, technical reports and best practice recommendations.

OSAC is administered by the National Institute of Standards and Technology (NIST). OSAC publishes the *Registry of Approved Standards* and the *Registry of Approved Guidelines* for the forensics community. Each document listed in the registries is required to be based upon sound scientific principles and to have been developed in a *consensus-based* processes. OSAC has 23 subcommittees, each focused upon a specific area of forensics. These subcommittees are responsible for determining which documents to submit to the Registries, but also to identify gaps and needs in standards and related documents. Another function of the subcommittees is to identify research needs and publicize these needs to Federal agencies.

The term *voluntary consensus standards* is the key as to why the ASB was created, and why OSAC needs the cooperation and participation of the ASB and other SDOs. In 1995, Congress passed a law called the National Technology Transfer and Advancement Act (NTTAA). This law states "All federal agencies must use voluntary consensus standards in lieu of government-unique standards in their procurement and regulatory activities, except where inconsistent with law or otherwise impractical." This also has a trickle-down effect, since Federal grants involving standards are also subject to NTTAA. The important point for this discussion is that OSAC was not created to generate voluntary consensus standards. The NTTAA and the policy document explaining it (*available at http://www.nist.gov/standardsgov/omba119.cfm#3)* define the processes required to develop a voluntary consensus standard: *"i. Openness; ii. Balance of interest; iii. Due process; iv. An appeals process; v. Consensus, which is defined as general agreement, but not necessarily unanimity and includes a process for attempting to resolve objections by interested parties…"*

The AAFS Academy Standards Board (ASB) meets these criteria. In fact, it has been accredited by the American National Standards Institute (ANSI), which requires adherence to the principles defined above. OSAC is not an SDO and will not become an SDO. While an OSAC subcommittee may identify a gap in existing standards for a field, and even develop a draft document for submittal to an SDO, it is the role of the SDO to ensure that the procedures are properly followed so that the requirements of the NTTAA for *voluntary consensus standards* are met.

The ASB accomplishes this by forming consensus bodies (CBs). Currently there are 13 such CBs (Anthropology, Bloodstain Pattern Analysis, Disaster Victim Identification, DNA, Dogs and Sensors, Firearms and Toolmarks, Footwear and Tiretracks, Forensic Document Examination, Friction Ridge, Medicolegal Death Investigation, Patterned Injury, Toxicology, and Wildlife Forensics). With the exception of Patterned Injury, these exactly correspond to OSAC subcommittees. The CBs are made up of individuals from different backgrounds, which are characterized by 'interest categories,' of which we have eight: academia, consumer groups, general interest (typically lawyers and judges), laboratories and testing facilities, producers, subject matter experts, user/government and user/industry. This helps to ensure *balance of interest*—one of the key requirements for an SDO.

Consensus bodies (which develop the standards) hold meetings *open* to all interested parties and are comprised of experts from the eight interest categories listed above. There is a defined process to develop the documents – ensuring *due process*, including an *appeals procedure*. Each document is put out for public review, so that any interested party—even if they do not participate on the consensus body—may comment on the document. The consensus body is responsible for adjudicating any issues that may arise during the review. *Consensus* must be reached among the members of the consensus body for a document to be adopted. In addition, the Board of the ASB must approve the document prior to submission to ANSI (which allows a standard to become an American National Standard).

This is all well and good, but it still doesn't answer the question of why the AAFS now has an SDO.

When OSAC was established, it became apparent that some fields in forensic science had existing relationships with SDOs – such as in fire science and gunshot residue. Others may have had professional organizations (such as the American Board of Forensic Odontology) which had issued guidance documents. In some fields there were Scientific Working Groups (SWG), such as in DNA. However, the standards and best practice guidelines produced by professional organizations and SWGs do not meet the requirements of the NTTAA for being *voluntary consensus standards.* OSAC approached several professional groups, including AAFS to see if any were interested and capable of establishing an SDO to generate *voluntary consensus standards.*

The AAFS accepted the challenge and created the ASB. The ASB CBs have close relationships with their corresponding OSAC subcommittees but the CBs may also generate documents on their own. Some documents may be proposed directly by professional organizations, or even by individuals not associated with OSAC.

The CBs need assistance in determining the scientific underpinnings that must be included in ASB standards and best practice recommendations. CBs will typically reach out to OSAC subcommittees to provide the necessary scientific and operational foundation for the requirements in a standard or best practice recommendation.

Once a standard or best practice recommendation is finalized by the ASB, the corresponding OSAC subcommittee may refer it for inclusion in the appropriate Registry – thus completing the loop of interrelationship of OSAC subcommittees and ASB CBs.

The ASB Consensus Bodies are open to anyone with an interest in forensic science. Updates as well as applications for a Consensus Body membership can be found at http://asb.aafs.org/

**Secretariat, Academy Standards Board*

Biographies of Forensic Pioneers Needed

Saw the latest edition of the newsletter with my Luke May article.

Sorry it went over two pages, but glad you were able to fit it in. But I also saw something else, which triggered a thought.

The Feedback letter from Professor DeForest [*3rdQ CACNews*] suggests an unfortunate choice of words in my earlier letter about Luke May. In saying that Paul L. Kirk was "late to the game" in criminalistics, I in no way meant to imply that Dr. Kirk did not make monumental contributions to the field. The positive result of that, however, was the brief but very informative biography of Kirk, with a summary of his many accomplishments. Dr. DeForest rightly points out: "It is unfortunate that there is no biography of Dr. Kirk." And that got me to thinking about other pioneers whose lives have perhaps not received the attention they are due. So I made up a list of pioneers and did some research. The list was not meant to be exhaustive, but just to assess the situation and to share with you and your readers (if you choose). So here they are with references to biographies … or lack thereof:

Victor Balthazard—Biography in French, published in 1974, out of print. Many articles.

Alphonse Bertillon—Henry T. F. Rhodes, *Alphonse Bertillon, Father of Scientific Detection*, Literary Licensing, LLC (2013); reprint, originally published in 1956.

Sir Francis Galton—Nicholas Wright Gillham, *A Life of Sir Francis Galton: From African Exploration to the Birth of Eugenics*, Oxford University Press, New York (2001)

Col. Calvin Goddard—Several articles, no book-length biography.

Hans Gross—Several articles, no book-length biography.

Edward O. Heinrich—Eugene Block, *The Wizard of Berkeley,* Coward-McCann, New York (1958). [Long out of print, used copies sometimes available.]

Paul L. Kirk—Many articles, no book-length biography.

Edmond Locard—Marielle Larriaga, *The Fabulous Story of Edmond Locard, Provincial Cop*, Traboules Editions (2007). [French, no English translation.] Several articles, no book-length biography in English.

Cesare Lombroso—Paul Knepper, Per Jørgen Ystehede (eds.) *The Cesare Lombroso Handbook*, Routledge, New York (2012). [Minimum price on Amazon.com [1] for a print edition is about $70, Kindle version is over $52.]

Luke S. May—A few articles, no book-length biography (yet).

Mathieu Orfila—Several articles, could not trace a book-length biography.

Albert S. Osborn—Several articles, no book-length biography.

Sir Bernard Spilsbury—Andrew Rose, *Lethal Witness: Sir Bernard Spilsbury Honorary Pathologist*, Sutton (2007). Colin Evans, *The Father of Forensics: The Groundbreaking Cases of Sir Bernard Spilsbury…*, Berkley Books, New York (2006). And several more.

August Vollmer—Gene E. Carte, Elaine H. Carte, *Police Reform in the United States: The Era of August Vollmer*, University of California Press, Berkeley, California (1975). [Out of print, but copies available.] Alfred E. Parker, *Crime Fighter: August Vollmer*, MacMillan, New York (1961). [Out of print, but copies available.]

So of these fourteen pioneers, we have just four with book-length biographies in English that are still in print. And one of those is very expensive. For two more, there do seem to be copies of out-of-print biographies available. That leaves eight including, obviously, Paul Kirk for whom we have no book-length biographies in English. Sad, really.

Evan Filby

IAI/NIST Invitation to Submit Abstract for Oral Presentation to Receive NIST Stipend

This message is an attempt by the International Association for Identifications subcommittee on General Forensics to reach out to members who have identified themselves as criminalists or forensic scientists that work in a forensic laboratory performing analysis on physical evidence in such specialties as forensic biology (DNA) serology, firearms and toolmarks, trace evidence analysis including hairs, fibers, paints, soils, small particles, flammable liquids and explosives analysis, controlled substances analysis, clandestine laboratory investigations, and toxicology. Other disciplines include questioned documents, forensic anthropology, and forensic odontology. This subcommittee while small in terms of numbers of members is by far the most diverse in the International Association for Identification. My purpose as chair of the subcommittee on General Forensics (GFS) is to inform its members and potential members of activities in which the subcommittee is engaged. The GFS is part of the Science and Practices Committee. It serves the IAI in providing subject matter experts in the previous mentioned disciplines. It also provides the annual seminar training program chair with potential speakers for the program and workshop presenters. More information about this subcommittee can be found by accessing the IAI website at http://www.theiai.org/disciplines/general/index.php.

My main purpose in this letter is to extend to you an opportunity to receive free travel, lodging, and registration for the next IAI annual training conference in Atlanta, GA. After a year's absence this subcommittee in concert with NIST will be providing two stipends to individuals who submit an abstract and agree to make an oral presentation at the conference. The abstracts are reviewed by members of the subcommittee then the selected applicants will be notified by the chair. The two winners must then submit their abstracts to program chair by the printed deadline and must make their presentations. The selected winners will be reimbursed by NIST for domestic travel, lodging, and registration. This year the application process is open to all bench level criminalists and criminalistics students forensic document examiners, forensic anthropologists, and forensic odontologists. Membership in the IAI is not required. Applicants must reside within the United States. It is hoped through this program that those identifying themselves as forensic scientists will become more active in the organization and also tender their names for membership of this subcommittee. You may contact me through the IAI website by selecting http://www.theiai.org/contact_position.php and clicking the e-mail button in the field marked General Forensics Subcommittee. Attached is a document that illustrates step-by-step instructions on how to submit your abstract electronically. The application deadline to submit an abstract for oral presentation is December 31, 2016. The subcommittee would prefer that abstracts be submitted sooner than the published deadline so as to allow ample time for review for the selection process. I thank you for your time.

Gregory Laskowski

Overturning Convictions Based on "False" Expert Testimony

*Michael Chamberlain**

Introduction

Your expert opinion is elicited by the prosecution at trial. The defendant is convicted. Later, because the theory, method, or technology underlying your opinion evolved, you come to reject your trial opinion in favor of a modified view. The defendant files a petition for a writ of habeas corpus, claiming that your now-recanted trial opinion means that "false evidence" was offered against him at trial, rendering his trial fundamentally unfair. The court agrees and vacates the conviction. How do you feel about that? How *should* you feel about that? What does this mean for your career and credibility? Will your "false" testimony now follow you around as "*Brady* material"?

These are important questions, because in light of a change to California law effective January 1, 2015, as interpreted in a May 2016 decision from the California Supreme Court, the above scenario is increasingly plausible. My message to criminalists and expert witnesses in any field, however, is that you should not feel the slightest bit of reproach or stigma at having your trial testimony labeled "false" for habeas corpus purposes, as long as that original opinion was offered in good faith. Your career and credibility will remain intact. Your reputation may even be enhanced, given your demonstrated fidelity to the scientific method.

2012: A Recanted Expert Opinion Does Not Necessarily Imply "False" Trial Testimony

In 2012, the California Supreme Court was first presented with the significant question of whether an expert opinion, recanted at some point following the trial, can be the basis for overturning a conviction based on receipt of "false evidence."

The writ of habeas corpus

The question arose in the context of a state petition for a writ of habeas corpus. (A habeas petition can be raised in federal court as well.) The writ of habeas corpus is essentially the final safety valve protecting against illegal incarceration or an unjust conviction or sentence. Often pursued even after a conviction is affirmed on appeal, habeas litigation can involve presentation of additional evidence not considered at trial or on appeal.[1] In California, a partial list of grounds for habeas relief is listed in Penal Code section 1473. Among them is when "[f]alse evidence that is substantially material or probative on the issue of guilt or punishment was introduced against a person at a hearing or trial relating to his or her incarceration."[2]

The Richards case

The 2012 case was *In re Richards* (2012) 55 Cal.4th 948. It involved William Richards's 1997 conviction for murdering his wife, Pamela, at their remote dwelling in the Mohave Desert. He was sentenced to 25 years to life in prison.

In its 2012 opinion, the California Supreme Court described the case against Richards as "strong." The court summarized the evidence of Richards's ("petitioner") guilt as follows:

> When Pamela's murder took place, petitioner and Pamela were in the process of ending their marriage, and Pamela planned on leaving petitioner. No other motive (such as robbery or rape) appears for Pamela's murder. The remote property where the couple lived was guarded by several dogs that were hostile to strangers, so it is unlikely that a person other than petitioner (who was familiar to the dogs) would have had access to the property. Footprints and tire tracks in the soft ground at the couple's property indicated that no one other than petitioner, Pamela, and the sheriff's investigators had been present on the night of the murder. When the deputy sheriff responding to petitioner's 911 telephone call arrived at the murder scene at 12:30 a.m., petitioner's demeanor seemed "rehearsed," and petitioner knew an unusual amount of detail about the crime scene, despite the darkness.
>
> At that time, petitioner told the deputy that the battery in the camper had lost its charge, that he did not turn on the generator, and that he had no light. Yet petitioner was able to take the deputy on a detailed tour of the crime scene. He knew that Pamela's pants were lying next to the generator. He knew that her underwear was inside the camper. He knew that her blood was inside the camper on the pillow. He knew that there was "blood on rocks up against the hill." He knew that there was a bloodstained paving stone that had been thrown "over the side of the hill." He also theorized about what Pamela was doing when her murderer arrived, where the murderer confronted Pamela, and what she did in her defense. And he surmised that the murderer had used a cinder block to kill Pamela.
>
> Furthermore, Pamela's artificial fingernail was broken (apparently in her struggle with her assailant), and fibers matching petitioner's blue cotton shirt were found wedged in the crack of the broken fingernail. Also, petitioner had Pamela's bloodstains on his pants and shoes—stains that in the opinion of the prosecution's expert witness were from blood spatter, not from drips or contact (indicating that petitioner was present when Pamela's skull was smashed).

In addition, when Richards first spoke to a telephone caller that night about the crime, and before he called 911, he said that Pamela's "head was bashed in and her eye was hanging out of its socket."[3] But when he called 911 minutes later, he told the operator that "he thought Pamela fell off the porch steps and hit her head." Also, Pamela's body was naked from the waist down, but there was no indication of sexual assault.

Bite mark evidence

Among the evidence offered by the prosecution at trial was an expert opinion that a lesion on Pamela's hand was a

[1] See generally *In re Reno* (2012) 55 Cal.4th 428, 449-450.

[2] Pen. Code, § 1473, subd. (b)(1).

[3] This, and some other factual references, were included in the subsequent, 2016, California Supreme Court decision addressing this case. This second decision was In re Richards (2016) 63 Cal.4th 291, and will be discussed below.

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human bite mark "consistent" with Richards as the source, given Richards's unusual dentition. A defense expert in forensic dentistry opined at trial, however, that "the bite mark evidence should be disregarded because of the generic nature of the bite and the low quality of the photograph . . . ."

Habeas argument

In the years following his conviction, Richards pursued habeas corpus relief in the state courts. Richards argued, among other theories, that his murder conviction was based on false evidence. At the time, Penal Code section 1473 referred to "false evidence" as a ground for habeas relief, but did not define the concept.

To support the false evidence claim, Richards provided a declaration from the prosecution's forensic dental expert, who by then had recanted his trial opinion. The expert disavowed his trial testimony about the statistical rarity of Richard's abnormal lower canine tooth, and declared his uncertainty whether the mark on Pamela's hand was a human bite mark at all. In a later hearing, the same expert further suggested that the mark on Pamela's hand was not consistent with Richards's teeth. Richards offered additional expert declarations and testimony as well. The defense odontology expert from trial asserted that advances in computer software now permitted him to review of photographs of Pamela's hand without angular distortion, and based on that review he "'would tend to exclude [Richards] as the suspected biter.'" Another expert testified that examination of the photograph of Pamela's hand, corrected for angular distortion, showed that Richards's lower teeth did not match the observed wound. But, he could not exclude Richard's teeth as a possible source of the mark.

The California Supreme Court's opinion

By 2012, the habeas proceeding had wended its way through the hierarchy of state courts and had arrived at the California Supreme Court. The court agreed with a lower appellate court that Richards, even with his new evidence, had not demonstrated that his 1997 conviction rested upon "false evidence" in violation of due process protections.

Significantly, the 2012 opinion drew a distinction between what makes an expert witness's testimony "false" and what makes a lay witness's testimony "false." "Expert opinion is qualitatively different," stated the court, because even good faith expert testimony has a subjective component, and can reasonably rely on "evolving theories, assumptions, or methods" while being limited by existing technology. "Thus, it is conceivable—even reasonable—that an expert witness's opinion may change over time without that change implying any lack of integrity on the expert's part." Sometimes, explained the court, merely having second thoughts, changing one's mind, or recanting an opinion rendered previously does not make the earlier opinion false. It just demonstrates the inherent subjectivity of expert opinion testimony. After all even in the same trial experts often disagree with each other, and such disagreement does not necessarily require "true" and "false" labels. On the other hand, an expert opinion may be "false" in hindsight if it is now "objectively untrue" because there has been a "a generally accepted and relevant advance in the witness's field of expertise" or "a widely accepted new technology" that permits "experts to reach an objectively more accurate conclusion . . . ." Thus, our Supreme Court sought a balance between an opinion changed based on subjective considerations, and an opinion that had become "objectively untrue."

In the 2012 court's view, the recanted bite mark opinion did not satisfy the false evidence test because, even with new digital photograph software, none of the experts could definitively rule out the possibility that it was a bite mark made by Richards. Thus, concluded the court, Richards had failed to show that the bite mark evidence presented at trial was "objectively untrue." The court denied Richards's habeas petition.

2014 Legislative Response

The Legislature, as reflected in both Assembly and Senate committee analyses, felt that the California Supreme Court's view of "false evidence" was too narrow. So, in 2014 (effective January 1, 2015), it amended Penal Code section 1473 to define "false evidence" more broadly than the court had. The Legislature added subdivision (e)(1), which reads, "For purposes of this section, 'false evidence' shall include opinions of experts that have either been repudiated by the expert who originally provided the opinion at a hearing or trial or that have been undermined by later scientific research or technological advances." With the first clause of that sentence, the Legislature eliminated any distinction between an expert witness who changes her mind, and a lay witness who does so. It left unchanged the requirement that false evidence be "substantially material or probative on the issue of guilt or punishment." "Materiality" means there is there a reasonable probability that the trial outcome would have been different in the defendant's favor had the false evidence not been received.

2016: *In re Richards* II

In the wake of this new statutory language, William Richards filed another habeas petition with the California Supreme Court. On May 26, 2016, the court issued a new opinion in the case: In re Richards (2016) 63 Cal.4th 291. This time it reversed course, granted habeas relief, and vacated Richards's conviction. In line with the new statutory directive, the court opined that the trial bite mark expert had "clearly repudiated his trial testimony," thus rendering it false for purposes of Penal Code section 1473. Moreover, held the court, the new photography software developed since trial had permitted more definitive examinations that undermined the expert's trial opinion.

Then, the 2016 opinion addressed materiality, i.e., whether the false evidence was so significant that there is a reasonable probability it affected the outcome. Despite evidence of guilt it deemed "strong" in its 2012 opinion, the 2016 court concluded that it was not strong enough to render the bite mark opinion less than "substantially material or probative." In doing so, the court emphasized the weakness of the prosecution's case against Richards, noting (1) the chronology of events left only minutes in which Richards could have killed Pamela; (2) the absence of shoe prints was unremarkable given the landscape; (3) Richards's familiarity with the crime scene and location of the bloody rocks could be reasonably attributed to his 30-minute wait for the first responding sheriff's deputy; (4) no evidence definitively established Pamela's time of death; (5) Richards had no visible injuries despite the apparent sustained active violence of Pamela's murder; and (6) the size and quantity of blood stains on Richards's clothing appeared inconsistent with what would be expected had he

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Ethical Dilemmas

Discussion Corner with Carolyn Gannett

Cognitive Bias and Ethical Responsibilities

The Scenario

Mary attended some training on cognitive bias in forensic science. The instructor stressed that this bias is not an ethical issue. Yet, bias is a topic included in many forensic science ethics documents. Now she's wondering just what her ethical responsibilities are concerning bias, if any.

Discussion

Cognitive bias is an unavoidable characteristic of the human mind. Everyone is vulnerable. Most of it takes place unconsciously. It cannot be completely willed away, even with training and a system of rewards and punishments in place. Because engaging in such bias is not a willful, intentional act, one cannot and should not be held responsible simply for falling prey to it. That is why psychological scientists assure the forensic science community that bias is not an ethical issue.

Yet, "bias" is mentioned in several forensic science ethics documents. It's on page one of the National Commission on Forensic Science's (NCFS[1]) "National Code of Ethics and Professional Responsibility for the Forensic Sciences."[2] There, as in the original source[3], it is listed as one of four major categories found to be addressed by every code of ethics reviewed, namely: "avoiding bias and influence, real or perceived."[2]

To quote a few of those documents that may apply directly to the reader (underlining is mine):

- CAC I.A: *The criminalist has a truly scientific spirit and should be inquiring, progressive, logical, and unbiased.*
- CAC II.F: *The scientific mind is unbiased and refuses to be swayed by evidence or matters outside the specific materials under consideration. It is immune to suggestion, pressures and coercions inconsistent with the evidence at hand, being interested only in ascertaining facts.*
- ABC Rule 14: *Maintain an attitude of independence and impartiality in order to ensure an unbiased analysis of the evidence.*
- NCFS #7: *Conduct full, fair and unbiased examinations, leading to independent, impartial, and objective opinions and conclusions.*

Others include[1] ABFDE, AFDAA, AFTE, CIS, IABPA, IAAI, IAI, KBI, NWAFS, SWFS, and TIAFT. (You may go to http://www.cacnews.org/ethics/quotes.pdf and search "bias" if you want to see what these documents say.)

Ethics documents were written, in part, to underscore the values and practices of the scientific method. Addressing bias is one of them. In a nutshell, the scientific method does not promote the idea, "don't be biased." Instead, it promulgates the responsibility to recognize potential biases that may affect the experiment or its outcome, take measures to eliminate or at least mitigate those biases, document and report those measures, and report how residual biases might have affected the results.

In my opinion, that is just what forensic science practitioners need to do in order to practice ethically. In particular, practitioners are ethically responsible to, at least:

- *learn about biases that could impinge upon their results,*
- *learn about the various means to address biases that are pertinent to one's area of expertise,*
- *practice those means as needed, and*
- *document and report the use of those means and any inadvertent (or willful) failure to apply them adequately.*

Some documents, for example AAFS's[1] Code of Ethics, assert a responsibility to promote competency, training, and research. Such content may make it an ethical obligation to become educated in cognitive bias in order to improve one's overall competence. Similarly, there may be an ethical responsibility to help arrange for high-quality training specific to cognitive bias in forensic science. And, when psychological scientists approach you or your lab looking for participants in their studies, you may need to weigh an ethical consideration to cooperate.

> Managing cognitive bias is an ethical obligation.

Perhaps the most important ethical prod to becoming versed in cognitive bias is the responsibility to serve the justice system. As stated explicitly in the CAC Code of Ethics' Preamble:

- *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 sentiment is echoed in several other documents, including those of AFTE, ASQDE, CSDIAI, CSOFS, ENFSI, FS-Reg, IABPA, KBI, NWAFS, and SCAFO.[1]

To fulfill this concept, it is imperative that forensic practitioners take all measures possible to ensure that their results are as accurate and precise as possible, and that any limitations, including those due to cognitive bias, are clearly communicated. The practitioner cannot do this under a cloud of ignorance about cognitive bias. Perhaps before the 70's, when cognitive bias began to be studied in earnest, one could justify remaining ignorant because, well, *everyone* was ignorant. Now that we have decades of studies clarifying its nature and effects, including several studies specific to forensic science, practitioners need to catch up.

Speaking of catching up, some of the wording in ethics documents may need to be tweaked. For example, consider the first quote from above:

- *CAC I.A: The criminalist has a truly scientific spirit and should be inquiring, progressive, logical, and unbiased.*

It could be argued that it is impossible to be "unbiased." Bias is an inherent characteristic of being human. Or, the meaning could be understood to be that the criminalist has removed all sources of potential bias. Practically speaking, that is probably not always possible in every forensic science examination.

And,

- CAC II.F: *The scientific mind is unbiased and refuses to be swayed by evidence or matters outside the specific materials under consideration. It is immune to suggestion, pressures and coercions inconsistent with the evidence at hand, being interested only in as certaining facts.*

Current knowledge is that human minds are biased. Period. Also, no matter how motivated or trained they may be, individuals cannot always keep their minds from being "swayed by evidence or matters outside the specific materials under consideration." As studies have demonstrated, the human mind cannot willfully always be "immune to suggestion, pressures and coercions inconsistent with the evidence at hand."

And,

- ABC Rule 14: *Maintain an attitude of independence and impartiality in order to ensure an unbiased analysis of the evidence.*

Attitudes, no matter how strong, are not always enough "to ensure an unbiased analysis of the evidence."

But,

- NCFS 7: *Conduct full, fair and unbiased examinations, leading to independent, impartial, and objective opinions and conclusions.*

This wording is better. It merely promotes the necessity to conduct unbiased examinations. It doesn't say how. It doesn't assume causes of bias or ways to lessen it (erroneous or otherwise). The phrase simply asserts the ethical obligation to do whatever it takes to end up conducting unbiased examinations. In practice, however, there may be no way to avoid all potentially biasing situations. To address those instances, I'd like to see wording that acknowledges this, and promotes awareness and documentation of potentially biasing situations that could not have been avoided.

I encourage each forensic practitioner and crime lab manager to do whatever it takes to produce unbiased examinations, as an individual and as a lab. Engaging in cognitive bias is unavoidable. However, managing it is not only possible, but an ethical obligation.

[1]KEY TO ACRONYMS

AAFS	Am. Academy of Forensic Science
ABC	Am. Board of Criminalistics
ABFDE	Am. Board of Forensic Document Examiners
AFDAA	Assoc. of Forensic DNA Analysts and Administrators
AFTE	Assoc. of Firearm and Tool Mark Examiners
ASQDE	Am. Society of Questioned Document Examiners
CAC	CA Assoc. of Criminalists
CIS	Canadian Identification Society
CSDIAI	CA State Division of the IAI
CSOFS	Chartered Society of Forensic Sciences
ENFSI	European Network of Forensic Science Institutes
FSReg	Forensic Science Regulator of the UK
IABPA	Int'l Assoc. of Bloodstain Pattern Analysts
IAAI	Int'l Assoc. of Arson Investigators
IAI	Int'l Assoc. for Identification
KBI	Kansas Bureau of Investigation
NCFS	Nat'l Commission on Forensic Science
NWAFS	Northwest Assoc. of Forensic Scientists
SCAFO	Southern CA Assoc. of Fingerprint Officers
SWFS	Society of Wildlife Forensic Science
TIAFT	The Int'l Assoc. of Forensic Toxicologists

[2]"National Code of Ethics and Professional Responsibility for the Forensic Sciences" (2016), National Commission on Forensic Science, https://www.justice.gov/ncfs/file/788576/download, accessed 2016-09-01

[3]"Recommendation to the Attorney General National Code of Professional Responsibility for Forensic Science and Forensic Medicine Service Providers" (2010) Education, Ethics, and Terminology Inter-agency Working Group of the White House's Subcommittee on Forensic Science, www.ascld.org/wp-content/uploads/2016/03/Final-Draft-Recommendations-Document-on-National-Code-of-Professional-Re....pdf, accessed 2016-09-01.

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Chamberlain, cont'd

killed her. It was only to the prosecution's bite mark evidence, observed the court, that the defense lacked a substantial response. Accordingly, there was a reasonable probability that the bite mark evidence affected the outcome.

The Takeaway

So, where does this leave expert witnesses? On its face, the 2014 amendment to Penal Code section 1473 means that a changed expert opinion can be considered "false" for a very specific legal purpose, i.e., litigating the merits of a state habeas petition. It does not mean, necessarily, that the expert lied at trial, or provided unjustified opinion testimony, or fell short of professional standards, or acted in bad faith. To the contrary, most often it will mean just what our Supreme Court described in its 2012 opinion, namely, that theories or methods or instrumentation evolved following the trial, causing the expert to reevaluate her former opinion. This is to be encouraged, not condemned. It should reflect favorably on an expert's professionalism and credibility. It reveals an absence of bias and inclination toward a particular outcome, while embracing the reality that science is a dynamic endeavor, not a static one. For the same reasons, revising an expert opinion in light of subsequent developments in the field does not reflect negatively on an expert's competence or credibility, and thus should not be considered "*Brady*" evidence subject to disclosure in other cases. Therefore, do not let the legalistic "false evidence" label deter you from maintaining your allegiance to the scientific method and integrity as an expert.

The Proceedings of Lunch

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Fundamental Principles of Forensic Science: *Letting go of Individualization*

All truth passes through three stages: First, it is ridiculed; Second, it is violently opposed; and Third, it is accepted as self-evident.

—Arthur Schopenhauer

This POL derives, not from a nice lunch at a pleasant venue, but from a presentation one of us was invited to give to PCAST (Presidential Counsel Advising on Science and Technology). Preparing for that presentation prompted us to reconsider the core principles of forensic science, a subject that became dear to our collective hearts almost two decades ago when we first began to consider and write about such things. As the new millennium dawned, we proposed our forensic science paradigm, published both in our book *Principles and Practice of Criminalistics, The Profession of Forensic Science*, and also in our paper, *The Origin of Evidence*. In fact, a discussion of these principles was the impetus for our first formal POL in 2001. (Rudin and Inman, 2001)

One significant change that has recently occurred in the field of forensic science is the creation of the alphabet soup of groups known as the NCSF (National Commission on Forensic Science), the FSSB (Forensic Science Standards Board), and the OSACs (Organization of Scientific Area Committees). We affectionately have dubbed this extended organization as the Headless Monster (Fig 1) (not to be confused with the Flying Spaghetti Monster[1]). What strikes us about the organizational chart is the conspicuous absence of overarching guiding principles and practices. Nor is any such guidance found in any of the supporting documentation surrounding the creation and stated mission of these interconnected groups. It is our contention that such a set of fundamental guiding principles would serve to unify the forensic disciplines, and would provide a structure to articulate common problems and possible shared solutions. However, such fundamental principles need not be created *de novo*.

Individualization

Before proceeding with a discussion of a set of principles, it is worth articulating the historical principle of individualization, and why it deserves no place in forensic science. The idea of individualization is inseparable from the idea of source determination, commonly understood as the stated goal of a forensic science examination. In a conclusion of source determination, evidence and reference samples are ascribed to a single common source. The definitive common source conclusion is individualization, in other words, one and only one object is the source of both the evidence and the reference.

A belief in uniqueness is required for individualization; however, this proposition cannot be tested; and if a proposition cannot be tested, it is not scientific. Rather than continue to embrace the idea of uniqueness as a fundamental principle, and to continue to attempt to justify it, we should accept that uniqueness is not the question, nor is it a useful concept. It then follows that, if we don't accept uniqueness as either relevant or scientifically defensible, it cannot serve to support a conclusion of individualization.

We are hardly the first to condemn the use of individualization and uniqueness in forensic science. Cogent arguments have been put forth by Simon Cole in his two seminal papers, *Forensics without uniqueness, conclusions without individualization: The new epistemology of forensic identification* (Cole 2009) and *Individualization is dead, long live individualization: Reforms of reporting practices for fingerprint analysis in the United States* (Cole 2014). For an in-depth and well-reasoned discussion of these issues, we refer the interested reader to these papers.

Why is it that we remain so tied to the idea of individualization, and have such difficulty letting go of it? One factor may be our unique relationship with the legal system. The *raison d'etre* for forensic science practitioners is to assist the legal system in its quest to determine guilt or innocence. The problem is this: While the judicial system is ultimately required to make a binary decision, this is not the purview of the scientist. Science, by definition, traffics in quantitating uncertainty; individualization suggests that no uncertainty exists in the conclusion of source determination. Thus science and individualization are antithetical to each other. If we are to assist the legal system through the realm of science, individualization cannot be the goal of the practitioner. Neither uniqueness nor individualization are required to assist the judicial system.

It has become unequivocally evident to us that, for forensic science to survive as a credible science, we must dispense with the idea that forensic scientists are somehow special and can make pronouncements of individualization based in part, and sometimes solely, on human subjective judgment. Given this dichotomy between legal binary decisions and scientific probability, we must reject the temptation to subvert science, better serving the legal process through good science and good scientific practices. While human subjectivity can never be completely removed from the equation (in forensic science, any other science, or in life), quantitative, or at least probabilistic approaches, would go far to increase our stock in the scientific community, and to provide a solid, rational basis for legal conclusions. DNA has finally, belatedly, begun the process of instituting probabilistic weighting of evidence; for

[1] https://en.wikipedia.org/wiki/Flying_Spaghetti_Monster

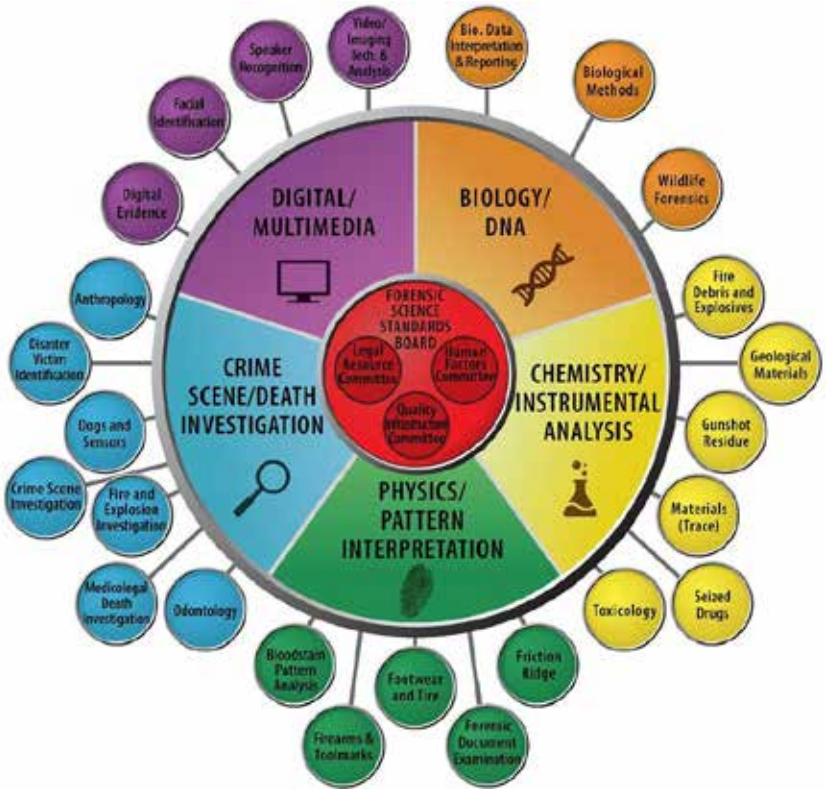

Figure 1.

NIST

other disciplines to ultimately survive in the long-term, they must follow suit.

Thinking about these issues has inspired us to formally reissue our forensic science paradigm, replacing "individualization" with the probabilistically inspired "probability of the evidence" which can support an "inference of source." (Fig 2)

Fundamental Principles of Forensic Science – a paradigm

While various principles and paradigms have been proposed over the course of a century or more of forensic science practice, the field has neither had a vehicle for articulating, nor taken the time to accept, a core set of principles. A consensus paradigm of forensic science principles would help to unify the disciplines under a common scientific umbrella. This would result in a structure to articulate common problems and possible shared solutions. Because many of the forensic science disciplines have grown up outside of the mainstream scientific community, they have historically been isolated from rigorous academic scrutiny, instead achieving acceptance through the judicial system. This has contributed to the lack of acceptance as a legitimate science. To some extent we have created this situation by defending practices that don't conform to normal science[2]. A paradigm articulating fundamental principles of forensic science would contribute to legitimizing forensic science in the eyes of the scientific community.

In 1963 Paul Kirk wrote "The Ontogeny of Criminalistics." In this work he infamously defined forensic science as the "science of individualization." He also spoke of the requirement to apply statistical methods to quantitate the weight of evidence, but this idea got lost in the oversimplification and easy branding of the profession as that of "individualization." In 2001 we (Inman and Rudin) published *Principles and Practice of Criminalistics, The Profession of Forensic Science*, in which we proposed a Paradigm of Forensic Science. In this paradigm, we followed Kirk and included "individualization" as a fundamental principle. Although we also discussed the idea that individualization could never be achieved through quantitative means and essentially constituted a "leap of faith" (following Stoney, 1991) we nonetheless perpetuated the concept. Over the years, we have become convinced that this idea of "individualization" does not serve forensic science well. It has been perhaps a main, if not *the* main, factor in holding back forensic science from developing and maturing appropriately as a true and complete scientific discipline. In *Criminalistics*, we mark an adolescent phase of forensic science; it has not matured as it should have since that time, at least, and perhaps in large part, because of its allegiance to the false idol of individualization.

Any paradigm shift must include educating the legal actors, in particular the judiciary, as gatekeepers of forensic science testimony in the courtroom. A proactive campaign to educate judges about evolving principles, practices and standards in forensic science would go a long way to advance the cause of holding forensic science to the standards of normal science.

From DNA to pattern comparison

DNA has, since its inception, been held out as the gold standard of forensic science. It enjoys this status in part due to its roots in academia, but also because of two characteristics inherent to genetic data: 1) DNA typing, at the detection level imposed by current methods, produces discrete patterns that are readily amenable to statistical analysis, and 2) human reference populations are stable and well characterized. It is important to recognize, however, that fundamentally, forensic DNA typing is no different than the traditional forensic disciplines—ultimately they are all an exercise in pattern comparison. What distinguishes the various forensic science disciplines at a practical level is 1) the type of data (discrete or continuous)

[2] https://en.wikipedia.org/wiki/Normal_science

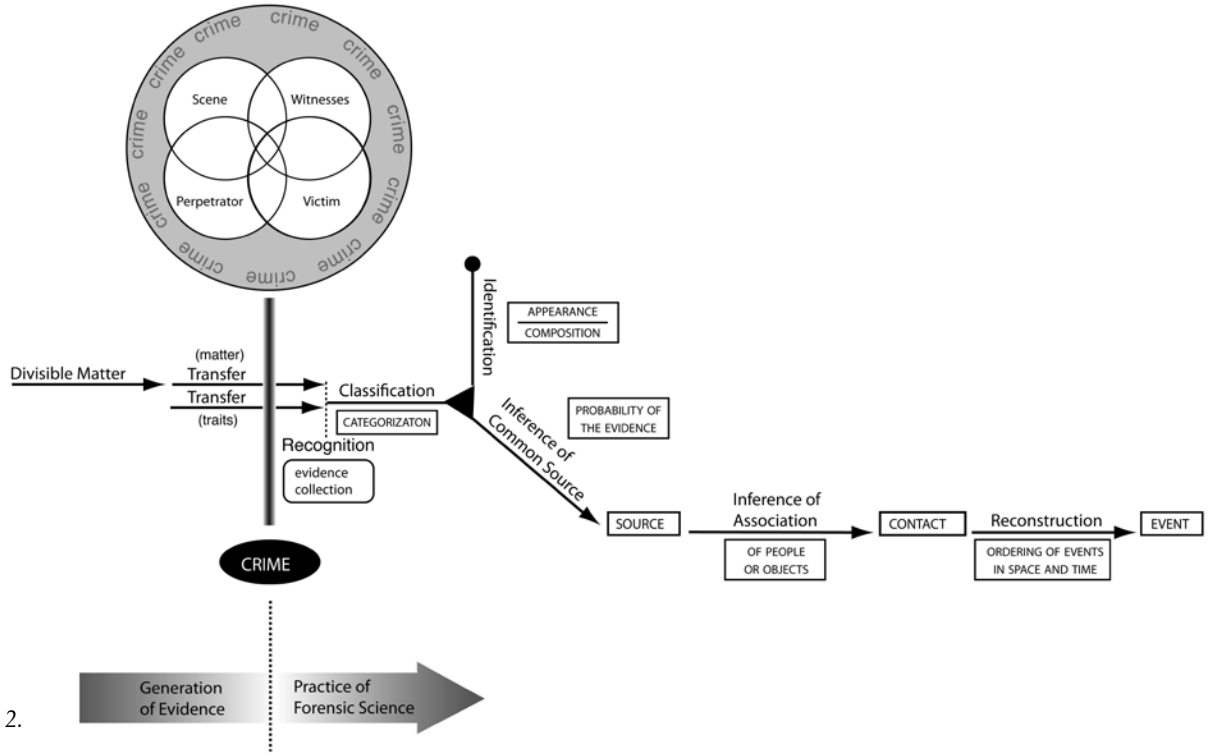

Figure 2.

and 2) the nature of the population (stable, well characterized, or unstable, poorly characterized). This understanding is what should direct the challenges and inform the solutions for different disciplines. The differences must be recognized and articulated before they can properly be addressed.

Dermal ridge prints

Other forensic disciplines face challenges that DNA is able to avoid, in particular complex patterns that are effectively continuous, or whose reference populations are unstable and more difficult to characterize. For example, while dermal ridge prints (finger and otherwise) derive from the same stable human population as DNA, and the basic pattern types do have a genetic basis, the development of the minutiae used for individual differentiation is a stochastic process occurring during fetal development of friction ridges. The population of print patterns has not yet been well-described; however, huge databases of fingerprints, in particular, exist from which this data could be mined. Attempts have been made to model print patterns since Galton himself; for an in-depth treatment of the subject, we recommend the many publications David Stoney, summarized in the 2001 book chapter he authored. The more difficult challenge has been getting buy-in from the dermal ridge print community – and empowering judges to think critically about print evidence rather than reflexively admitting it just because it has a long history in the courtroom. We had long maintained that the impetus to overhaul both the foundation and practice of dermal ridge examination and comparison must come from academia, almost certainly an interdisciplinary group including experts in automated pattern recognition, statistics, and bioinformatics. However, we were wrong. A recent quantum leap forward in this thinking originates from Henry Swofford, chief of the Latent Print Branch, US Army Criminal Investigation Laboratory. (Swofford et. al., 2016)

Toolmarks and firearms

Firearm and toolmark analysis is the discipline perhaps most highly wedded to binary subjective judgments, and most resistant to adopting quantitative methods to characterize uncertainty and the weight of the evidence. Because these comparisons can only link inanimate objects and have no inherent primary capacity to link a person with an item or event, their significance in relation to a crime event is fundamentally reduced; thus incorrect calls may have less impact on the totality of a case and may not receive the high profile media attention of, for example, a false DNA or fingerprint match. This may be one reason that this discipline has been able to, at least so far, continue to exist on a platform of analyst assertions about individualization with little quantitative support.

Populations of manufactured objects are amenable to characterization of patterns introduced by the manufacturing process itself – at what toolmark examiners would call the class characteristic level. Similarly, stochastic variation introduced by wear and firing should also be amenable to mathematical modeling and prediction; this is, after all, the entire rationale for comparing consecutively manufactured items. However, simply testing analysts on their ability to distinguish consecutively fired cartridges or consecutively manufactured tools – a method that has been a mainstay of this discipline for decades – is insufficient to explore the limits of variation of these patterns. It assumes, without proof, that the patterns that most closely resemble each other are those from consecutive events. Exploration of the different sources and kinds of variation, both empirically and by simulations, are necessary to better understand the risk of error under various scenarios. These issues are beginning to be investigated, but the work is far from providing executable solutions. Perhaps in contrast to dermal ridge evidence, a sophisticated group of focused academic scientists with expertise in topographical mapping techniques, automated pattern recognition, and statistics may in fact be necessary to move this discipline forward.

Trace evidence

Trace evidence (particles and fibers) is eminently amenable to sophisticated and accurate characterization using specific physical and chemical characteristics that comprise a descriptive set. The chemical and physical properties of trace items comprise a pattern that is compared between items, and can also be extended to comparison between sets of items. The great difficulty, and it may be the greatest difficulty among all of the forensic disciplines, is characterizing the unstable, ever shifting and highly segregated (unevenly asymmetrically distributed) populations of particles and fibers. This challenge makes it extremely difficult to estimate the weight of matching characteristics, whether between single items or groups of items. This issue may be one of the most difficult challenges to bringing a forensic discipline into the scientific arena; however, they should not be insurmountable. Yet again, this is a challenge best addressed by an interdisciplinary academic research group.

When will we ever learn …DNA repeats its early mistakes

To return to the issue of DNA, it is important to understand that the original perceived simplicity and power associated with forensic DNA typing came from comparing high quality single source profiles, mostly devoid of ambiguity. As the technology improved in the beginning of the 21st century, and we gained the ability to detect minute biological samples, and concomitantly began to accept samples of "touch" DNA, the ambiguity in evidential DNA profiles increased. Indeed, DNA began to experience many of the challenges long associated with legacy or traditional pattern comparison disciplines—complex patterns, missing information, increased artifacts etc. Essentially, the technology exceeded our ability to interpret and weight evidence from these complex profiles. In essence, DNA had devolved to look much more like traditional forensic evidence, and the community was unprepared to reliably interpret and weight the resulting profiles. In fact, a great amount of resources (human, laboratory, monetary) have been wasted in generating profiles that could not be reported. With "touch" samples, DNA also lost its advantage as highly significant associative evidence; because these minute samples were no longer linked to any obvious physiological material, in particular body fluids most characteristic of violent or intimate contact, their significance in the context of the case has decreased. This also highlights the commonality of DNA and other forensic evidence when working with compromised or complex DNA samples.

The lesson from DNA is that the solution is not necessarily more technology that merely produces more data. The question we are trying to answer must carefully be considered: first we must decide if the increase in data or signal will ultimately provide reliable information relevant to the question, or whether the increase in the level of ambiguity or the decreased ability to separate signal from noise will outweigh any benefit of that increase. ***If new technology is adopted, we must simultaneously develop and implement the interpretational and statistical framework to be able to reliably report conclusions reached from the data.*** The DNA community is slowly starting to implement probabilistic genotyping; this adoption is trailing the technology requiring it by probably a decade. Nevertheless, our experience implementing this approach for DNA will assist in what will almost certainly be an even more difficult road for other disciplines.

The Maturation of Forensic Science

All forensic science conclusions, whether rendered in a report or testimony, should be based on a strong scientific foundation. The capabilities and limitations of any and all techniques used must be established empirically. The limitations, in particular, must be fully explored and characterized. One way to achieve this is to make sure that validation studies are designed to stress the system such that limits are truly tested. And then guidelines derived from these validation studies must be tested and verified on an independent data set to confirm their veracity and effectiveness. Another requirement for establishing a solid scientific foundation is to quantitate the risk of error. A different way to say this is that the uncertainty associated with the test must be established. Finally, conclusions can never be expressed in absolute binary terms, but must be expressed in informed probabilistic terms.

Conclusion

If the traditional pattern comparison disciplines are to continue to provide information to the judicial system, their capabilities and, importantly, their limitations (quantitation of uncertainty) must fully be explored and characterized. Further, casework conclusions cannot exceed the knowledge base of validation studies; in other words, guidelines developed from particular sets of validation samples cannot be used to inform the interpretation of casework samples that are markedly more complex. Conclusions must be expressed in informed probabilistic terms; if the risk of error cannot be determined experimentally, and if the probability of the evidence under competing hypotheses cannot be compared, then it must be considered whether such evidence is useful to the administration of justice.

Denouement

Maybe now is the time for an adult beverage?

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Twenty-five for Twenty-five

When CAC President Carole Sidebotham called me that fateful day in 1991, she asked me to "volunteer" for a committee. I wasted no time offering to do a makeover of the *CACNews*, but I could not have imagined that I'd be putting the finishing touches on my one-hundredth issue a quarter-century later. It's been a treat working with Lisa Brewer, Raymond Davis, Nancy McCombs, John Sims, Ron Nichols, Greg Matheson, Meiling Robinson—terrific, supportive and encouraging editors, every one.

In celebration, I've collected what I think are some of the more memorable images to appear in the *News* over the past 25 years. My criteria was simple: Choose twenty-five photos that never made the cover but were published inside. Each made me smile and I think capture the flavor of our meetings and seminars. I hope you will enjoy seeing these images as much as I did selecting them. If you had the pleasure of attending these seminars you'll no doubt get a nostalgia kick as well. Thanks for letting me serve as your art director for so long! Oh, and be sure and look at these pages in full color via the *cacnews.org* website.

—John Houde

(upper l) The fall 2003 CAC seminar included a trip the San Diego Zoo.

(lower l) Polynesian dancer entertains the CAC banquet at the 2008 San Diego meeting.

(above) Reminiscent of the Charlie's Angels movie poster, these attendees work out a trajectory at the shooting scene reconstruction workshop. Concord, 2006

(below) Hiram Evans compares Tony Longhetti's head to the CAC coconut at the 1999 Oakland seminar.

Jennifer Mihalovich and Sabine at the the 1997 seminar in Irvine.

The crowd gets involved in the banquet entertainment at the San Diego, 2008 seminar.

The 100th CAC seminar was held in Huntington Beach (2002). John DeHaan supplied the fire demonstration.

(right) A student in Luke Haag's workshop calculates trajectories at the spring 2007 meeting in Garden Grove.

(far right) Three Cols. Mustard at the Clue-themed seminar in Modesto (2013).

(right) A glue fume workshop student is "framed" at the 2005 Oakland meeting.

Celia Lukomski and friend at a fire debris workshop. (100th seminar, 2002)

"Elvis" entertains the membership at the 2013 Pasadena meeting.

Linda Phelps and Trevor detect accelerants at the fall 2014 seminar in Rohnert Park.

How it began... Carole Sidebotham presents Walter McCrone with the Roger Greene award at the San Bernardino meeting in 1991.

Entomologist Lee Goff conducts a workshop at the Glendale seminar in 2001.

Chris Coleman vs the Mercedes at the 2008 Sacramento meeting.

The rustle of satin at the 2016 banquet in North Hollywood.

George Sensabaugh receives a toast at his retirement party in 2012 at the San Jose meeting.

Mary Gibbons receives the Longhetti Distinguished Member award at the 2006 Concord seminar.

An unexpected bit of weather at the Yosemite seminar in 2010.

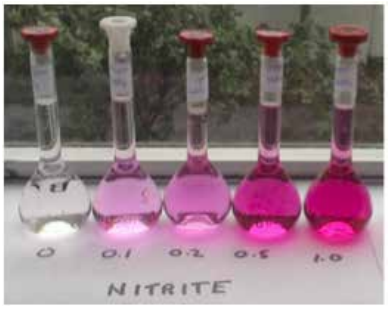
Vendor exhibit, San Francisco, 2002.

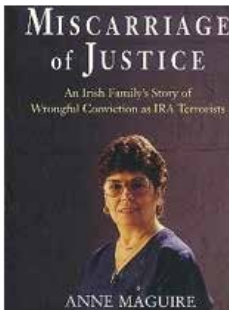
After-dinner parlor games at the winery. (Rohnert Park, 2014)

Everyone's favorite fire-bug: Dr. John DeHaan at the Huntington Beach seminar in 2002.

Kristin Rogahn ready for action at the Ventura seminar in 2004.

Steve Dowell leads a tour through the LA Medical Examiner's facility as part of the fall 2001 meeting.





Part One: **Chemistry and Law—*Complementary Sciences***

Seán Ó Muircheartaigh

Introduction:

The general circumstances surrounding the Maguire case may be seen in the BBC video available on line.[1]

In the early seventies there was a series of criminal cases in Great Britain (including the Birmingham Six, the Guilford Four and Judith Ward cases, not considered in detail here) in which persons, predominantly of Irish origin, were convicted of terrorist offences. Many of these convictions were subsequently, indeed very much later, quashed and seen as miscarriages of justice. When Gerry Conlon of the Guilford Four was being questioned in 1974, he implicated his aunt Annie Maguire saying she had taught him to make bombs in her kitchen. "*Later that day Gerard Conlon made a further statement in which he allegedly named Annie Maguire as the person who had shown him how to make bombs.*"[2] This allegation triggered a police raid on the Maguire house and resulted in the arrest and trial of the seven persons subsequently tried and convicted.

This paper reviews the legal processes, reports, and use of forensic science involved. The Maguire Case continued from 1974 to 1991 in the London Courts. First the Maguires were tried before a judge and jury in the Central Criminal Court at the Old Bailey in March 1976 and were convicted and given long prison sentences. The Court of Appeal upheld most of that decision in 1977. Three law lords (senior judges) sitting in one court in the final appeal, which resulted in mounting doubt about the forensic evidence (1991) quashed their convictions, nevertheless in a manner which seems to the authors incomplete. At least seven forensic and analytical scientists, as highly qualified and experienced as any in the world, assisted the courts and subsequent inquiries in their deliberations.

Important details of the trials and inquiries.

These judicial proceedings were initiated in 1974. This was a time when a series of random bomb attacks on civilians was being carried out by the Irish Republican Army (IRA) and which killed many people. Several other similar instances of trial and imprisonment in England, following upon bombing outrages, at around that time, gave rise to some disquiet, which was publicly aired by a few prominent citizens.

The British Home Secretary then engaged the Rt. Hon. Sir John May (a retired judge from the court of Appeal) to carry out a Judicial Inquiry into "all aspects" that lay behind the conviction of the Maguire and Guildford Four cases in 1989. Three reports were produced.[3] Not only was the science that lay behind the convictions dealt with in detail, but also the mechanisms by which the case came to be initiated by the Law Officers and the Home Office were examined. This comprehensive Inquiry concluded there had been a miscarriage of justice. As part of this Inquiry, Sir John appointed a scientific committee (the West Committee) under a very experienced scientist—Professor T. S. West, and representing many of the senior professionals involved in the trial (prosecution, defence, Home Office, independent experts etc.) to investigate the science. His first two reports are online and deal with the Maguire case. The Inquiry was very thorough and cost the British taxpayer £2.14 million. This published data makes *Regina v Anne Maguire* (and others)[4] one of the most documented and in that regard important forensic cases known.

Background:

[May Inquiry Section 1.9 interim report] [5]

> *"I write this report against the backcloth of a continuing terrorist campaign in the United Kingdom and Europe by the provisional IRA. In 1990 the campaign has already claimed 32 lives. In 1974, when the Guildford Four and the Maguires were arrested, 45 people were killed in Great Britain alone as a result of similar terrorism."*

The following are three of a long list of atrocities which were carried out around this time and were linked (at least in the public mind) to these cases which may have motivated the authorities to be seen to be very active in pursuing the culprits:

- 5th October 1974 Bombs went off in Guildford and Woolwich killing 4 soldiers and injuring 44; (Guildford Four convicted for this attack)
- 21st November 1974: Birmingham pub bombings – 21 killed and 182 injured; (Birmingham Six accused of this and subsequently convicted)
- September 1973 / February 1974 ; Eight soldiers and 4 civilians killed in M62 coach bombing (Judith Ward convicted of this and other atrocities).

A list of terrorist attacks in the UK in 1970's and 1980's is to be found on the internet.[6]

The Facts of the Maguire Trial:

(from court and inquiry proceedings) [7]

> *"On 4 March 1976, in the Central Criminal Court, Anne Rita Maguire, Patrick Joseph Maguire, Patrick Joseph Conlon, William John Smyth, Vincent John Patrick Maguire, Patrick Joseph Paul Maguire and Patrick Joseph O'Neill were each convicted of a separate count charging an offence contrary to S4(1) of the Explosive Substances Act 1883. The particulars of each count alleged that on a day between 1 and 4 December 1974 the defendant knowingly had in his or her possession or under his or her control an explosive substance, namely*

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nitroglycerine, under such circumstances as to give rise to a reasonable suspicion that he or she did not have it in his or her possession or control for a lawful object.

The sentences were as follows: Mrs Maguire 14 years, Patrick Maguire 14 years, Conlon 12 years, Smyth 12 years, O'Neill 12 years, Vincent Maguire 5 years and Patrick Maguire junior 4 years' detention.

All the defendants sought leave to appeal against conviction and sentence. On 30 July 1977 this court dismissed all the applications for leave to appeal against conviction. Leave to appeal against sentence was granted to O'Neill and his sentence was reduced to eight years. Otherwise the applications for leave to appeal against sentence were refused.

On 23 January 1980 Mr. Conlon died while still serving his sentence. All the other defendants have now served their sentences."

The Crown's case[8]

"The Crown sought to establish that each of the male applicants had nitroglycerine (NG) on their hands. For this purpose they relied upon the factual evidence of the TLC [thin layer chromatography explained in Appendix 1 of this paper] tests given [sic] by Mr. Elliott and the opinion of Mr. Elliott, Mr. Higgs and Dr. Hayes that these results showed that the substance was NG. ….

... that the results could not be confused with a non explosive substance which might mimic the results on the TLC……..

… " They also sought to show that NG could not have got there innocently, by innocent contamination with some object which itself was contaminated; but must have got there by kneading or handling the explosive.. For this purpose they relied on the opinion of Mr. Elliott and Mr. Higgs that the presence under the nails of traces of NG was only consistent with the latter hypothesis…."

…"The case against Mrs. Maguire was based on the positive tests on the gloves, the suggestion was that she must have used the gloves to handle the NG and this is why her hands were clear. "

Forensic Evidence in Maguire Case

The examination of the hands of the accused on the evening they were arrested was carried out by swabbing their hands with cotton wool containing organic solvents into which traces of chemicals such as nitroglycerine would dissolve. The forensic science procedure involved was to analyse the contents of these swabs, and identify the chemicals, if any, recovered from the prisoners' hands. Thin Layer Chromatography (TLC) was used as the analytical tool.

Description of positive spots: [10]

"The evidence was to the effect that the pink spots had a similarity of colour across the plates. It was suggested that it would be remarkable if each tested area of the hands and nails produced the same quantity of NG. This matter was not explored at the trial when more accurate recollections would have been available. But as we have explained the test is not a quantitative one: similarity of colour to the standard means a quantity of approximately 200 to 1000 ng. After that the spot becomes more diffuse, and possibly will have a yellow centre. It is not possible to conclude that precisely the same quantity was found at each source. Both Mr. Higgs and Dr. Hayes, and no doubt Mr. Elliott too) were surprised at so many positives, but this is because on field tests, as opposed to experiments with HTK's (hand test kits) were rare. We do not think this point casts any doubt on the integrity of the tests."

A thin layer plate of nitrite (NO_2^-) standards was run to investigate this observation. TLC analysis of NG is a difficult technique to get quantitative results and is quite unsuitable as a definitive (as distinct from a screening) analytical technique. (The chemistry will be discussed in part 2.) The high volatility of NG does not help, and anyway, particularly in 1974, the preparation of the plates was not an exact science either. However, from the point of view of this paper it is adequate to do an illustrative experiment on standards of nitrite to observe the colour formation. It is accepted that NG is converted stoichiometrically (i.e. in a one to three ratio) to nitrite in the analysis.

Various documents give detail of how a substantial colour was obtained in the thin layer plates of the Maguire Seven:[10]

"*7.4 It appears that positive results on this scale were something of a rarity in the laboratory. Mr. Higgs gave the Inquiry a vivid impression of the impact these results had on the RARDE staff when he was asked whether he remembered viewing these particular plates:*

'Yes indeed. There was a great deal of excitement. Never before had we seen so many positives on a plate at a reasonably high level of intensity. We just did not believe it quite honestly. He [Mr. Elliott] *brought them to me, I was in my office writing at the time, so I have a distinct memory of those spots and their strength relative to the standard…My view at the time was that they contained a rather appreciable amount of nitroglycerine. The hue was similar to the standards*."

These statements show the analysts had thereby concluded that a measureable amount of NG was detected on the accused persons.

	Dry Swab		Ether Swab		Nails		Paper
	L	R	L	R	L	R	
Guiseppe Conlon	–	+	+	+	+	+	+
Shaun Smyth	+	+	+	+	+	+	+
Patrick O'Neill	–	–	–	–	+	+	+
Paddy Maguire	–	+	–	–	+	+	+
Vincent Maguire	–	–	–	–	–	+	+
Patrick Maguire	–	–	–	–	–	+	–
Annie Maguire	–	–	–	–	–	–	–
John Maguire	–	–	–	–	–	–	–

TLC Results in Maguire Case:[9]

A positive "+" sign in the table indicates that a pink spot corresponding to a significant amount of NG was detected.

The first (dry) swab is designed to remove material from the surface of the hands. Any recent handling of explosive will be picked up on the swab unless the hand has been very thoroughly washed. The second (ether) swab is designed to draw out material which has been absorbed subcutaneously because explosives such as NG are readily absorbed under the skin.

Fig 1 Note how pink colour has yellow centre at higher concentration

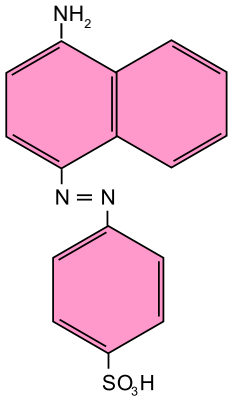


Fig 2 Azo dye formed in 1974

Court of Appeal Judgement: [11]

*"… there were two distinct factual issues at the (original) trial. **First** [sic] , was the substance on the male appellants' hands and Mrs Maguire's gloves nitroglycerine? **Secondly**, if so, could there be an innocent explanation for the presence of the nitroglycerine? It was implicit in the jury's verdict that they had answered both issues against the appellants."*

The Court of Appeal (COA) decided to re-examine the above two critical questions in the re-examination and would allow the defence to bring up any other issues they wanted to.

The COA therefore considered inter alia whether the spots found on the TLC plates were NG; whether it was possible that there was another non-explosive substance which mimicked NG; whether there was material irregularity because of non disclosure of evidence in the trial; the relevance that PETN (another explosive) was indistinguishable from NG using the TLC test and that this was known by prosecution but not disclosed to the defence at the trial; the issue of accidental contamination of the hands of the accused and whether contamination occurred before testing took place or in the laboratory during analysis. (These were the six grounds specified in Court of Appeal Judgements) [12]

Although the COA had said at the outset it was allowing the appellants to argue all new points, it overruled nearly all of them, on the basis that no new substantial evidence had been produced. Therefore the issues being raised had already been decided by a court and/or jury, and the matter was therefore "*res judicata*"—i.e., the matter had been decided.

Discussion:

First: was the substance on the male appellants' hands and Mrs. Maguire's gloves NG?

The key witness regarding this question in the Court of Appeal was Professor Thorburn Burns (an expert appointed by the Court see *infra*).

"Finally Professor Thorburn Burns gave evidence before us. His evidence was not in dispute.. Indeed it had been suggested by both sides that we should simply read his report as containing his evidence……"[13]

"….are we satisfied that the results showed that the substance was NG?

Extensive experiments were done by both the RARDE (prosecution forensic scientists attached to the Department of Defence) and Mr. Yallop (expert adviser to defence counsel and retired former head of laboratory at RARDE) with a view to determining if any other substance [substance X] could be confused with NG in the TLC test. Those tests have continued after the trial. Nothing has been found. Professor Thorburn Burns said the search had been "not undiligent". He put it this way in his report [14]

'Any compound having a false positive reaction must have the following characteristics: persist on hands, be ether extractable, chromatograph with an R_f close to NG, hydrolise to nitrite ion under the same or similar conditions than does NG, Despite extensive laboratory based laboratory searches prior to trial at RARDE and by Yallop and since, no such compound has been reported other than PETN and EGDN. I discount EGDN which appears always with NG.'

This evidence is unchallenged."

*"Moreover, as we have said, in spite of diligent search, substance X has not been discovered. In our judgement ….. based on all the evidence in the case, **the substance was NG (nitroglycerine)."*** [15]

The final Court of Appeal hearing decided that, based on all the evidence, nitroglycerine was found on the hands of the male members of the Maguire Seven, and on Mrs. Maguire's gloves. The ground of appeal to overturn this decision by the original trial was not accepted by the court.

Secondly, if so, could there be an innocent explanation for the presence of the NG?

The court, accepted the findings of the West 16 committee (see appendix 2) here.

"Conclusions on accidental contamination of Maguire samples in 1974.

… We have attempted to summarise briefly the reasons for and against thinking that contamination might have arisen from various sources. Opinion varied in the committee largely because of the absence of incontrovertible data against which to test the various hypotheses we advanced and perhaps because of the different weights given by members to what was available.

The committee counsels extreme caution over any attempt to translate this speculative review into actual probabilities of contamination thus to explain the original results. Whilst in respect of a number of possible contamination sources opinion was divided between those committee members who felt that contamination was likely or highly likely and those who felt it was neither, those that took the latter view accept the view that the possibility of contamination cannot be absolutely excluded"

" S 3.15. I am grateful to these four scientists Drs Hiley and Marshall (RARDE) and Drs Caddy and Lloyd for arguing their respective points of view in this way. The difference between them concerns the degree of probability or improbability of contamination of samples having occurred. The committee as a whole has advised me that the possibility cannot be absolutely excluded, and at this length of time it would in any event be impossible to reach a definitive conclusion that contamination had not occurred. I accept this advice." [17]

Confirmation that nitroglycerine could be transferred innocently from a contaminated towel to the hands of innocent users:[18]

[His Lordship …… continued:] *"In the course of the May inquiry Professor Thorburn Burns carried out a number of experiments with the assistance and co-operation of the scientific advisers of the Crown and the appellants. It is necessary to describe some of these experiments.*

The professor took a new cartridge of Gelamex which contained about 30% nitroglycerine, he unwrapped it, handled it and squeezed it in his hands and returned it to storage. He then washed his hands fairly briefly with soap and dried them on a well used but freshly laundered hand towel. After handling some mugs and glasses he rifled his hands through a box containing plastic gloves. Four subjects C, D, E and F then washed their hands and dried them on the towel. The results, shown in nanograms (ng) of nitroglycerine were as follows:

	Right Hand	Nails	Left Hand
C	24,900	717	17,300
D	13,900	68	5,500
E	5,500	388	4,399
F	6,200	93	11,200

These results came from swabs taken immediately after contamination. They do not therefore allow for the effects of delay. It is clear however that substantial quantities can be transferred to the hand of those subjects from the towel "

These quantitative results were obtained using HPLC, a modern method of analysis not available in 1974.

Evidence given in trials with regard to TLC plates:

They defence lawyers made the following points *inter alia:*

(a) There might be another non explosive chemical in ordinary everyday use [substance "X"] which might mimic the TLC test for NG in toluene.
(b) There was no certainty the substance on the TLC plates was NG in absence of confirmatory tests.
(c) There might have been some accidental contamination of the samples before they were tested. Possible contamination of samples before they reached RARDE was investigated at trial. Possible contamination in the testing laboratory could have occurred in particular by contamination of the ether used.
(d) Contamination of hands and gloves could have been by contact with object that was itself contaminated such as a towel.
(e) Contrary to evidence given at trial, NG under fingernails was not proof positive of handling or kneading explosives.

COA Conclusions:

(1) "Moreover, as we have said, in spite of diligent search, substance X has not been discovered. In our judgement ….. based on all the evidence in the case, the substance was NG (nitroglycerine)."[19 iv]
(2) There was no acceptable evidence to suggest that another non explosive substance was responsible for the spots found on the TLC plates.
(3) Even though there were some technical shortcomings in the evidence, these were not deemed by the jury or courts to be significant.

The possibility that the forensic evidence was fabricated by the analytical scientists was rejected.

Further finding which may cause confusion:

The test samples from the Maguire Seven which were used in 1974 investigation to convict the Maguires had been kept stored since the trial. Re-examination in 1990 with a more sophisticated and modern technique, not available in 1974, showed the presence of NG not only in the samples that were positive in 1974, but also in those that were then negative![20]

The Court of Appeal Final Judgement:[21]

The court rejected five of the six grounds of appeal (see judgement) bar ground 4 [22] as tendered by defence counsel:

"Ground 4:

The convictions of all the defendants were unsafe and unsatisfactory because fresh evidence has emerged as a result of the May Inquiry shows that (as the Crown now accepts)

(i) Incorrect evidence was given to the Trial Court on a crucial question, namely the significance of NG being found under the fingernails of male defendants; and

(ii) there is a real possibility of the hands and gloves of the defendants having become innocently contaminated with traces of NG as a result of contact with a surface, such as a towel, which of itself was contaminated with NG.

"Professor Thorburn Burns's conclusions on this matter as expressed in his report were: [23]

'Contamination at the levels expected to have been reported as "acceptably positive" caused by secondary transfer [of nitroglycerine] from coffee mugs, beer glasses or door handles is not very likely but is nonetheless a possibility. [Nitroglycerine] contamination at the levels expected to have been reported as "acceptably positive" from a communally used hand towel is a distinct possibility, but presupposes the presence in the house at some stage of at least one person who had significant contact with [nitroglycerine].'

What Professor Thorburn Burns meant by 'significant' can be explained as 'manipulation, not over a lengthy period of time, intimate physical contact with the material, modelling it, something like that', similar to the process by which he contaminated his own hands for the purpose of the experiment. We accept this evidence, which was not challenged. In our judgment it is possible that those whose hands were contaminated with nitroglycerine were innocently contaminated by contact with the towel. This itself must have been contaminated by one or more persons drying their hands upon it. The heavy contamination of the towel would have resulted from the type of contact described by Professor Thorburn Burns.

Similarly the gloves might have been contaminated, not by direct contact with explosive, but by contact with hands that had been in significant contact with it.

The evidence does not enable us to conclude who the person or persons were who so contaminated the towel or the gloves.

On the ground that the possibility of innocent contamination cannot be excluded and on this ground alone, we think that the convictions of all the appellants are unsafe and unsatisfactory and the appeals are allowed and the convictions quashed."

Conclusion:

This paper has attempted to set out the material facts as available to the Court of Appeal in 1991. The Court of Appeal quashed the convictions but indicated it was its view that NG had been found on the appellants' hands and gloves, which might have been contaminated, not by direct contact with explosive, but by contact with hands that had been in significant contact with a contaminated towel. However, it stated it could not say who it was contaminated the towel. Notwithstanding the acquittal, the validity of this part of the judgement does not sit well with the interpretation of the evidence by the authors, but remains to this day a slur on the integrity of the Maguire Seven.

Appendix 1

Thin Layer Chromatography (Griess) for Nitroglycerine

The following is a description taken from court of appeal judgement (unrevised):[24]

"Since the integrity of these results and the interpretation put upon them by the experts lay at the heart of the trial and also this appeal, it is necessary to give a brief outline of TLC. The system was used both for analyzing samples from HTK's (hand test kits) and other samples. The first stage is the extraction of the suspect substance from the swab or other item to be tested. This is done by washing in ether, which is placed in a beaker and the ether allowed to evaporate. The residue is then spotted onto a glass plate treated with silica gel on which standards or controls of known explosives were also applied. Normally these explosives were NG, RDX, TNT and Nitrobenzene (NB). All the spots were placed on a line known as the origin. The plate was then placed in a tank containing a quantity of liquid known as an eluent, usually toluene, in order to draw the known standard and the suspect substance up the plate by capillary action. The eluent front can be seen to rise on the plate. When it reaches a point 10 cm above the origin the plate is removed from the tank. Different substances rise up the plate at different rates, which can be measured after being made visible. This rate of rise is not expressed as an absolute measurement, but as a proportion of the total distance travelled by the eluent. The ration is called the R_f value. When the plate is removed from the eluent tank both the standard spots and the suspect spot will have risen up the plate, but will not be visible at this stage either in ordinary or ultraviolet light, and the plate has to be subjected to two further chemical processes before they become so. NG is an organo nitro compound of the nitrate ester grouping, and the plate must first be sprayed with sodium hydroxide (caustic soda) to liberate the nitrite ion from the nitrate compound; at this stage the plate will appear white from the spray. The plate is then heated in an oven to 110 degrees C and is then sprayed with what is known as Griess reagent which reacts with the nitrite present to form a pink spot. It is at this stage known as visualisation, that the distance travelled up the plate by the standard and suspect spots can be seen. If the suspect reached the same level as the standard a positive was recorded. If the two did not exactly coincide, a positive would still be recorded provided the difference was small, not more than 3 mm either side of the standard; this was known as the parameter. Professor Thorburn Burns was of the opinion that 0.03 was an acceptable parameter for recording a positive.

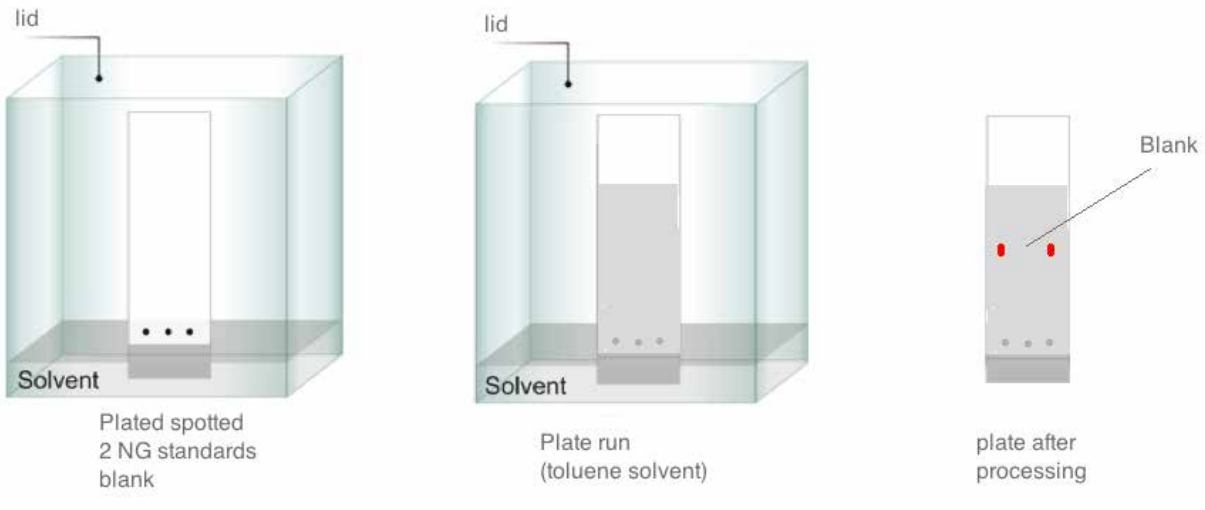
The test is a qualitative and not a quantitative one. That is to say it can give a positive for the substance but cannot give the amount. However, the practice at RARDE was to put a standard of 200ng (a nanogram is a millionth of a gram) on a TLC plate. If the pink colour spot of the suspect sample was equal to or exceeded the intensity of that standard, a positive was recorded; this would mean a minimum of 200 ng was detected. Otherwise the test was negative, although sometimes, usually in trials or experiments rather than in field tests, it might be recorded that there was a faint positive.

The test is a highly discriminating one: the substance must rise the same level as the standard; it must be soluble in ether; it must not show up on exposure to ultraviolet light, or after heating or spraying with sodium hydroxide; and it must produce a pink spot when sprayed with the Griess reagent…..

…..The mechanical part of the Griess testing – that it up to the final stage when the Griess reagent is applied and the plate is visualised, was often done at RARDE by relatively junior employees, in particular at the material time by Mr Wyndham, Mrs Brooker, and Mrs Cashen; but the visualisation was done, except sometimes in the case of Mrs Brooker who was the most senior and experienced of the three, by more senior officers namely Mr. Elliott, Dr. Hayes, Mr. Berryman and occasionally Mr. Higgs. But in fact the test on the appellants HTK's (hand test kits) were done by Mr. Elliott, who was the most experienced person at RARDE in the practice of TLC and they may also have been visualised by Dr. Hayes."

(Excellent description of TLC on Wikipedia):

The observation of the substantial pink coloured spots on the TLC plates in Maguire case indicated a considerable amount of nitroglycerine was present.

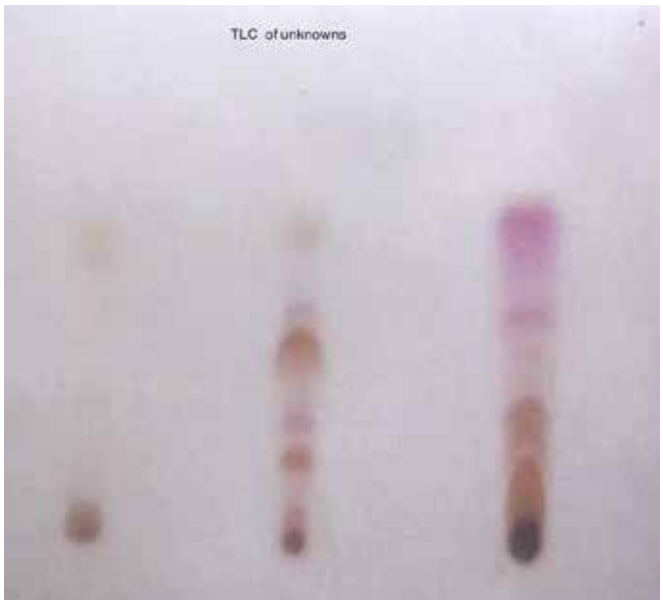


The TLC (Thin Layer Chromatography) Griess test:

[It is accepted that there is a one to three relationship between NG and nitrite released during the TLC Griess process.]

A thin layer plate showing pink spots of standards of nitrite is shown (Figs 1, 2) adjacent to azo dye diagram.

Below is a thin layer plate of a very impure sample with multiple spots, some possibly NG: this shows that TLC is not a very selective or precise analytical technique.



Appendix 2

The judges involved in original case:

Donaldson, J. subsequently was promoted to Lord of the Rolls, the second highest ranking British judge. He was the also the presiding judge in the Guildford Four trial.

Court of Appeal Judges: **Lord Justice Roskill** (Court of Appeal 1977); **Lord Justice Stuart Mills** (Court of Appeal 1991); **Lord Justice Mann** (Court of Appeal 1991); **Lord Justice Mc Gowan** (Court of Appeal 1991).

May Inquiry (1989 – 1994) into Guildford and Woolwich Bombings: **Rt. Hon. Sir John May** (May Inquiry) Court of Appeal Judge.

Scientific Personnel:

Independent Experts:

1. Professor Duncan Thorburn Burns, Ph.D., D.Sc., F.I.C.I., C.Chem., F.R.S.C., F.R.S.Edin., M.R.I.A., was appointed as an independent expert analytical chemist to the Guildford and Woolwich Inquiry. He appeared as an "expert witness" in the Court of Appeal. Among his numerous medals and awards is the first Boyle-Higgins Gold Medal of the Institute of Chemistry of Ireland in 1990. He has published over 450 scientific papers and 9 books, including 100 papers since formal retirement in 1999.

He is currently an Honorary Research Professor of Analytical Chemistry and resident in The Institute for Global Food Security, The Queen's University of Belfast.

Professor Burns' status in the Guildford and Woolwich Inquiry are made quite clear in the Interim Report on the Maguire Case (para 1.6)

> *".....Accordingly thought it right to have appointed to advise the Inquiry an independent expert analytical chemist. The Inquiry was fortunate to obtain the services of Professor Duncan Thorburn Burns, Ph.D., D.Sc., F.I.C.I. C. Chem, F.R.S.C., F.R.S Edin., M/R.I.A. of Queen's University of Belfast....." "He went on to say what I did, and commented very favourably about my approach and evidence. I did appear at the Court of Appeal as an "expert witness" with the duties and responsibilities that entailed to the Court."…… personal communication to author [SOM] correcting previous reference to Professor Burns in* Irish Chemical News *Issue 2 October 2015.*

2. Professor T.S. West CBE, FRS. Professor of Analytical Chemistry in the Imperial College in London. He set up a world famous research team that pioneered atomic absorption and atomic fluorescence spectrophotometry. He chaired the scientific committee that examined the science of this case for the May commission. Regarded as one of the great British scientists of the 20th century, by (cite reference). Decorated (CBE) for his contribution to Science.

Experts for Prosecution:

Dr. Marshall, head of Forensic Explosives Laboratory at RARDE

Mr. Elliott: (trial only: died some years before Appeal) Senior Scientific Officer. "His honesty was never questioned at the trial, his opinions were." He is described by those who knew and worked with him as meticulous and a fast experienced worker who took great care in the work.

Dr. Hayes was a careful and impressive witness He joined the forensic laboratory at RARDE in July 1974. He held the degrees of B.Sc. in chemistry, Master of Science, and Ph.D. in forensic science. He was also a chartered chemist and a member of the Royal Society of Chemistry.

Mr. Wyndham Apparently, he joined the forensic laboratory of that establishment in 1974 a few months before the tests were carried out in connection with this case. He was 17 years of age at the time. (He carried out the analysis on Mrs. Maguire's gloves). It is no slur on his abilities to point out that in most analytical practice it would be quite remarkable for such a junior to be held responsible for conduct of such a vital test on a matter of such importance.

Mrs. Brooker (Kemp): "Mrs. Kemp was a scientific officer. She joined the forensic laboratory in 1973 and left in 1977. She had an 'A' level, (the most senior examination for secondary or high school students) in chemistry. She judged the results herself.

Mr. Higgs was a Fellow of the Royal Society of Chemistry and a chartered chemist. He began work with RARDE at the age of 16 working on explosives at Fort Halstead. He went to Woolwich in 1973 and took over from Mr. Yallop as head of the forensic laboratory there. … He was a very knowledgeable about explosives, particularly those used by terrorists**. He himself had not done TLC tests, but was well aware of the theory and practice of them.**

Forensic Experts for the Defence:

Dr. / Professor Brian Caddy, lecturer and subsequently professor of forensic science in Strathclyde University, the UK's top academic institution of forensic science.

Dr. J. B. F. Lloyd Ph.D DSc. OBE – decorated (OBE) for his contribution to forensic science; retired from the Home Office Forensic Science Service and was private consultant to appellants.

Mr. Yallop retired head of RARDE

Mr. Clancy retired head of RARDE

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1. www.bbc.co.uk/programmes/p00hrdfw
2. May interim report S 3.16
3. Interim Report May Inquiry London HMSO, 12 July 1990, HC 556
Second Report May Inquiry, London HMSO, 3 December 1992 HC 296
Final Report May Inquiry, London HMSO, 30th June 1994, HC449
4. *R. v Maguire* and others 1992 2 All England Reports, 433; (netk.net.au/UK/MaguireFull.asp)
(*R v Maguire* and others 1992 Court of Appeal, draft judgement ("This is an unrevised judgement. It is available on the clear understanding that it be treated as such": this fact is acknowledged here)
5. May interim report, S 1.9; www.gov.uk/government/uploads/system/uploads/attachment_data/file/228724/0556.pdf
6. en.wikipedia.org/wiki/List_of_terrorist_incidents_in_Great_Britain#1970s
7. netk.net.au/UK/MaguireFull.asp
COA unrevised judgement R v Maguire and others Part 1; page 1. It is acknowledged that this is an unrevised judgement, and not approved by the judges.
8. COA unrevised, Part 1 P 22
9. COA unrevised judgement, Part 2; P3
10. Maguire interim report, S 7.4;
COA unrevised Part 2,P3
11. Court of Appeal,unrevised, Part 1; P 23
12. Court of Appeal, unrevised, Part 1; P36-41
13. Court of Appeal, unrevised, Part 1; P30
14. Court of Appeal, unrvised, Part 2; P4
15. Court of Appeal, unrevised,Part 2; P 32.
16. West Committee:

[Sir John appointed a subcommittee to thrash out the science of the case under Professor T S West. The deliberations of this Inquiry were referred to in the Judgement of the Court of Appeal in 1991.

"I therefore decided to set up a Scientific Committee to advise me further on the disputed issues. I was very fortunate that Professor T S West, now retired but formerly of Birmingham and Aberdeen Universities, and of Imperial College agreed to be chairman. The other members were Professor Duncan Thorburn Burns; Dr. Lloyd, acting for the Conlon family; Dr. Caddy for the surviving members of the Maguire Seven; Dr. Marshall for RARDE; Dr. Scaplehorn for the Home Office; and Mr. Higgs.."]

17. May Inquiry second report, S 3.15.
18. Court of Appeal, unrevised judgement, Part 3; P6.
19. Court of Appeal, unrevised, Part 2; P 32.
20. May Inquiry second report S3.8; www.gov.uk/government/uploads/system/uploads/attachment_data/file/228811/0296.pdf
21. *R. v Maguire* and others [1992] 2 All ER 433 (also:netk.net.au/UK/MaguireFull.asp
22. Court of Appeal, unrevised, Part 1; P39.unrevised,
23. COA judgment unrevised, part 3, P9 , www.chemguide.co.uk/analysis/chromatography/thinlayer.html

RARDE—(The Royal Armament Research and Development Establishment) is part of the Ministry of Defence. Then at Woolwich in South East London, the laboratory carried out forensic work for the Metropolitan Police on suspected explosives. Its Head was Mr. Douglas Higgs, Principal Scientific Officer. He had taken over the post from Mr. John Yallop, who was to be the principal witness for the defence. The original analysis of the Maguire samples were carried out by RARDE personnel.

About the Author

Seán Ó Muircheartaigh, B.Sc. PhD., MBA, LLB, F.I.C.I., retired lecturer RTC Galway/Galway Mayo Institute of Technology. He received his BSc and PhD from UC Dublin and MBA and LLB from UC Galway. In 1990, along with Eoin O'Neill, he authored a paper that helped release the Birmingham Six. He has worked at the Unilever Research Vlaardingen, Pfizer London, Sandwich and Cork, and supervised 100+ science projects and 50 + law projects up to level 9 (master's degree) Majority as level 7 and 8, as well as serving on the Council of Institute of Chemistry of Ireland for about 20 years.

The author wishes to acknowledge the invaluable contributions of Eoin O'Neill who was involved throughout the writing of this paper. The two had extensive discussions on the chemical and legal issues involved. Eoin is adjunct professor in the School of Business at Trinity College Dublin, and is expert on innovation and intellectual property. He was similarly involved in the previous paper on the Birmingham Six which contributed to the withdrawal of the forensic evidence and subsequent collapse of this case. Eoin has a PhD in physical chemistry from UCD, and a post doc from Leeds University.

Finding Your Voice

Raymond J. Davis

Over the past 25 years, I have observed certain trends exhibited by forensic experts in my courtroom training courses that are not in the best interests of the witness. That is the main thrust of my article. More is being demanded of the expert witness by lawyers, the courts as well as jurors putting greater pressure on experts to be informative, engaging and helpful. The days of rote responses laden with highly technical information has long passed into history. I now realize how dynamic courtroom testimony has become as a result of the changes through public opinion (jurors) as well as from prosecutors across the United States.

Expert witnesses are required to know something about the law that governs their work. Everyone should be aware of famous cases such as *Kelly-Frye, Daubert, Brady, et al*, and how the federal rulings impact their testimony. I never received any real training in testifying when I started my career with DOJ in 1972. However, the one-minute module on courtroom testimony told me the following: Wear a coat and tie, get to court on time, tell the truth, and don't argue with the lawyers. Then each of us underwent a mock testimony exercise. I had never heard that term before but soon realized that as I was mocked for my answers painfully learned how vicious that activity had become especially in front of my colleagues. At that, three weeks into my career, the concept for my courtroom training class began. I sensed that there had to be a better way to train people to testify.

The modules in the original course I gave at CCI in 1991 bears little resemblance to the material contained in my current offerings. Why? Because of the increased need to be more than just dispensers of technical information. Jurors want to be informed, educated and yes, even a little entertained. I have spoken to many jurors over the years when I was a defense witness about what helped them the most with my testimony. Their universal answer: That I made it interesting and kept their attention.

Since the late 90's, we have had millions of TV viewers entertained by the *CSI* series, and a number of others TV shows such as *Forensic Files* and *Forensic Detectives*. These viewers have become 'educated' and they expect the experts in their cases match the talents of movie and TV stars. Instead, most get lectures on science, medical procedures, accounting practices, etc., that do not match the juror's common experiences. Disappointment and boredom is the common experience most jurors experience.

I have had the unique experience of observing the testimony of over five thousand forensic professionals, from criminalists to CSI experts to Sexual Assault Nurse Examiners to Latent Print Examiners and police officers through 215 classes and believe the causes can be traced to: One, old fashioned thinking. "It was good enough when I started my profession 20 or 30 years ago, it should be good enough today." Unfortunately, this archaic attitude needs to be purged from any training. As our technology has increase from 20—30 years ago, we must also increase how we deliver our results and opinions at trial. Experts often make unfounded assumptions about what jurors really need to hear from the witness. Absent any feedback from jurors or attorneys, experts are left guessing at what is really needed. There's a difference between getting qualified and satisfying the jurors need to know how well educated and trained the expert is.

And, two, a general lack of education about courtroom testimony. I have had many prosecutors assist me on the third day of the course and they agree that most experts fail to adequately present their academic and formal training during qualifications, that they still don't appreciate the difference between responding versus answering the question, and most importantly, their inability to minimize the use of highly technical language without some explanation. There are a few additional issues which I will address later in the article.

Insufficient presentation of their qualifications:

Over the course of presenting my classes, Courtroom Presentation of Evidence©, Powerful Presentations© and Surviving and Thriving in the Courtroom© most students fail to provide a thorough accounting of their qualifications (formal education, formal training, professional symposia & workshops attended, papers presented, classes taught, awards & recognition, internships, certification, etc.)

When I've asked why they hold back on their credentials, here are some typical responses:

"It feels like I'm bragging about myself."

"I don't know how much I'm supposed to offer in order to qualify."

"It's the prosecutor's job to qualify me."

"I don't have a great deal of experience so there's not much to add."

Of course it feels like bragging but modesty is not a trait to display. Jurors need to know the depth and breadth of the witness's background in order to assess the weight (consideration) they are to give to their opinions during trial. The judge instructs jurors on the weight they are to give the witness after both parties have rested their cases and prior to their deliberations. In other words, no matter how perfect your tests and opinions may be, if a juror doesn't like your presentation/attitude they can ignore your findings.

Experts new to the field are not sure how much to offer, unaware of courtroom procedures on qualifying the witness. Proper training and staying current with articles written by attorneys and judges will alleviate this problem.

Most experts are content to follow the prosecutor's script not realizing how much is left unsaid about their background. This is particularly true when the prosecutor is unfamiliar with the witness. Generally, the prosecutor performs the minimum in order to get the witness qualified leaving jurors with the witness with an incomplete accounting of the depth of their qualifications.

Once you have qualified, your task is to communicate to the jury in their common experience. To do anything less is a disservice to them.

New members to the profession lack the experience base compared to senior professionals but that does not mean they should offer less. I was grateful for advice I had received early in my career to expand on some my training which allowed me to speak as long as a more experienced witness. There's nothing wrong in describing your training or educational experience for the benefit of the jurors. They will appreciate the depth and breadth of your training learning what is required to become a forensic scientist.

I learned an invaluable technique from Lou Maucieri when he was the program manager at CCI. He introduced a concept called the Audience Retention Curve (ARC) that allows the witness to provide a complete and thorough description of their qualifications without the feeling they're tooting one's own horn. By using this technique, the expert witness will have a much easier time qualifying and avoiding a rigorous voir dire or cross examination of their qualifications. The technique requires the witness to point out four areas that will qualify them as experts. *This is the preview.* Then the witness describes in detail each of those four areas highlighting one of them based on the case at hand. *This is the content.* Then the witness summarizes the four points just discussed. *This is the review.* By using this technique, the witness is able to offer their full qualifications and offer in such a way that the jurors will have heard it three times.

The challenge of answering versus responding to a question:

Responding to the question is challenging for everyone, including me. I continue to make this mistake thinking I'm having a conversation when it's clearly not what's happening in the courtroom. Every witness must be vigilant during this process when asked questions by counsel and then to give a responsive answer. If we're not vigilant, we'll hear an objection, "Non-responsive, your Honor."

Too many objections during your testimony can erode your credibility and disrupt your rhythm. We often answer the question the attorneys should have asked instead of responding to the question they did ask. It takes concentration to listen to each question patiently, then avoiding any thoughts about why they asked that question and simply give a responsive answer. It's not easy and I admit that I am just as guilty as the next person and work hard at it.

One way to improve your ability to respond is to have your colleagues challenge you when you've been unresponsive to their question and they do the same for you. Don't wait to go to court to improve this part of your testimony.

The inability to adequately explain scientific concepts and technology:

Most students in my classes agree that explaining the technology during their testimony is important. Rarely do I find someone who digs in their heels at the notion of explaining their work. These few believe that their job is to be technically correct at the expense of jurors understanding. Einstein, once opined that, "Things should be made as simple as possible but not simpler." There is a point where you don't cross the line with jurors speaking in a condescending tone.

I once heard a technical presentation on the theory of the FTIR that left me marveling at the complexity of the technology. There are many mathematical formulas used in scientific instrumentation and the Fourier Transform left me searching for a better understanding. I knew there had to be an easier explanation, so I asked the presenter how he would explain it to a jury. His answer, "Just the way I explained it to you." Surprised, I asked him how jurors could possibly understand his explanation. His terse response, "That's not my job." After a few beats, I told him, "It is your job." Silence.

I don't know why we just can't say, "I used a scientific instrument to analyze and identify illegal drugs." In my experience, few lawyers ever asked what the instrument was called or how it worked. When they did ask, I would answer, "It's called the Fourier Transform Infrared Spectrometer and it identifies individual components of the drug I'm testing and prints out a graph which is then identified with a chemical library of know illegal drugs." That satisfies most experts need to be scientifically correct about the technology employed while still communicating the nature of the work they performed. Always give the simple explanation first then use the technical one if pushed for a deeper understanding.

Not using one's voice to its full potential

Your voice is your most important asset in the courtroom. Neither your education nor your experience does a juror place on your testimony but how well they are engaged with you. Once you have qualified, your task is to communicate to the jury in their common experience. To do anything less is a disservice to them. Some still believe that our job is to simply respond to the question and do nothing more.

It is not good enough because jurors, attorneys and judges are demanding more from the experts. They want better visual aids, better explanations, demonstrations and from someone they can trust.

I have had less than a dozen students whose voice, both in terms of volume and quality required no improvement. It never ceases to amaze me that witnesses speak so softly that even with a microphone in the courtroom I have had to ask them to raise their voice time and again. Most experts speak much too quietly believing they can be heard from the witness stand. And, it's not enough to speak loudly but with a voice that compels the audience to sit in rapt attention.

Having vocal variety (volume, pace, energy and tone) will engage the audience to pay attention and consider the expert's work and opinions. Every expert would like jurors sitting on the edge of their chairs waiting for the next utterance from the witness. Earlier in my career, I observed jurors reading books, knitting, sleeping, doodling, etc., anything except listening to my testimony. I expected the judge to admonish them but never did.

What was I to do? No one told me that it was my job to keep them interested and how to go about accomplishing that. Experience is a great teacher but many mistakes are made in the course of gaining wisdom. When I finally tumbled to the secret of keeping jurors engaged, I found my time on the witness stand to be more effective and much more interesting. In fact, the better engaged the juror the shorter time I spent on the witness stand.

There's nothing more energizing than to see a juror give you the OK sign, or a thumbs up sign to let you know how well they're receiving the presentation. Because after all, that's exactly what it is, a presentation. Not unlike one given at a symposium, albeit simpler.

As a result of the many things I learned during my courses, I have been able to write twelve articles for the *CAC-News* and to present my findings at forensic symposia such as the CAC, NWAFS, SAFS, NEAFS, SWAFDE and AFTE. I

have learned more from teaching these classes than I thought possible. There's nothing like the constant practice that comes from becoming excellent in your work.

The Bright Side – The Future

The most positive trend that I have seen over the past twenty-five years is the level of advanced education, greater enthusiasm for the work and greater communication skills the new experts possess. It has been a pleasure working with a group of highly talented people who strive to do better in their careers. It has been a privilege to pass along courtroom strategies as well as the wisdom provided by previous students.

My biggest challenge has been communicating to a new generation of students—Millennials. I keep getting older but my students stay the same age, around 25-30. When I first began teaching the course, the students ranged from the late Baby Boomers (1946-1964) to early Gen Xers (1965-1980). Now it's mostly Millennials and their era's motto is: "Be realistic" They don't like to be commanded but prefer collaboration. They are more apt to build parallel careers and I have found that to be true of them. Their interests outside of the profession would have been astounding in my day. I have used this knowledge gleaned from the book, "When Generations Collide...," (Lancaster & Stillman) to better connect with them and admittedly have had much more fun being their collaborator rather than their lecturer.

One final thought. Every facet of forensic science has been scrutinized, standardized and codified by ASCLD/LAB & ISO except courtroom testimony. Why? For the past 25 years, I have worked with co-instructors Lou Maucieri, Richard Konieczka and Ronald Davis to offer suggestions to the students for standardizing their courtroom testimony. On a class I recently taught, I found the testimony of the latent print examiners to be uncomfortably different. Some people couldn't answer simple questions on fingerprint history, others didn't know what DFO stood for, others couldn't recall when and where the ten print card was designed and so on. If everything in the lab is standardized why not the testimony?

I know that the DNA guidelines include a section on courtroom testimony and I would like to see this broadened to include all disciplines. [See: www.fbi.gov/file-repository/quality-assurance-standards-for-dna-databasing-laboratories.pdf —*Ed.*]

I have been working with the California Clinical Forensic Medical Training Center in Sacramento since 1999 to standardize the courtroom testimony of the state's SART nurses. This is aided by the help of many county prosecutor's offices throughout California and we are seeing an amazing consistency between their testimony. Dr. Bill Green is the subject matter expert for the training center and he's pleased with the results we've seen over the years.

Wanting to end this missive on a positive note, I'm confident that everyone who has passed through the courtroom testimony courses will continue to deploy the skills they learned and to inspire others to improve the quality of their colleague's testimony. Sharing your experience and wisdom will benefit our profession and make us more credible. My final rant: Every expert witness needs formal training in courtroom testimony especially about legal issues that impact their testimony.

Lastly, my grateful thanks to all who made the Courtroom Presentation of Evidence course survive and thrive over the past twenty-five years. It's been a great ride and I have learned a great deal from you making the hours spent in preparation, travel and teaching well worth the effort.

Hair Today, Gone Tomorrow: Relevance of Hair Examination in Forensic Cases

Jessica Bouchet, Nicole Bracci and Reena Roy, Ph.D

Introduction

In 2012, an article released by the Washington Post (1) revealed that the Federal Bureau of Investigation (FBI) forensic unit had given biased and pro-prosecutorial testimony starting in 1989 in many of the trials that spanned for a decade or more. These cases involved physical examination of hair. According to the article, 26 of the 28 examiners who worked for the FBI Laboratory in the microscopic hair comparison unit had overstated evidentiary value of the evidence. Upon review, it was determined that overstatement occurred in 95% of the trials resulting in the possibility of individuals being wrongfully convicted. What is most distressing is that 32 of these defendants were sentenced to death, and fourteen of them have been executed. This report has emphasized the importance of understanding and drawing unbiased and neutral conclusion from results of physical examination of hairs, and the importance of refraining from being pro-prosecutorial while providing unbiased testimony.

Hairs are uniquely mammalian. Macroscopic and microscopic examinations of hairs from different sources are fundamental investigatory tools in forensic science and can play vital roles in the reconstruction of events. In this research project conducted by two undergraduate students in the forensic science program at the Pennsylvania State University, hairs from several sources, ranging from humans to animals, were examined using an ordinary compound light microscope to determine characteristics that would allow their identification. As the habitat and environment of a crime scene can range from a household (indoor) to a victim's body found in a wooded area, it is important to determine what is relevant and what is extraneous prior to subjecting these items to expensive and labor intensive DNA testing.

The ability to identify the evidence that is of value can stem from the understanding of the well-known Locard exchange principle. This principle states that when any two objects come into contact, there is an exchange of material – a transfer of physical evidence. Being able to recognize this, and use any collected evidence to show and explain how a crime occurred is a very useful task when it comes to reconstruction of the crime.

A hair examiner should therefore be able to determine what pieces of evidence are of significance to the crime scene by ruling out any commonly occurring objects that may not be of importance to the investigation. For example, the presence of a dog hair found at a crime scene may or may not be of any significance. If the crime scene is a residence where the victim owns a dog, these animal hairs will be of no significant value as they were most likely present prior to the commission of

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the crime. However, if the victim does not have a dog, and an analyst identifies dog hairs collected at the scene, this evidence becomes important, as it may have been transferred from the perpetrator to the scene. In addition, if a person of interest in that case does have a dog, then the evidence becomes crucial in the identification of a suspect and this evidence can play a major role in the case. With today's technological advances, nuclear and mitochondrial DNA testing is possible on human and animal hairs, however, it is costly and time consuming. For this reason, macroscopic and microscopic examinations are important, particularly for the purpose of exclusion.

In this modest research, hairs and other objects often found at indoor and outdoor crime scenes were analyzed using inexpensive and easily available items. The attempt was to show that in any educational system, as well as in forensic crime laboratories, undergraduate students or forensic scientists should, with proper training, be able to distinguish human hair from animal hairs, and hairs from other objects as well.

Materials and Methods

The samples used in this research were provided by Dr. Reena Roy (Professor, Pennsylvania State University). Through her work with the Nebraska State Patrol Criminalistics Laboratory, and since her joining The Pennsylvania State University in 2007, Dr. Roy has built a diverse personal collection of hair samples. The samples examined for this research were mounted on slides using Permount® and Xylene and covered with different sized coverslips. This method is non-destructive so that the hair mounted can be removed after examination and can still be sent for DNA testing if necessary after the physical examination is complete. The hairs were examined under a classroom quality compound light microscope (MicroMaster® from Fisher Scientific and VistaVision from VWR International). Hairs were microphotographed using an Apple iPhone 6 cellphone placed in front of the eyepiece.

Results of Analysis and Discussion

A hair is "a thin threadlike growth from the skin of a person or animal" (2). Hair is composed of mainly keratin, a family of structural proteins also found in nails, and is made up of three main regions: the cuticle, medulla and cortex. As shown in Figure 1, the cuticle is the outer layer, the medulla runs along the center core and the cortex is the space between the cuticle and the medulla. The outer cuticle serves as a layer of protection and consists of scales that cover the entire length of the shaft. These scales are like shingles on a roof that always point to the distal (tip) end of the hair – the end furthest away from the point of attachment to the body. Within the cortex are pigment granules, ovoid bodies, and cortical fusi. Cortical fusi are irregularly-shaped airspaces that vary in size and are typically concentrated near the root. The pigment granules are smaller than the cortical fusi, that are dark and solid structures with varying color, size and distribution in a single hair. In most human hairs, the pigment granules are concentrated near the cuticle and give a hair its color, whereas in animal hairs, the pigment granules are mainly found concentrated near the medulla. The ovoid bodies are larger than the pigment granules and oval in shape. The medulla is typically filled with air and can take on a variety of different patterns. These patterns are later discussed as a method for identifying species. In some cases, the proximal end will have

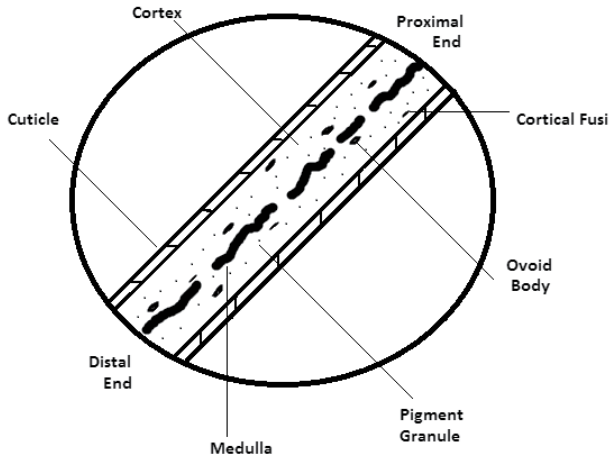

Figure 1. Schematic diagram depicting characteristics of a hair. This image is not to scale.

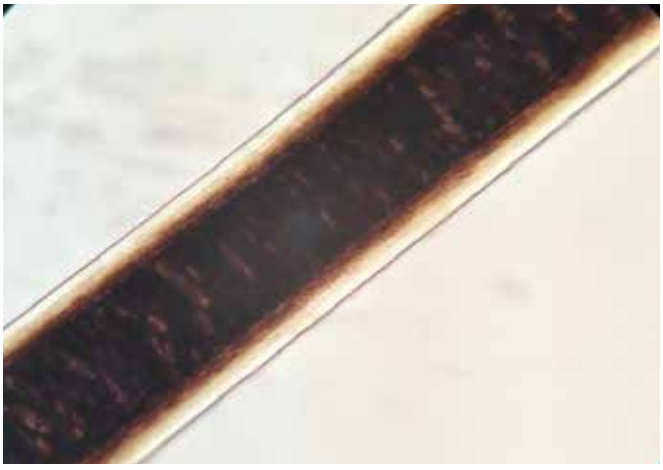

Figure 2. Microphotograph of medulla of a ferret with a medullary index >1/3

Figure 3. Microphotograph of medulla of a human with a medullary index <1/2

a follicular tab attached to the root. This could be any follicular tissue that may have adhered to the hair.

Hair can be thought of and compared to a pencil (3). This analogy explains the structure of a hair to laymen such as the jury members or to the judge in a bench trial. The painted waxy outer surface corresponds to the cuticle layer of the hair. In a natural hair, this paint should be thought of as transparent to better represent the cuticle, however, the yellow or other type of coloring can represent any modifications an individual might make, such as dying or bleaching. The inner wooden portion of the pencil represents the keratinized cortex with the brown resin flecks in the wood representing pigment granules. The black lead core of the pencil represents the medulla. As there are two ends to a hair, there are two ends to a pencil: the distal end of a hair, the end furthest from the site of attachment to the body, is represented by the tip of the pencil. This tip can be cut sharply, damaged, tapered, broken or rounded with use, just as a hair's tip can be. At the proximal end, the end closest to the body, the eraser is compared to the root while the ferrule, the metal sheath surrounding the eraser, can be compared to the follicular tab.

The findings of the research indicated that when analyzing a hair under the microscope, the first characteristic that is indicative of species is the width of the medulla in comparison to the width of the shaft. When looking at the medulla, it was determined that if the medulla takes up greater than half the shaft, this indicates the hair is of animal origin (Figure 2), however if the medulla appears to take up less than a third of the shaft width, the hair is most likely human (Figure 3). Many analysts use an equation to determine what is called the medullary index. This is calculated by dividing the diameter of medulla by the diameter of shaft, and the result can then be compared to a table of data for possible sources (2).

When a medulla is present, it can be described as one of three main types. These are often described as trace, discontinuous and continuous. As depicted in Figure 4, when the medulla is present through the entire length of the hair without any breaks in the pattern, the medulla is described as 'continuous'. When the medulla is present the entire length of the hair for the most part with a short break in the pattern every so often the pattern is described as 'discontinuous' as shown in the same figure. Lastly, a medulla is described as 'trace' when the medulla is fragmented and exists in many short stretches (Figure 4 and 5). These three known patterns were observed in the many hairs the students examined and this was true in both humans and animals.

Human Hairs

In general, a human hair is unstructured and varies greatly, however there are certain characteristics that are indicative of humans. The first characteristics more prominently seen in human hairs are those of the stages of growth, which are reflected in the structure of the root. A hair goes through a single cycle of anagen, catagen and telogen hair growth phases.

The anagen stage is the first stage when the hair is in the process of growing (Figure 6). The second phase is the catagen phase, which is considered a transition stage; during this time, the hair is still attached to the body however is no longer growing (Figure 7). The final stage, telogen, is the resting stage – the hair is no longer growing or fully attached (Figure 8). This is the stage at which hair typically falls out in its own (3, 4). Although animal hairs go through growth stages as well, they

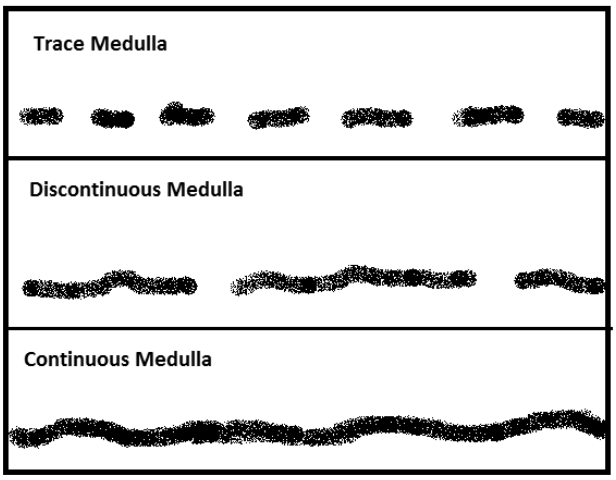

Fig. 4. Different types of patterns seen in the medulla of human hair

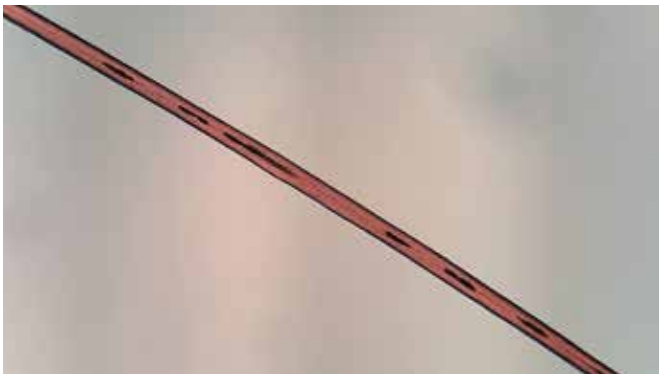

Figure 5. Example of trace medulla pattern in a dyed human head hair

Figure 6. Microphotograph of Anagen phase in Human hair.

Figure 7. Microphotograph of Catagen phase (with follicular tab) in Human hair

Figure 8. Microphotograph of Telogen phase in Human hair

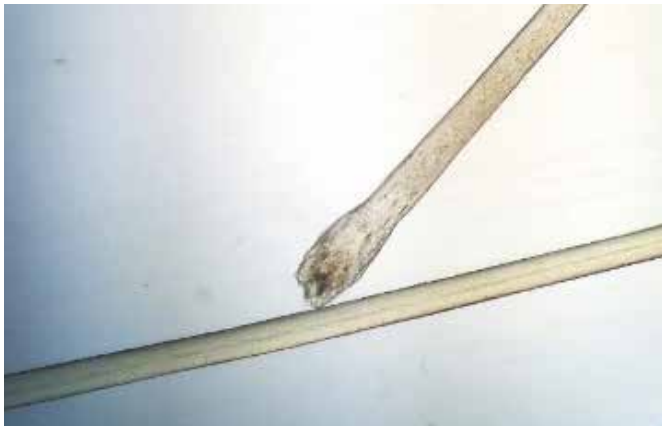

Figure 9. Microphotograph of Human head hair

Figure 10. Microphotograph of Human pubic hair

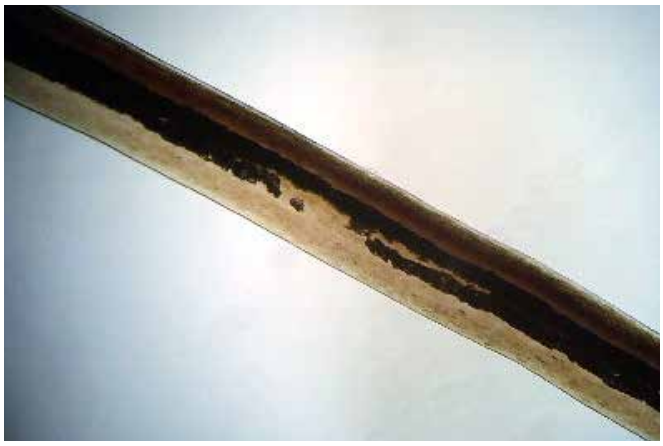

Figure 11. Microphotograph of Beard hair with double medulla

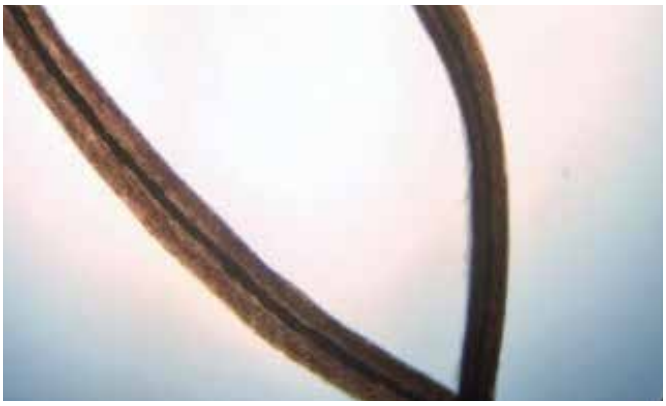

Figure 12. Microphotograph of Negroid head hair

were not observed on any of the exemplars studied. This, however, does not mean that it is not possible to find them.

Human hairs also vary in microscopic features depending upon their location on the body. Although there are many body areas that have hairs with different characteristics, three were chosen based on possible relevance and importance at a crime scene. These three areas were head, beard and pubic areas. The last two were considered as they were sexual hairs and often found at crime scenes, on the body of a victim and in pubic combing collected from victims of sexual assault. As observed in Figure 9, head hairs may have either absent, trace or continuous medulla. Medulla in heads hairs is relatively narrow in diameter. Most of the head hairs examined were noted to have their tips either cut or damaged. Figure 10 is an example of a pubic hair, which tended to have an uneven shaft diameter with wide variations and sometimes showing buckling. This last phenomenon can be described as an abrupt change in the shape and orientation (4). The medulla in the pubic hairs appeared to be relatively broader than those of human head hair and typically continuous when present. Lastly, as noted in Figure 11, most of the beard hairs are distinguishable by the presence of a double medulla and a very coarse shaft diameter.

Human hairs can further be classified by one of three main ethnicities: Caucasian, Negroid or Mongoloid. In some cases, this determination was found to be difficult and impossible, however, in most cases differences were noted among them. These differences are found in the characteristics of the medulla, the shape of the cross section (not performed in this project), the shaft diameter and the presence of undulation (4). Negroid hairs (Figure 12) have considerable diameter variation, often referred to as undulation, and a flattened cross sectional shape. The mongoloid hairs (Figure 13) had little to no variation in the shaft diameter. However, these hairs are described as having more round cross section (4). The Mongoloid hairs often displayed the most prominent medulla compared to the hairs examined from the other two ethnic groups. Figure 14 is an example of dyed Caucasian hairs. These hairs were found to have the least shaft diameter variation. Previous research indicated Caucasian hairs show oval cross sectional shape (4).

As shown in Figure 15, when examining a hair retrieved from a crime scene, the characteristic of the tip can also provide some information about the donor. For example, this sample hair was recently cut with clippers. When comparing this ev-

Figure 13. Microphotograph of a Mongoloid head hair

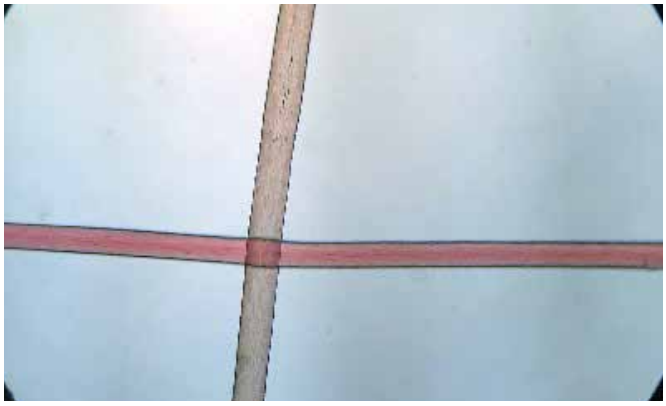

Figure 14. Microphotograph of Dyed Caucasian head hair

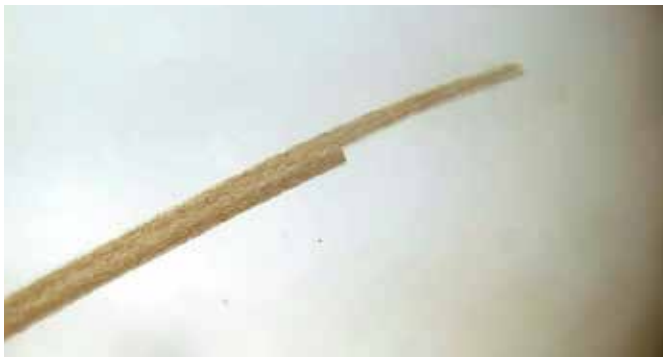

Figure 15. Microphotograph of Clipper-cut distal end of a Caucasian head hair

Fig. 16. Microphotograph of a burnt Human head hair at distal end.

idence with the reference samples from the donor of this hair, this microscopic feature can be important since the donor's reference samples would also show similar characteristic.

Figure 16 shows an example of a Caucasian hair burnt at the distal end. This type of hair, when found at a crime scene often involves arson or homicide victims. The suspect may sometimes try to burn the house, the crime scene and the body in efforts to get rid of any evidence. These burnt hairs, where the damage of the hair takes place at the distal end, can be easily distinguished from other hairs because of the unique feature as shown in the photomicrograph below.

Animal Hairs

After determining that a hair is from an animal based on the medullary index, the characteristics observed to determine species are the patterns of the medulla and the microscopic characteristics of the root. Animal hairs are normally well defined and do not typically have as much variation within a single hair as humans do. This was confirmed by the plethora of hairs examine that were obtained from the same animal.

Animal hairs can be categorized into one of three main categories for identification (5). These categories are domestic animals, commercial animals and common wild animals. In this research, domestic animals were distinguished mainly on basis of scale pattern and root structure allowing for the distinction between common animals such as cats and dogs. Commercial animals are those such as rabbits and chinchillas whose hair can be found in commercial products, like clothing. These were distinguished mainly by color and banding pattern as well as scale and medulla patterns. The wild animal hairs most commonly found at a crime scene are deer (animals from antelope family) as they inhabit most wooded areas, as well as bats or coyotes. These are distinguished from other animals by the unique structure of the root and the medulla. Feathers and plant materials are also common at crime scenes in wooded areas, however these are not considered "hair."

When analyzing hairs from domestic animals most of the hairs collected at crime scenes involve cats and dogs, as they are the most common pets. When comparing cat hairs to dog hairs, the roots are useful structures. A cat root is elongated and frayed, while a dog root is more spade-shaped (figures 17 and 18, respectively). When comparing both hairs, it was observed that they are comparable to paintbrushes – a cat root is similar to a coarse paintbrush used to cover big surfaces while a dog root resembles more of an artist's paintbrush used for fine details. Most cat hairs obtained from different types of cats showed continuous medullas as shown in Figure 19, while dogs mostly have amorphous medullas (not shown). The last difference observed between the hairs from these two animals were the scales. Cat hairs showed spinous and prominent scales, while dog hairs did not display any prominent scales by microscopic examination.

Within the category of commercial animals, banding patterns observed macroscopically helped indicate the possible species. This is helpful for identifying species such as skunks and chinchillas. Rabbits were recognizable by their characteristic uniserial or multiserial ladder medulla (Figure 20). This pattern resembles corn on the cob and can be found in other species as well, such as in chinchillas and cats (not shown) (may want to reference Cat uniserial depicted in Fig. 19), however it is noticeably more prominent in rabbit hairs. To distinguish between these species with the common corn on the cob medulla, the root was analyzed. The cat, as pre-

Figure 17. Microphotograph of cat hair with root

Figure 18. Microphotograph of dog hair with root

Figure 19. Microphotograph of uniserial medulla of a cat hair

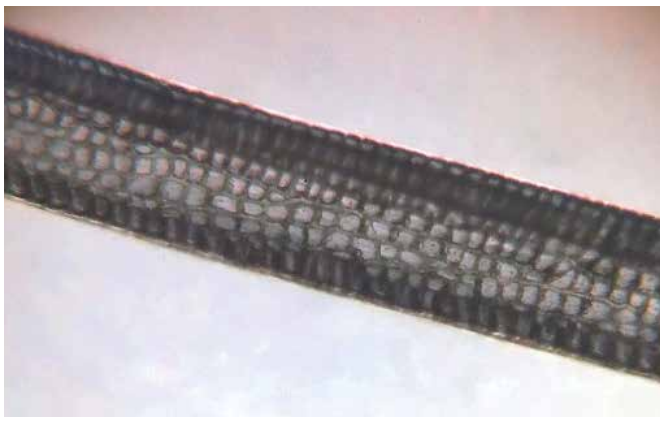

Figure 20. Microphotograph of a multiserial medulla of a rabbit hair

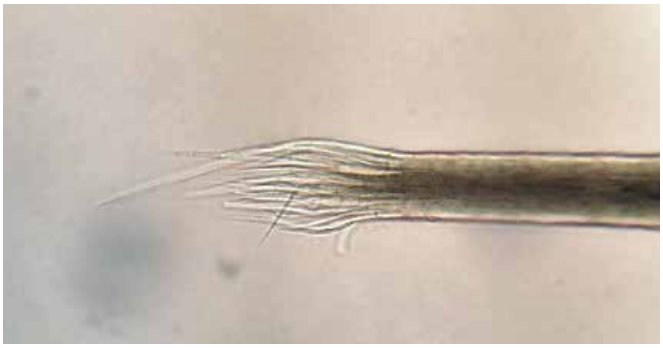

Figure 21. Microphotograph of the root of a chinchilla hair

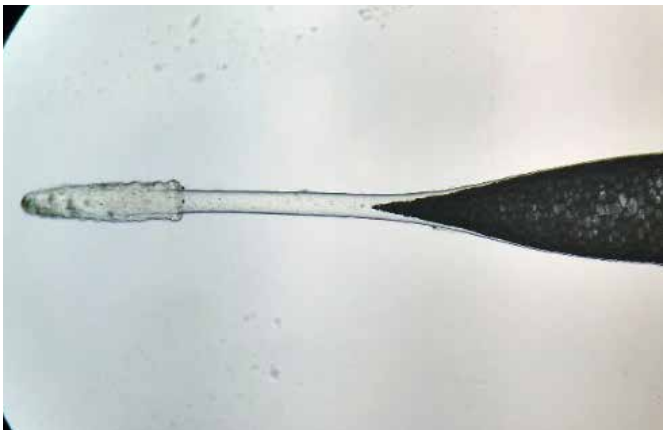

Figure 22. Microphotograph of the wine glass root of a deer hair

Figure 23. Microphotograph of scales on a deer hair

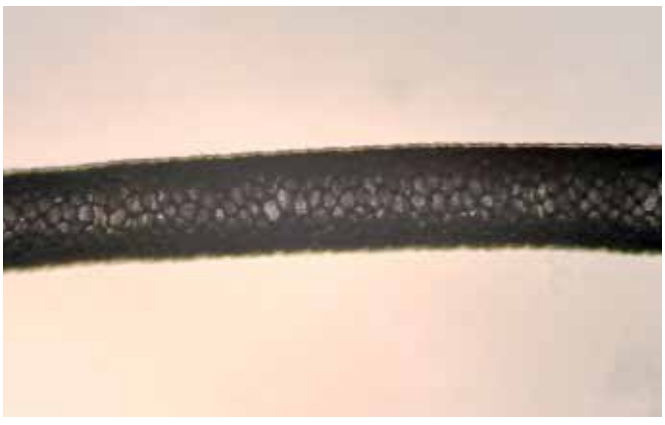

Figure 24. Microphotograph of scales on an antelope hair

viously discussed, has a root that is elongated and frayed. The rabbit does not have a distinguishable root with unique features, however, as shown in Figure 21 the chinchilla hair shows an unique distinguishable root with many long thin extensions, dissimilar to cat hairs.

In wild animals, species was determined mainly on the basis of root structure and medullary patterns. As seen in Figure 22, deer hairs have an identifying, unique root that is commonly described as a wine-glass shape (2, 5)). Even though this characteristic is found in both antelope and deer, it is sometimes possible to differentiate them by the scaling pattern. It was observed that the deer has slightly more rounded scales like a fish, however the antelope have more of a diamond shaped scale (figures 23 and 24, respectively). The difference between the two is so minute that species determination between antelope and deer should not be confirmed unless tests, such as 12SRNA or nuclear DNA assay with short tandem repeat (STR) are performed. It can, however, be stated that a hair with this characterizing root shape can be classified as a part of the deer (antelope) family.

Some other mammals have identifying characteristics, unique to a single species. A common example of this is hairs from bats as shown in Figures 25 and 26. The hairs shown in Figure 25 show a bulbous, beaded look to the hair. Upon closer examination, these hairs may sometimes appear to have a triangular pattern to them. Observing this characteristic can be a unique identifying feature to distinguish this mammal from others, however, bats also have other types of hairs that do not have this identifying characteristic (Figure 26). As shown in this figure the hairs on a bat's body can be of various types, some of them are quite different than other hairs on the same bat.

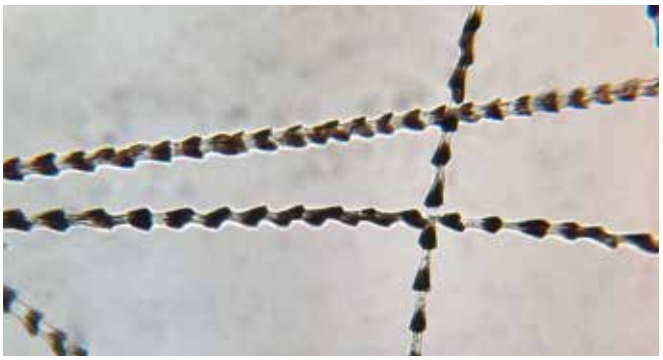

Figure 25. Microphotograph of bat hairs showing uniqueness

Figure 26. Microphotograph of bat hairs showing more than one type of hair in the same field.

Evidence which are not hairs but need to be differentiated

There are many objects that may look like hairs upon visual examination, which are collected as evidence from crime scenes. In this research project, several commonly found crime scene items were included for microscopic analysis. Some of the objects analyzed were dyed and un-dyed fibers from clothing items. The fibers were either cotton, synthetic, dyed fibers, or plant material such as grass. Bird feathers were also examined. These types of evidence fall into the category of trace evidence and can be sent to another specialist for determination of relevance to the crime. These objects, especially fibers, can be easily mistaken by the students or inexperienced criminalist, who may identify them as hairs.

Upon careful microscopic examination, it was noted that these objects could be differentiated. For example, cotton tended to "undulate" (Figure 27) and can be confused as a hair with Negroid hair characteristics. However, as shown in this example, cotton fibers lack a medulla, although not uncommon phenomenon in human hairs, cotton also lack others characteristics such as scales, cuticles, ovoid bodies, cortical fusi and pigmentation. Figure 28 demonstrates microscopic features of dyed, synthetic fibers. These fibers also lacked the characteristics typically observed in hairs. As is evident in Figures 29 and 30, it is easy to distinguish objects such as grass and bird feathers from hairs, which are uniquely mammalian.

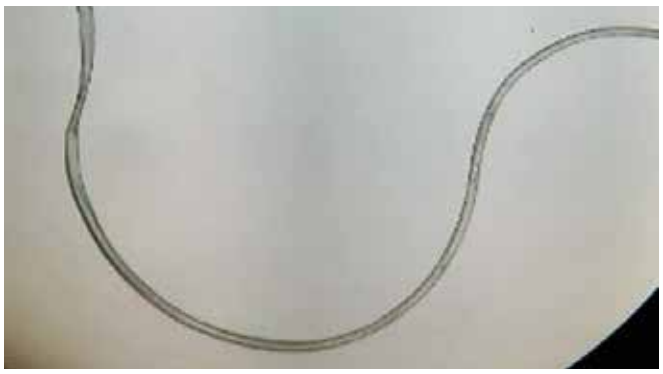

Figure 27. Microphotograph of a cotton fiber

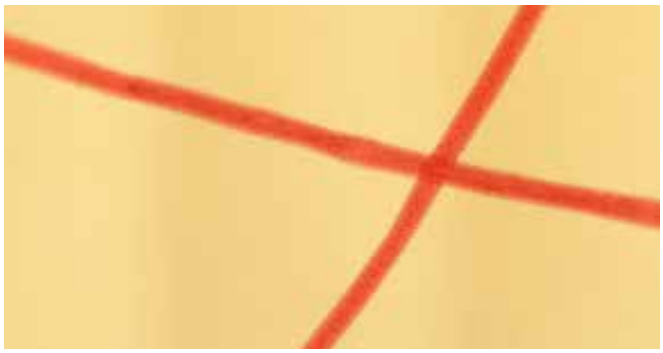

Figure 28. Microphotograph of synthetic red fiber

Conclusion

Evidence such as hairs and fibers are commonly found at crime scenes, however, not every item found is of significant value or relevant to the crime. By considering the envi-

Figure 29. Microphotograph of grass

Figure 30. Microphotograph of feather

ronment of the crime scene, the examiner can filter through the evidence that is relevant to the case. There are many tests, which can be performed on hairs and fibers, but the most advantageous and least expensive is trying microscopic examination, particularly for the purpose of exclusion. As demonstrated in this undergraduate research project, human hairs can be easily distinguished from animal hairs and from miscellaneous items encountered at crime scenes. When a human hair is identified, it can then be submitted for nuclear or mitochondrial DNA analysis, and if needed an animal hair can also be submitted for analysis. A human hair, however, can never be individualized using physical and microscopic examinations to a single donor, as two head hairs from the same individual can be different as human hairs are biological evidence and thus variation is quite common. Alternately, two humans can have very similar hairs and their hairs cannot be distinguished from each other by microscopic examination.

It is vital that a report on hair analysis using physical and microscopic analysis should not be stronger than the actual strength of the evidence and the results of the examinations. Microscopic hair analysis can identify an object as hair, but cannot individualize it without DNA testing. An analyst should never overstate the conclusions, identifying the donor without further analysis using assays based on nucleic acid analysis. Identification by using physical characteristics is a type of classification, and can only determine if the source is human, or animal and if neither, the object is then characterized as miscellaneous.

When physically and microscopically comparing two hairs from same or different individuals, reporting of hair analysis in a lab should always include a disclaimer sentence similar to previously published statements: "It is noted that hair does not possess a sufficient number of unique individual microscopic characteristics to be positively associated with a particular person to the exclusion of all others." (3, 4) This statement ensures that conclusions are not overstated and cannot be used to incriminate an individual without analysis using nucleic acid assay.

Microscopic and macroscopic analysis should be used in all cases where hairs and fibers are submitted as these assays can be used to distinguish relevant evidence from all other extraneous material. This added step ensures the minimization of the number of items of evidence, which are processed for DNA testing, thus preventing unnecessary backlog in DNA analysis laboratories and minimizing expensive assays.

Although microscopic identification of hairs is not a perfect science, further steps can be taken in attempt to normalize the processes internationally. From the research, it is believed that creating a certification program could be an important way to standardize the field of hair analysis. This would require the analyst to learn how to properly characterize hairs and devise a conclusion based upon characteristics agreed upon by the forensic science community to be specific to a species. Agencies and private labs should require a certification program prior to full employment of the analyst by administering a test with questioned samples. This would aid in making a national standard for hair analysis and would minimize any possibility of overstatement in the future. In this day and age of forensic science, an emphasis is put on being a part of professional organizations and attaining certifications - hair analysis needs to be a part of this reform in order to be an integral part of forensic science.

Forensic science has slowly been shifting towards national databases for many of the sub-fields and sub-disciplines within forensic science. A database of common hair characteristics could be made to include a list of identifiable differences between human and animal hairs. It could also include characteristics of each race in order to better characterize human hairs, and a section that could include root characteristics and possible origins. It is highly important to note that this database could be used only as a source for reference, not a source for identification. As every hair is unique, even two hairs from the same individual show differences, no database can be created that would allow for accurate identification such as AFIS (automated fingerprint identification system) for fingerprints. However, this database would help regulate the field of forensic science across the globe, and is a step closer to preventing conviction of the innocent.

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