The CACNews

News of the California Association of Criminalists • Second Quarter 2017

brooke
BARLOEWEN

CAC President

Your participation has made this past year a memorable one. Normally, I would focus on attending DNA-specific meetings in these days of specialization, but this year has given me the opportunity to refocus on criminalistics as a whole.

A Year Well Spent

I have been reflecting back on the past year serving as CAC President. Having worked in the field for over twenty years, it has been fascinating to interact with people who are both starting and finishing their laboratory careers. I have met many new criminalists and watched them begin their journey in a rewarding career. This year, I have welcomed new CAC members, encouraged young criminalists to participate more in professional activities, and seen some fantastic posters and presentations from college students. I have also enjoyed networking with seasoned criminalists, seeing "retired" criminalists continue to contribute to the profession, and awarding some criminalist veterans for their continued leadership over the years.

It has been my pleasure to serve as your CAC President, but I could not have done it alone. I appreciate having a strong Board of Directors and dedicated CAC Committee members who have supported me, moved this organization forward, and maintained CAC's level of excellence in the profession. Thank you to each CAC member who has contributed to the organization, whether by serving in a CAC position, presenting at a CAC meeting, or hosting a CAC event. It is important that we all continue this steadfast collaboration so that the CAC stays strong and continues to provide leadership and training opportunities in the future.

Your participation has made this past year a memorable one. Normally, I would focus on attending DNA-specific meetings in these days of specialization, but this year has given me the opportunity to refocus on criminalistics as a whole. I have thoroughly enjoyed the past couple of seminars by visiting new places, hearing from people outside of my everyday disciplines, and interacting with criminalists from all over California. Being at all of the CAC Meetings has reenergized my interest in the whole field of criminalistics, which is actually an entangled web of these sub-disciplines we now tend to specialize in. Presentations at CAC meetings have reflected this theme. Through CAC's friendships, camaraderie, and togetherness, we can all continue to work together to advance our profession, face challenges, and succeed in the future. This leads into the theme of the upcoming seminar in San Francisco – "No lab is an island." I look forward to seeing many of you in the City by the Bay.

Brooke

The CACNews

www.cacnews.org

SECOND QUARTER 2017

Many Hands

Ed Jones and Jose Montelongo prepare an impromptu microscope specimen at the Rancho Mirage meeting.

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The CAC is a private foundation dedicated to the furtherance of forensic science in both the public and private sectors.

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

Notice to Contributors: We publish material of interest to our readers and are pleased to receive manuscripts from potential authors. Meetings and course announcements, employment opportunities, etc. are also solicited. Advertisements are also accepted, although a fee is charged for their inclusion in *The CACNews*. Please contact the advertising editor for further information.

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

Make plans now to attend the Spring 2017 CAC meeting at the San Francisco Kabuki Hotel. Planned workshops include: **Legal Interactive Workshop** (Tuesday All Day, lunch included, limit 40), **Firearms Double-Casting Workshop** (Tuesday All Day, lunch included, limit 25), **DEA Workshop** (Tuesday All Day, lunch included, limit 25), and the **DNA Workshop** (Tuesday All Day, lunch included, limit 100). Visit www.cacnews.org for registration details.

Changes to Title 17

Title 17 for forensic alcohol labs is updated with many new changes. It is publically available on the westlaw.com website and goes into effect on April 1, 2017. [Online version of *CACNews* has the full link.]

McCrone Inst. Offerings

Since 1960, McCrone Research Institute in Chicago has offered intensive courses in microscopy that emphasize the proper use of the microscope and more specialized microscopy, focusing on a particular technique, material, or field of application. All courses are hands-on, featuring lectures, demonstrations, and laboratory practice.

Chemical Microscopy Course
Cornell University, Ithaca, NY July 31 - August 4, 2017.
McCrone's Chemical Microscopy (1202) is a graduate-level applied polarized light microscopy (PLM) course that covers all the necessary techniques of PLM for identifying and analyzing optical and chemical properties of small particles.
In this hands-on course, students will learn how to:
Perform reliable PLM operations and techniques; Identify small particles, including organic and inorganic chemical compounds; Characterize fibers from animal, mineral, vegetable, and man-made origin; Perform microchemical and microcrystal tests; Practice visual/thermal methods; Study crystals and optical crystallography. Lectures and laboratory demonstrations using video for macro- and micro-projection will cover PLM theory, techniques, and interpretation. Each student will perform applicable exercises on the polarized light microscope.
Learn more and register online at mcri.org

Other McCrone Courses
Asbestos Fiber Counting [NIOSH 582] -- May 1-5

Food Microscopy -- May 8-12

Fluorescence Microscopy -- May 16-18

PLM, Forensic Microscopy, and Advanced Microscopy Courses

SEM, FT-IR, Fluorescence, Raman, Sample Prep, and Other Micromethods Courses

Specialty Microscopy and Other Courses

Visit www.mcri.org for full descriptions of all courses, secure online registration, hotel information, and more.

Inter/Micro 2017

69th Annual International Microscopy Conference
June 12 - 16, 2017 at McCrone Research Institute, Chicago
Call for Papers: Abstract submission deadline:
March 17, 2017 View abstract submission guidelines at www.mcri.org. Join professional and amateur microscopists from around the world as they present new research on techniques and instrumentation, environmental and industrial microscopy, and chemical and forensic microscopy.

Workshop: Image Processing and Measurement
June 15-16: This two-day workshop, taught by Dr. John C. Russ, will emphasize the tools, methods, and workflow used to extract relevant and accurate information from digitized images through the step-by-step application and comparison of algorithms. Several different public domain and commercial software programs will be used to process and measure images. Students will also learn image-correction techniques such as adjustments for color, brightness, contrast, illumination, and noise reduction. Learn more and register online.

RAISING AWARENESS OF WRONGFUL CONVICTIONS

Hosted by:

CFSI California Forensic Science Institute

CALIFORNIA INNOCENCE PROJECT

FRIDAY, APRIL 28, 2017

Host: California Forensic Science Institute at Cal State LA

Where: Golden Eagle Ballroom, Cal State LA campus
5151 State University Drive, Los Angeles, CA

Time: 7:45a.m. - 2:00p.m.

Please join us for this free civic engagement forum. Continental breakfast and lunch will be provided

AGENDA

PANEL 1:

Prof. Justin Brooks & Supervising Attorney Alissa Bjerkhoel, California Innocence Project, California Western School of Law, San Diego
Prof. Steven J. Frenda, Dept of Psychology, Cal State LA (Eyewitness Identification)
Prof. Iris Blandon-Gitlin, Dept of Psychology, Cal State Fullerton (False Confessions)

PANEL 2:

Robert Grace, Deputy in Charge, Conviction Review Unit, Los Angeles County District Attorney's Office
Post-conviction Testing of DNA Evidence (Supria Rosner, DNA Technical Lead, LAPD Forensic Science Division)

PANEL 3: EXONEREE CASE STUDIES

Brian Banks, Uriah Courtney, Rafael Madrigal, Kimberly Long

Audience Q & A

For questions or registration information please contact:
Katherine A. Roberts (krobert2@calstatela.edu) or Katharine Tellis (ktellis@calstatela.edu)
This forum is made possible thanks to support from the Gilbert W. Lindsay Endowed Chair Fund

Open For Comment...

meiling
ROBINSON

CAC Editorial Secretary

Only thirteen people in this nation have noticed, read, and/ or cared to voice their opinion regarding these work products. This means we have less than twenty days (at the time of writing) to add any additional thoughts to the current collection of opinions.

"If a DNA tech is accurate 40% of the time in proficiency checks, the jury should have that information. . . . Civil service regulations should be adjusted, so test failure could be considered in employee retention."

—James Kunkel

"While this document provides some useful suggestions for 'things' that the customer should be aware of, our underlying responsibility is to the customer."

—Josh Connelly

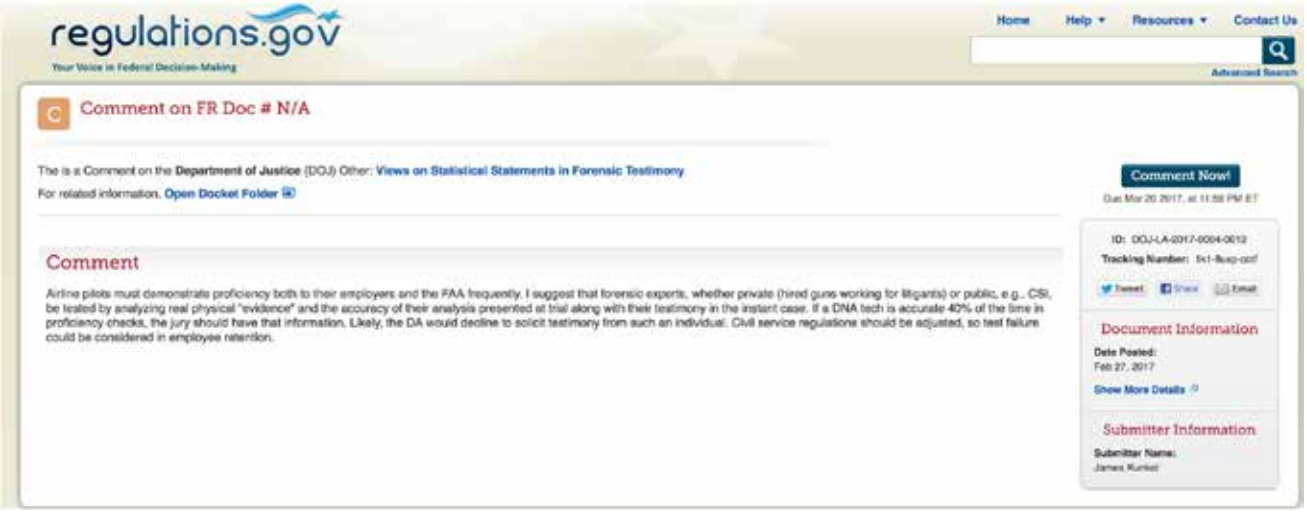
"Some of the source materials you listed for this document are more than two years old."

—Anonymous

Did we fall asleep at the wheel?! Were you aware that as of February 17th the Department of Justice opened a comment period on two revised subcommittee draft work products of the National Commission on Forensic Science (NCFS)? I certainly was not aware until a couple of days ago when I slipped into the usual trance induced by scrolling the endless scroll that is Twitter. Somewhere in the middle of my emotional rollercoaster ride, between queasy and abject fear, I stumbled across this website [https://www.regulations.gov/docket?D=DOJ-LA-2017-0004] referenced in a *Forensic Magazine* article entitled "National Commission on Forensic Science Asks for Public Comment". Bad news. While we were all stumbling around like baby giraffes trying to catch our bearings after the New Year, the "new" NCFS has been busy, already issuing two draft work products: *Views of the Commission Statistical Statements in Forensic Testimony* and *Views of the Commission Report and Case Record Contents*. Worse news, the comment period closes March 20, 2017 at 11:59 p.m. E.T. Worser still, there are only *thirteen* comments to date. Only thirteen people in this nation have noticed, read, and/ or cared to voice their opinion regarding these work products. This means we have less than twenty days (at the time of writing) to add any additional thoughts to the current collection of opinions.

I encourage you all to read the two "Views," as I will only highlight one of the positions expressed by the NCFS. It is not only controversial but also a particularly tenebrous opinion. In "Statistical Statements in Forensic Testimony", with regards to trace and pattern evidence, it is the Commission's opinion that: "…. most efforts to provide probabilistic statements about features and their degree of association often rest on the personal impressions of examiners, supported by their subjective judgment developed through individual training and experience, or by reference to empirical studies of the reliability of the judgments of examiners. Training and experience are important in applying valid techniques, but they are not a sufficient basis for establishing the uncertainty in measurements or inferences."

According to the SWGTREAD document "Range of Conclusions Standard for Footwear and Tire Impression Examinations" published in 2013, standard conclusions include varying degrees of "associations" such as "non-association", "limited association", and "high degree of association". In statistics, association tells you whether two variables are related—positive correlation (positive direction of association), no correlation or negative (negative direction of association). Historically, the use of "association" as it is applied in forensic science has not been a purely probabilistic statement, but rather one assessment to describe a collective of qualitative, quantitative and categorical data. In forensics, "association" is used to indicate a connection based on empirical data. All scientific knowledge is based on empirical evidence. Despite having no current widely accepted, implemented statistical means to define the level of uncertainty or



error rate for the inference, the comparative examinations and empirical data generated still have scientific merit. Furthermore, with regard to comparative examinations, "association" has been translated by and interpreted solely under legal context. So while the NCFS's assessment is partly true I think the underlying disagreement rests in the interpretation of and use of the word "association" and their insistence that an association can only occur through statistical means. Forensic science is a multidisciplinary science, which applies statistical science, not a sub-discipline of statistics. As to the NCFS's underlying intention that statistical analysis needs to be a part of comparative examinations, I would argue that there is no real disagreement from the field. Rather the crux of the issue is that the "Views" provides:

1. No viewpoint that holds other stakeholders accountable for assisting criminalists in research and implementation of such statistical methods. Most criminalists work for public laboratories under federal, state or municipal government and/or police agencies, however there is no mention of these entities and their vital and necessary role in supporting criminalists with this goal. For example, the 2009 NAS report resulted in valuable research such as the 2012 Petraco *et al.*, which established a method for associating striation patterns with a scraping tool using statistical measures of similarity, error rate and confidence. The "Views" would be more useful if the NCFS identified whose collective responsibility it is to bridge the gap from research to implementation. The criminal justice system, law enforcement agencies, laboratory managers, criminalists? Why have five years passed and research like this and other similar research have not yet been recognized as existing by the NCFS or even by laboratories?

2. No recommendations regarding identifying and securing funding for this research and method development. By now it is a widely known fact that crime laboratories and forensic science educational programs are underfunded. How are laboratories and universities expected to support research this extensive? When there is valuable research in the areas of comparative examinations, who is not only accountable for ensuring and assisting criminalists with implementation, but where are the resources coming from to provide the training necessary to carry out such statistical methods?

3. No valuable insight on what purpose these "Views" serve. There is nothing new in this information. The views expressed by the NCFS are either the same criticisms or statements echoed by PCAST's "Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods" (or other similar publications), or obsolete recommendations which have long since been implemented by crime labs.

Perhaps we didn't fall asleep at the wheel, as it were, but maybe we didn't care enough at all to even get into the driver's seat. Maybe you think this is just the hot button topic of the moment and that it'll run its course soon. Perhaps you're retiring soon and can't be bothered with this since you believe this is not your fight to fight. Or as a bench criminalist you simply feel as though you don't have a stake. Whatever your personal reasons may be for not commenting or not following this issue more closely aside, do you feel that *someone else* should be advocating for the interests of criminalists? And if so, *who*?

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Petraco, Nicholas D. K., Peter Shenkin, Jacqueline Speir, Peter Diaczuk, Peter A. Pizzola, Carol Gambino, and Nicholas Petraco. "Addressing the National Academy of Sciences' Challenge: A Method for Statistical Pattern Comparison of Striated Tool Marks." *Journal of Forensic Sciences* 57.4 (2012): 900-11.

CAC Board of Directors Candidate's Statements

For President-Elect

Mey C. Tann

My career in criminalistics began as a graduate student assistant at the CA DOJ Riverside Laboratory in 1998. My CAC membership began right around the same time. Throughout those years and through CAC, I have been able to meet and draw upon the vast knowledge and experiences of those in Criminalistics. My service involvement in CAC began on the Awards Committee. I served on this committee for approximately four years (2005-2009). In 2010, a friend and colleague asked me to serve on the Board of Directors as the Regional Director South. I served for approximately five years in that capacity. Now I have been asked by another friend and colleague to serve as President. I would appreciate your support in this endeavor. I will do my best to live up to the standards set by those preceding me.

For Editorial Secretary

Meiling Robinson

I am honored to be considered again for the position of Editorial Secretary. I am thankful for the opportunity to have served the membership for these past two years, and it would be my great pleasure to continue serving in my current capacity as Editorial Secretary. If confirmed, I will continue to strive for continuous improvement in preparing and delivering the *CACNews*. With this opportunity, I will reaffirm my commitment to the CAC Board and will steadfastly serve the membership.

For Regional Director (South)

Jamie Daughetee

I have held the position of Regional Director South for the last two years. I have planned at least two study groups a year and have tried to place them in different regions around southern California. DOJ Santa Barbara, for the first time, got to hold a study group. I have tried to fill the chairs for all of the positions and also allowed for new people to be chairs of the different study groups. I have brought the firearms study group back into the fold of CAC. I am currently getting a digital forensic chair and arson chair. Once I complete those tasks, we will be at full capacity for the Southern Chairs. I have enjoyed the position and hope to continue for the next two years. I continue to promote CAC wherever I am and try to encourage new membership. Thank you for your consideration.

For Treasurer

Helena Wong

I am a criminalist at the Oakland Police Department Criminalistics Laboratory. I began my career there in 2009 as an intern and then as a forensic technician. I continued to pursue my passion in forensics by joining professional associations such as the CAC in 2009, by attending as many CAC seminars and various other professional meetings as I can, and by getting certified by the American Board of Criminalistics. I have had the privilege of serving the CAC as Treasurer for the past two years. During these two years, I have learned to appreciate all the time and effort that our members dedicate to the CAC in making it a successful organization. I would be honored to continue to use my time and efforts in serving the CAC as Treasurer.

A Newbies Perspective: Understaffed and Underfunded. The Crime Lab's Mantra

A Newbies Perspective is a blog post series looking at the world of forensics through the eyes of a young forensic scientist

First off I want to say Happy New Year. For me, the New Year is always a good time to reflect on the past and lessons learned, especially lessons my mentor taught me growing up. One quote he DRILLED into my head, was by author Robert Greene and it went "No structure can stand long when it rots from within." An aspiring body builder doesn't start off bench pressing 300 lbs (fitness is a personal hobby of mine :-]). A beginning pianist doesn't immediately jump to playing *Clair de lune* by Claude Debussy. Case in point, nothing substantial can be built without a strong foundation. This leads me to a topic I brought up in my previous post: the lack of funding and inadequate staffing of crime labs across the country.

I don't think anyone in this industry would disagree with the notion that proper funding and staff are the foundations (or a few) of a successfully run crime laboratory. Continuing with my "newbies perspective", I didn't realize the seriousness of this issue until I started doing more research and learned how detrimental it can be. Issues such as these are not typically taught in forensic science classes (at least not in mine) and I was astonished, to say the least, when I first learned of the matter. Article after article I found criticizing labs for having "long turnaround times" and "too few analysts", usually relating to financial limitations. In consideration of the current media portrayal of forensic science laboratories, I have concluded that this is a bigger issue and not just an isolated incident. When I read things like this it upsets me, not only because this is the field I care about, but also for the victims' whose justice is delayed.

Despite this, steps in the right direction are being taken. In the article titled *The Balanced Scorecard: Sustainable Performance Assessment for Forensic Laboratories* by Max Houck et. al. (*illustration*) details how "continuous improvement is a necessary condition for successful organizations, including organizations in the public sector." The article then proceeds to explain The Balanced Scorecard theory and how it can be applied to crime laboratories. The Balanced Scorecard is a business concept, and I am learning there is a great need for business concepts to permeate forensics. The old ways of doing things are not sustainable.

—Dante Webb

MicroPrecious

The fabulous microscopic art of Ed Jones has been featured on these pages before. Here is one of his most recent creations.

Microscopical Soc. of So. Calif. 2016 Exhibition

Actual size

Key for Slide:

Center—1 faceted blue sapphire (1.5 mm square cut)
1st circle—8 faceted emeralds
2nd circle—5 faceted diamonds (smallest commercially available)
3rd circle—18 1.00 mm ruby balls made for ballpoint pens
4th circle—61 miscellaneous objects
5th circle—81 flakes of placer gold
6th circle—38 colored microspheres (glass, plastic and metal
7th circle—54 electronic components (26 are from one mini ipad)
8th circle—43 brands of gunpowder (64 different grains)
9th circle—103 different seeds

443 different objects are on this slide. Twenty-one of the gunpowders have two grains of powder to show the range is size or the profile view. The microstuff is held on to the microscope slide with double-sided sticky tape. Each object was placed on the double-sided sticky tape with very fine forceps. All of the items on this slide were collected by me, purchased by me or given to me by friends and/or professional colleagues. The outside circle of seeds has a 17 mm diameter.

—Ed Jones

An Argument for Including Dispersion in Glass Evidence Procedure

John I. Thornton

Glass evidence is typically characterized by color, fluorescence, refractive index, density, (thickness when possible), and elemental composition. Refractive index may be further refined by a consideration of dispersion, i.e., the variation of refractive index with wavelength. Very close agreement in all of these properties must be observed in order to support an opinion that an evidence sample of glass is consistent with an exemplar sample.

With respect to density and refractive index, criteria have been advanced for their interpretation in any consideration of whether evidence and exemplar samples are from a common source. The "Miller Criteria" are advocated by Elmer Miller, formerly of the FBI laboratory and probably the leading forensic glass expert of the past century. These criteria state that in the absence of a physical match, commonality of source requires agreement in density of ±0.001 g/cm3 and refractive index agreement to within ±0.0002 for the yellow 589 nm D line and to within ±0.0004 for both the red 656 nm C and the blue 486 nm F lines.

Determination of the refractive index at the red 656 nm C and the blue 486 nm F lines provides more information and allows a summary statistic of the dispersion of the sample to be developed.

In general practice in forensic laboratories, however, dispersion measurement is often not attempted. There are several reasons for this. Two of these dominate the subject. The first is that automated (read merciful) methods of refractive index measurement, such as the GRIM of Foster and Freeman and the rIQ of CRAIC Technologies, are optimized solely for monochromatic light of the 589 nm D line. Refractive indices developed at this wavelength are denoted by nD. The second reason is that the work of Locke et al. in the United Kingdom [1] suggested that little additional information was developed when dispersion was added to nD determination. Locke's work thusly provides a rationalization for not going to the bother of determining dispersion, a rationalization that certainly does have a seductive appeal. The third reason, which is almost trivial in comparison to the first two, is that if the refractive index is to be determined by the immersion method, the red 656 nm illumination results in the Becke Line being devilishly hard to discern, and as a consequence diminishes the analyst's enthusiasm for dispersion measurement.

It is the second reason with which I wish to take issue. I have no quarrel with the work of Locke, but there's another point to be had here. The work of Locke has diverted our attention from this other point. Within a homologous series of glasses, such as float window glass, beverage bottle glass, disannealed glass, etc., a plot of refractive index versus wavelength shows that most samples have very similar slopes. This is the point that Locke makes, and I don't in any way dispute this. The obvious conclusion from this is that dispersion is of little utility. Yes, two disparate samples of glass could coincidentally match at the D line, but the prospects of this happening are quite slender.

But dispersion offers something else to us, and I believe this to justify the additional effort of making determinations at the red C and blue F lines. Part of this I have developed previously [2].

Consider an item of glass. For the moment, let us ignore dispersion. Some variation in density and refractive index will be observed within the item due to small differences in composition and annealing history. But these properties are very highly correlated; if upon analysis of another sample from this item the density of the glass was to be perceptibly increased, then an increase in refractive index is obligatory by virtue of electrostatic theory. The converse is true; if a perceptible decrease in density was observed, it would be accompanied by a decrease in refractive index. A plot of density and refractive index for a single item of glass will therefore show a straight line. (This should not be confused with a 'dispersion curve'. A plot of refractive index versus wavelength will be nonlinear for most liquids and solids). Although within a given sample the precise values for density and refractive index may vary, the slope will not. The slope of the line may be considered as a property of a sample of glass, with 'within-item' variation sliding up or down the line, but not deviating from it. The significance of this is that some 'within-item' values which could be countenanced as legitimate variation by the Miller Criteria are not truly acceptable; they would not honor the slope. This is an important point. And this point may be exploited.

Until now, we have only been considering 'within-item' variation. But now if we add dispersion, we can develop a metric that will distinguish "within-item" variation from "between-item' variation, *i.e.*, a sample that has not shared a commonality of source, *e.g.*, some other window, some other headlight, some other bottle.

Dispersion V is typically denoted as:

$$V = (n_D - 1) / (n_F - n_C)$$

This formulation of dispersion is termed *relative dispersion* or the V number or the Abbe number, There are other formulations, but this formulation will serve our purpose here. Dispersion will provide additional information concerning the precise character of the sample under consideration. To ignore the additional discrimination achieved if dispersion is incorporated into a slope-driven formulation of 'within-item' variation would diminish the utility of this approach. Dispersion is easily computed, but of course requires that the refractive indices for the blue n_F and the red n_C be determined, which many are loath to do but is what I am arguing for.

If the density D of a sample is divided by the dispersion V, the quotient is the tangent of the slope of the line that would be observed if we were to plot the data graphically. We may denote the slope as *k*. (It should be recognized that a mention of plotting is being used here only to conceptually develop the rationale of deriving the *k* value. The simple math here drives the line through the 0,0 origin, thereby providing the slope while recognizing that glasses obviously do not have a density or refractive index less than unity.)

$$k = D / V$$

As a mathematical concept, the *k* value is a very sensitive metric. A *k* value shift of 0.001 or less is consistent with 'within-item' variation, while a shift of greater than 0.001 in *k* value is a strong indication of 'between-item' variation and suggests the glass is of another provenance. This can be seen

by taking any sample of glass, altering values in accordance to what is permitted by the Miller Criteria, and observing the effect on the *k* value. A slight change in any value, the change being well within the Miller Criteria, will have a profound effect on the *k* value.

Consider the following two samples of glass, taken from actual casework and representing incidents widely separated both temporally and geographically.

Density	n_D	n_C	n_F	V	k
2.4895	1.5231	1.5178	1.5152	65.5443	26.3283
2.4890	1.5235	1.5178	1.5153	63.1463	25.3701

These samples could not be discriminated by conventional criteria for the interpretation of commonality of source. They may be easily distinguished on the basis of their *k* values, however.

There's the argument in favor of including dispersion. Yes, it's more work and it would be of benefit to be a Zen master when determining the index for the red 656 nm line, but the *k* value appears to be of great utility in the interpretation of this evidence.

[1] Locke, J., Underhill, M., Russell, P. Cox, A., Perryman, A.C. The Evidential Value of Dispersion in the Examination of Glass. *Forensic Science International*, 32:219-227 (1986)

[2] Thornton, J. The Use of *k* Values in the Interpretation of Glass Density and Refractive Index Data. *J. Forensic Sciences*, Vol. 34, No. 6, p. 1323-1328 (1989).

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Human Habitat Profiling

Bob Blackledge

In criminal investigation I've never liked things that were subjective. That's likely why I'm a "criminalist" rather than a "criminologist." But in investigating some crimes, it may seem we are virtually "clueless." What can we do then?

One approach that has received lots of attention in various forms of fiction is behavior profiling. In reality, its success has been rather mixed. One could say, "When you have nothing, it's better than nothing."

Today there is an emerging investigational approach that is in-between. By itself, it can't convict anyone; it can only provide investigative leads. But rather than being primarily subjective, any investigative leads will have been based on the non-subjective identification and relative quantization of various particle types and their frequency of occurrence in various geographical localities.

This is not an extensive review, so doubtless I'll fail to mention some important contributors. David Stoney is the first name that comes to mind. He has shown how carpet fibers may have evidential value beyond the same fiber types being found associated with the victim/suspect/crime scene. Microscopy can reveal tiny particles adhering to the fibers. These particles may be identified and together the various types may provide a profile of the fiber's original location. If the particles found on similar fibers from the victim/suspect/crime scene all have similar habitat profiles, it would add to their value as associative evidence.

Wikipedia defines "metabolomics" as "The scientific study of chemical processes involving metabolites." It goes on to say, "Specifically, metabolomics is the systematic study of the unique chemical fingerprints that specific cellular processes leave behind." Amina Bouslimani, PhD, UCSD, is one of the presenters at the NIJ Forensic Science R&D Symposium in New Orleans on Valentine's Day as part of the AAFS 69th Annual Scientific Meeting. The title of her presentation is "Illuminating Lifestyles by Metabolomics of Personal Objects." A well-illustrated print version of the same material may be found at: "Lifestyle chemistries from phones for individual profiling"
http://www.pnas.org/content/113/48/E7645.full.pdf

Amina is a member of the Dorrestein Lab (Pieter Dorrestein, Principal Investigator), at UCSD. So how could research taking place in the Dorrestein Lab have application to forensic science? Go to: "The man who can map the chemicals all over your body", at:
http://www.nature.com/news/the-man-who-can-map-the-chemicals-all-over-your-body-1.20035

One of the problems with trace evidence today is a lack of databases that can identify traces, indicate their distribution, and provide estimates of their rarity. There is a 42-slide PowerPoint program that shows how Dorrestein and other collaborators are putting together various databases: "Mapping microbial and molecular universe."
http://nas-sites.org/emergingscience/files/2016/01/8-Garg-Mapping-microbial-and-molecular-universe.pdf

The next article, although it deals with environmental health concerns rather than forensic science, "Dust, unsettled" by Janet Pelley, is very encouraging in regard to the development of such databases. And best of all, because these databases will not be assembled by forensic scientists, there will be no reason to believe claims of "cherry picking" by opposing counsel.

Dust, Unsettled

Janet Pelley

Researchers are making an ever-longer list of the chemicals in dust and trying to understand what the compounds mean for health.

As sure as the sun rises, houses collect dust. It gathers on our knickknacks and dirties the carpets. More than just dirt, house dust is a mix of sloughed-off skin cells, hair, clothing fibers, bacteria, dust mites, bits of dead bugs, soil particles, pollen, and microscopic specks of plastic. It's our detritus and, it turns out, has a lot to reveal about our lifestyle.

For one thing, it's far from inert. Those shed hairs and old skin cells can soak up a constellation of contaminants

originating from consumer products that we bring into our homes. Other environmental contaminants can be tracked indoors on the soles of our shoes. So in addition to fluffy hair and garden dirt, dust can hold a witch's brew of persistent organic pollutants, metals, endocrine disruptors, and more. Not only does dust hold a long memory of the contaminants introduced to a house, it's also a continual source of exposure for the residents. Dust gets resuspended when it's disturbed and will recirculate throughout the house, picking up substances before returning once more to the floor. "Year over year, dust accumulates in the home," says Miriam L. Diamond, an environmental chemist at the University of Toronto. Even after regular cleaning, it still accretes since homes are tightly sealed environments, and the dust gets entrenched in carpets and crevices. Dust from an old house will retain legacy pollutants such as DDT that were banned almost half a century ago, she says.

Scientists study dust to try to get a handle on both sides of this coin: as a proxy to better understand what chemicals are in our surroundings and how they move, and as a way to characterize what exactly we are exposed to via dust. Still, the relationship between dust and human health remains uncertain. Researchers know that dust is an important source of exposure to certain pollutants especially for infants and toddlers, who spend 90% of their time indoors, put everything in their mouths, and are more sensitive than adults to many of the compounds found in dust. But they haven't nailed down the extent of health risks from dust exposure, nor which compounds and sources are of greatest concern. And many compounds remain unknown. "The few to a hundred compounds that we know are in dust don't encompass the universe of chemicals in commerce, which number in the tens of thousands to over a million", says P. Lee Ferguson, an environmental chemist at Duke University. To reveal the full spectrum of chemicals in dust, researchers are turning to high-powered analytical tools. Dust is no longer something to be swept under the rug.

DUST BATH

Scientists first realized that dust had a story to tell about environmental health in the 1940s when they measured human pathogens stuck to the dust in operating rooms as a way to monitor cleanliness. In the 1970s, researchers began assessing house dust for lead from paint and gasoline as a way to determine the levels children might be exposed to. And in more recent studies, researchers have found carcinogenic compounds such as now-banned polychlorinated biphenyls (PCBs), once used in electrical cables and wood floor finishes, and endocrine disruptors such as phthalates, which soften vinyl flooring and other plastics.

Researchers are still building their understanding of the complex ways that volatile and semivolatile compounds interact in our surroundings, sorbing and desorbing from surfaces. They do know that consumer products vinyl flooring, personal care products, electronics, furniture, carpet pads, paints, cleaning products, and more have a strong driving force to shed compounds into materials with lower concentrations of the substances. For example, a flame retardant might volatilize off of the plastic parts of a TV set into the air, stick onto airborne particles, and move into dust, which settles on floors and carpets. The compounds will continue to migrate until they reach equilibrium with the surroundings, says Diamond. And heating the product, such as when we turn on a computer, also speeds migration into the home environment; a compound will condense in a cooler part of the room where dust often resides.

High molecular weight compounds, such as the flame-retardant decabromodiphenyl ether, don't volatilize but instead enter dust when people physically knock fibers or minute bits of plastic off of couches or computer cases. "Another mechanism that we stumbled on is direct transfer or diffusion into dust," says Stuart Harrad, an environmental chemist at the University of Birmingham. For instance, if dust settles onto a television set or Wi-Fi router, there is a very good chance that flame retardants will migrate directly into the dust.

With people in the room, things get even more complicated. "Just like the Peanuts comic strip character Pigpen, people walk around in a dust cloud all day," says Heather Stapleton, an environmental chemist at Duke University. People add to the dust's organic load as their warm bodies volatilize deodorant or fragrance compounds from personal care products. "Our skin cells and clothing fibers may also accumulate chemicals from the air before they are then shed to dust, where they can accumulate yet more chemical," Diamond says. Those compounds can be absorbed through skin, inhaled, or ingested when people put dusty hands to their mouths, complicating the scientist's task of determining which exposure route is most important.

Most research to date has focused on identifying individual classes of compounds in dust, like the polybrominated diphenyl ether (PBDE) flame retardants found in furniture foam, carpet pads, and electronics; phthalates like those found in vinyl flooring; or pesticides tracked in on shoes or evaporated off of pet collars. Now researchers are trying to get a more comprehensive view of the mixtures people are exposed to by probing the overall contaminant load in house dust. By combining toxicity tests with emerging methods for determining a complete profile of compounds in dust, researchers may be able to determine what chemicals or combinations of chemicals are most toxic, Stapleton says.

In one new approach, scientists combed through two dozen dust studies of 45 compounds to create a snapshot of nationwide exposures, says Robin E. Dodson, an exposure scientist at the Silent Spring Institute. She and Veena Singla, a staff scientist at the Natural Resources Defense Council, ranked the substances according to the amount in dust, and estimated intake and health hazard (see table). The phthalate plasticizer di(2-ethylhexyl) phthalate, known as DEHP, topped the list. Phthalate plasticizers make plastic more pliable and are found in vinyl flooring, food containers, and cosmetics. DEHP can disrupt hormone function in human and animal studies and is linked to reduced sperm motility in men. Other compounds on the list include phenol preservatives found in deodorants and cosmetics, flame retardants, a fragrance compound known as Galaxolide, or HHCB, and perfluorinated stain repellents.

DUST AND HEALTH

What all of this means for health is a sticky question. For some compounds, like PBDEs, researchers have shown that dust is a major source of human exposure to these potentially endocrine-disrupting chemicals. But for other compounds, dust's contribution is less certain. For this and other reasons, researchers still don't have a clear picture of the risk to health from house dust. Many of the contaminants identified so far in dust are associated with hormone disruption, cancer, and reproductive damage, according to human epidemiological and cell studies, but, "for many of these compounds, governments have not set safe levels," Singla says. After she and Dodson completed their study, she compared the amounts of contaminants in dust to soil-screening thresholds set by the Environmental Protection Agency that indicate a chemical might pose health risks and thus require further investigation. She found that the concentrations of some phthalates and flame retardants in house dust exceeded these standards.

Meanwhile, Stapleton's work hints that exposure to contaminants in dust could be implicated in weight gain. Her lab has found that flame retardants will bind to a human cell receptor that triggers fat storage in human cells. When testing human cells in the lab with extracts of dust at levels that a child might be exposed to, the scientists observe activation of these receptors around 50% of the time, suggesting the dust extracts may increase weight gain.

Todd P. Whitehead, an environmental scientist at the University of California, Berkeley, is part of the California Childhood Leukemia Study that aims to identify the risk factors for the disease, which has become more common since 1975. He and his team are sampling dust in California homes because his work shows that dust is a useful indicator of exposure to PAHs, PBDEs, and PCBs, compounds that are suspected leukemia risk factors. "Compared to homes of healthy control children, the homes of children diagnosed with acute lymphoblastic leukemia tended to have, on average, higher levels of PAHs, PBDEs, and PCBs in dust after adjusting for other relevant factors such as household income," he says.

"This is the strongest type of evidence to suggest that these compounds are risk factors for childhood leukemia", Whitehead says. But researchers can't say if the dust accounts for the increased leukemia risk, or if it's correlated with the presence of something else in the home. And there are other sources of exposure whose importance relative to dust is unknown. "We know that dust exposes us to these chemicals, but at the same time, if someone eats smoked salmon or a grilled burger, there are potentially carcinogenic PAHs on those items," Stapleton says.

A DEEPER DIVE INTO DUST

Until now, scientists have been constrained by technology to study just the few hundred compounds that they know are in dust and for which they have analytical standards. Furthermore, based on the measured toxicity of known contaminants and their concentrations in dust, these compounds only account for a fraction of the toxicity found in tests of household dust. So scientists reason that there are still a substantial number of unknown contaminants in dust that could pose health risks.

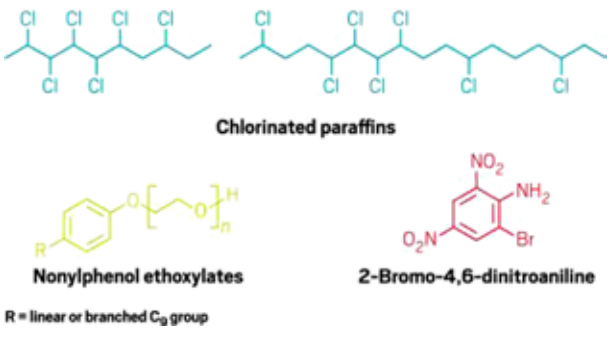
Over the past five years a new strategy called nontargeted analysis has caught on that promises to open a window on the complete swath of compounds we encounter in daily life, says Duke's Ferguson. The strategy combines high-resolution mass spectrometry with data processing tools to tease out the identities of chemicals from a mass of data.

Ferguson and his team recently took extracts of household dust, separated the extracts into fractions using high-performance liquid chromatography, and then analyzed each fraction with ultrahigh resolution mass spectrometry. This generates up to 10,000 candidate molecules, Ferguson says. The team's software interrogates chemical databases such as PubChem and comes back with a list of potential matches then predicts their hypothetical mass spectra. Using this, patent information, and literature references, the researchers prioritize the likelihood of compounds to be in dust samples.

Testing dust with this approach, Ferguson's team found some of the usual suspects, like flame retardants. "But we also saw compounds we don't usually think of as organic contaminants in dust, such as nonylphenol ethoxylates", he says. These are nonionic surfactants used in household cleaners and suspected endocrine disruptors. Because most cleaning products get washed down the drain to sewage plants and discharged with treated effluent, scientists have been tracking surfactants in lakes and rivers, but haven't looked for them in dust, he says. Ferguson's lab has shown that nonylphenol ethoxylates cause the proliferation of fat cells in a laboratory assay, hinting at a role in obesity. "These surfactants give the highest analytical signal compared to all the other components, such as flame retardants, that we measure in house dust using mass spectrometry," he says.

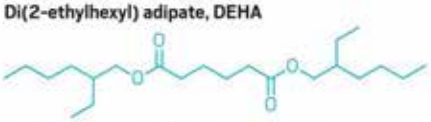
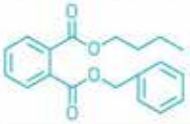
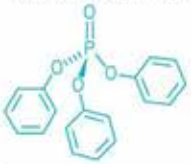
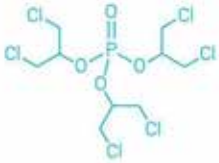
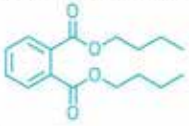
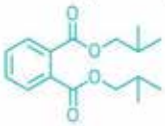
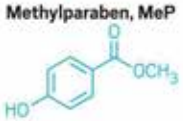
Ferguson's analysis also uncovered dog and cat flea treatments, fungicides, components of foods including pepper, and even cocaine. The team is working to get standards for these compounds to confirm their identity and quantify them in dust, he says. "This work has the potential to open up our understanding of exposure far beyond the limited set of compounds we've typically studied to date", he concludes.

It's beginning to do so already. In addition to Ferguson's work, researchers at the University of Saskatchewan recently used nontargeted analysis to identify azo dyes as the largest class of brominated compounds in house dust. And Cynthia A. de Wit, an environmental chemist at Stockholm University, and her team can now identify groups of chlorinated paraffins in unknown mixtures with the strategy. This large class of compounds acts as flame retardants, plasticizers, and lubri-



Nontargeted analysis has revealed that chlorinated paraffins (representative compounds in blue), nonylphenolethoxylates (green), andazodyes, many built using 2-bromo-4,6-dinitroaniline (red) as a backbone, are major components ofhousehold dust.

Dust, cont'd

COMPOUND	CHEMICAL CLASS	HEALTH HAZARDS	COMMON PRODUCTS CONTAINING THIS CHEMICAL
Di(2-ethylhexyl) phthalate, DEHP 	Plasticizer (phthalate)	Reproductive system toxicity, developmental toxicity, hormone disruption	Vinyl flooring, food contact materials
Di(2-ethylhexyl) adipate, DEHA 	Plasticizer (phthalate replacement)	Reproductive system toxicity, developmental toxicity	Vinyl flooring, food packaging
Hexahydrohexamethylcyclopenta-γ-2-benzopyran, HHCB 	Fragrance	Uncertain	Scented products
Butyl benzyl phthalate, BBP 	Plasticizer (phthalate)	Reproductive system toxicity, developmental toxicity, hormone disruption	Vinyl flooring
Triphenyl phosphate, TPHP 	Flame retardant	Reproductive system toxicity, nervous system toxicity	Treated furniture, baby products, carpet padding, electronics
Tris (1,3-dichloro-2-propyl)phosphate, TDCPP 	Flame retardant	Cancer	Treated furniture, baby products, carpet padding
D-*n*-butyl phthalate, DBP 	Plasticizer (phthalate)	Reproductive system toxicity, developmental toxicity, hormone disruption	Nail polish, paints
Diisobutylphthalate, DIBP 	Plasticizer (phthalate)	Reproductive system toxicity, developmental toxicity, hormone disruption	Vinyl products, personal care and beauty products
Hexabromocyclododecane, HBCD 	Flame retardant	Reproductive system toxicity, nervous system toxicity, hormone disruption	Polystyrene building insulation
Methylparaben, MeP 	Phenol	Reproductive system toxicity, hormone disruption	Cosmetics, lotions, deodorants

Better not bite the dust: These 10 compounds are found in 90-100% of U.S. dust samples, according to an analysis of two dozen studies that measured 45 compounds in dust. Source: Natural Resources Defense Council.

cants for metal parts, appearing in caulking for buildings and windows, and even in hand-held kitchen mixers. "There are thousands of isomers, and conventional mass spectrometry can't separate them," de Wit says.

She and her colleagues ranked concentrations of flame retardants in dust from five countries and found that chlorinated paraffins topped the list at 700 μg/g dust, more than 200 times the level of halogenated flame retardants. The finding is "alarming", de Wit says. "Chlorinated paraffins have been known as contaminants for several decades but lack of analytical methods has hindered determining them in environmental samples," she says.

These new findings are just the start, researchers say. In fact, an international collaboration aims to pick apart dust to get its complete profile, says Pawel Rostkowski, an environmental chemist at the Norwegian Institute for Air Research. Members of the team, called the NORMAN Network, from the EU, US, Canada, Australia, and Japan have each received part of a pooled dust sample from Canadian homes to analyze with nontargeted methods. They will then pool the results to build an open-access library of mass spectra for the thousands of compounds they hope to identify.

"The good news is that when we take action to phase out or ban chemicals of concern, the levels in our bodies go down," the NRDC's Singla says. She points to PBDE declines in blood and breast milk after PBDE flame retardants began to be phased out more than 10 years ago. Research from Stapleton's lab and others' has shown that frequent hand washing, using a vacuum with a HEPA filter to capture the smallest particles, and dusting with a damp cloth will reduce personal exposure to chemicals lurking in dust. Wood floors, which can be easily cleaned with a damp mop, are preferable to carpets since carpet fibers permanently trap 90% of the dust that lands on them.

A new California law requires all labels on upholstered furniture to declare the presence or absence of added flame retardants. "We can start thinking about moving more upstream by selecting products without these chemicals and working with manufacturers to remove these compounds from their products," SSI's Dodson says. But she adds that ultimately, safety testing needs to be done before compounds are added to products and not after before they even have the chance to turn into dust.

Janet Pelley is a freelance contributor to Chemical & Engineering News, the weekly newsmagazine of the American Chemical Society. 9 DOI: 10.1021/acscentsci.7b00006 ACS Cent. Sci. 2017, 3, 5-9

Why is *Subjective* a Naughty Word?

John I. Thornton

Criticism of several aspects of forensic science has recently been leveled by those who are disturbed by the subjective nature of many of the processes in which we engage. Much of this criticism is no more than academic sophistry, but increasingly courts have been troubled by the subjective nature of some examination protocols. A salient example is in the area of firearms examination, as discussed below.

There is no getting around the subjective nature of many comparisons. (Well, yes, color may, for example, be assessed instrumentally with no human involvement, but then the results of this assessment must then in turn be evaluated subjectively)

Within the adversary system of justice, in which anything and everything is subjected to partisan scrutiny, subjective examinations are a rich target for criticism. It is one thing for a forensic scientist to say that the concentration of alcohol in the blood of a subject was 0.08% with a certainty of 2%. It is an entirely different matter for a document examiner to defend a statement that the handwriting on a forged check was executed by a particular person, or for a firearms examiner to testify that a severely deformed bullet was likely to have been fired through a particular weapon. Subjectivity in forensic examinations has, is, and will always be troublesome, but it does not follow that subjective examinations are bankrupt of validity. Not in the forensic sciences, and not elsewhere either. It is validity that is the presiding issue, not subjectivity or objectivity.

The terms *subjective* and *objective* may cause confusion, and that confusion has been capitalized upon by those interested in challenging the work of forensic scientists. In order to place the subjective examination of evidence in proper perspective, we must come to grips with these two concepts. Careless use of these terms lead to odd views, some of which might well be removed to the advantage of both reason and justice. We should be careful in how words are used here, as they appear to mean different things and have different significance to different people and in different circumstances.

Critics frame this issue in terms of "objective—good, subjective—bad." It isn't that easy. A simplified view of the

The author with "Ritchie," one of twenty-six horses at a horse rescue center.

dichotomy is that the word "subjective" is the exact opposite of the word "objective." If something is subjective, it then, is not objective. This simplified view may indeed be the one unhappily entertained by the judiciary, by criminal and civil attorneys, and by the public at large. This is an area where science and the law are somewhat at odds with one another because of different perspectives on the matter. This one-way-or-the-other dichotomy lacks nuance, and this is an area where nuance should not be unwelcome. Subjective is thought to mean "from someone's particular point of view," while objective is thought to mean "*not* from someone's particular point of view." An objective matter is therefore one that everyone would agree upon, assuming they are rational and appropriately informed. A subjective matter is therefore one that allows for some difference of opinion. (To confuse the issue further, however, the term "a lack of objectivity" has a distinct aroma of inappropriateness, signifying a personal bias).

In this simplified view, subjective refers to private cognitive considerations: personal beliefs, feelings, prejudices, emotions, notions, and a history of previously held opinions. Objective, on the other hand, refers to publicly observable things. A point which is lost on academic critics is that publicly observable things are countenanced by subjective processes as well.

While a lonely belief held by an individual forensic scientist but bereft of defensible scientific basis would be subjective, a belief shared generally by others in his or her field would be objective. *Beliefs that are so shared are considered to be knowledge*, and knowledge should have comfortable residence in courts as well as other venues. This point has eluded those who have criticized the forensic sciences for employing procedures whose nature may subjective in part. Subjective examinations and the scientific method are by no means enemies, and forensic scientists need not apologize for employing subjective procedures, and users of forensic science should not view subjective procedures as substandard science.

Knowledge is an approximate description of reality. The trenchant question here is whether a subjective opinion is incapable of being in consonance with reality. The answer is yes, it can be, and in general forensic practice, it certainly is. While a simplified view of the subjective objective dichotomy admittedly has a certain intrinsic and perhaps seductive appeal, its slavish application to forensic work does violence to aspects of reality, and it is reality with which we must contend.

Let us now abandon this simplified view and scrutinize the matter further. It is important to understand how the subjective procedures routinely carried out in forensic science laboratories fit into the schema of validity.

The value of thoughts and beliefs owe much to the approach to their understanding. Let us approach by examining the Webster's New Collegiate Dictionary definitions:

Subjective: Relating to or determined by the mind as the subject of experience; characteristic of or belonging to reality as perceived rather than as independent of mind; phenomenal; arising out or identified by means of one's awareness.

Objective: Existing independent of mind; belonging to the sensible world and being observable or verifiable, especially by scientific methods; expressing or involving the use of facts; derived from sense perception.

These definitions provide some insight into common ground between the two, as it is difficult to define precisely where the sensory observation of facts ends and the sensory awareness of them begins. If one accepts the definitions above, one is still at the mercy of his or her perceptions. Let us look at a matrix of the Webster definitions with the purpose of determining the extent of overlap.

Characteristic	Objective	Subjective
Subject to experience		x
Belonging to reality	x	x
Phenomenal	?	?
Arising out of awareness	x	x
Belonging to the sensible world	x	
Observable by scientific methods	x	x
Involving the use of facts	x	x
Derived from sense perception	x	x
Existing independent of mind	x	

If one closely examines the dictionary definitions of subjective and objective and compares them within the context of forensic examinations, it is apparent that there is considerable overlap. It is in this shared overlap that forensic procedures are performed, given that the scientific method is employed and that personal bias is curtailed.

Those who challenge the forensic sciences on the basis of subjectivity should actually be challenging reality. Is there anyone whose life is not guided, and in some instances totally dominated, by subjectivity? We willingly follow the advice of a physician who diagnoses a common cold based on a very short and very subjective examination. We select our own toothbrush from those of other family members. We assure ourselves that our shoes are mates of one another. We recognize our spouse in a crowded airport. We occasionally err, but rarely. In the forensic laboratory we may occasionally err, but rarely.

Let us now project this discussion onto the issue of firearm identification, as an example. Critics of firearms and toolmark identification decry the subjective aspect of these identifications and suggest that on that basis they be disallowed in court. But harken back to reality. The striae noted on fired bullets are real. They arise out of awareness. Others can see them. They can be photographed. They are derived from sense perception. They satisfy the criterion of reality. They can be shared with others. They form the basis of knowledge. Such knowledge deserves our respect.

Subjectivity may be reasonably defended without stooping to an attack on objectivity. But some recognition should be given to the shortcomings of objectivity as well, as objectivity must be harnessed as well as subjectivity. One of the supposed hallmarks of objectivity is that a person will keep an open mind, and a competent examiner will certainly do so. But at some point, after an examination that involves both objectivity and subjectivity, a conclusion must be reached. A perpetually open mind will prevent that conclusion from being reached; there will always be yet one more thing to consider, and consequently nothing would ever be accomplished. An open mind must be accorded respect, but a perpetually open mind may not be any better than a perpetually open mouth.

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NIST 3-D Ballistics Research Database Goes Live

New forensic science database will provide a statistical foundation for more reliably linking bullets to the guns that fired them.

It's a staple of the TV-crime drama: a ballistics expert tries to match two bullets using a microscope with a split-screen display. One bullet was recovered from the victim's body and the other was test-fired from a suspect's gun. If the striations on the bullets line up—cue the sound of a cell door slamming shut—the bad guy is headed to jail.

In the real world, identifying the firearm used in a crime is more complicated. However, the basic setup is correct. Ballistics examiners match bullets visually, and they've been doing it this way for almost 100 years. But testimony based on visual examination leaves out something important.

"When an expert testifies that two bullets are a match, the jury wants to know, 'How good a match is it?'" said Xiaoyu Alan Zheng, a mechanical engineer who conducts forensic science research at the National Institute of Standards and Technology (NIST). "No forensic results have zero uncertainty.

"Researchers are developing statistical methods for quantifying that uncertainty, and the main obstacle they face is a lack of sufficient data. This month NIST released the largest open-access* database of its kind—the NIST Ballistics Toolmark Research Database—to help remove that obstacle.

Led by Zheng, this database effort is partly in response to a 2009 report from the National Academy of Sciences, which highlighted the need for statistical methods to estimate uncertainty when matching ballistic and other types of forensic pattern evidence. The development of the database was largely funded with a grant from the National Institute of Justice.

Sources of Uncertainty

When matching a bullet to a gun, examiners look at striations that are carved into the bullet by rifling in the gun's barrel. If the cartridge case is left behind, they can also look at impressions left on it by the weapon's breech face and firing pin.

But these clues can sometimes be misleading. For instance, two gun barrels that are manufactured consecutively may produce bullets with very similar markings. That can lead to false matches. On the other hand, a gun might change over a short time due to wear on the parts or accumulation of debris in the barrel. If that happens, a single firearm might produce bullets that look like they were fired from different guns.

These confounding factors introduce uncertainty into examination results. Researchers would like to quantify this uncertainty using statistical methods, and to do that they need large databases of test-fired bullets and cartridge cases. The databases already in use for solving crimes, such as the National Integrated Ballistics Information Network (NIBIN), are proprietary and contain sensitive information. Researchers cannot download bulk data from them for use in statistical studies.

The NIST database, on the other hand, is open-access and the data is freely available.

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Standardized File Formats

To seed the database with data, Zheng went to forensics and law enforcement conferences asking agencies to test-fire every 9-mm firearm in their reference collection—9 mm being the caliber most commonly used in the commission of crimes.

After completing the test fires, labs sent the bullets and cartridge cases to Zheng at NIST, along with data on the gun that fired it. At the lab, technicians scanned these samples using a microscope that produces a high-resolution, 3-D topographic surface map—a virtual model of the physical object itself.

These surface maps produce more detailed comparison data than the two-dimensional images that are traditionally used to match bullets. For this reason, the field of forensic firearms identification is starting to make the transition to 3-D.

To facilitate the transition, NIST co-founded, with microscope manufacturer Cadre Forensics, the Open Forensic Metrology Consortium, or OpenFMC. This group, which includes members from industry, academia, and government, has agreed on a standard file format for 3-D topographic surface maps for use in ballistic imaging. NIST's new research database will use this open standard, which will allow researchers to easily share data, though the database will also accept traditional two-dimensional images.

The database currently has only about 1,600 test fires—a relatively small number. "But, it's like the first forensic DNA databases," Zheng said. "They started off small but filled up quickly."

Open-Source Methods

In the meantime, the data that is available is already proving useful. Eric Hare, a Ph.D. student in statistics at Iowa State University, is using the NIST research database to develop bullet-matching algorithms. His work is supported by CSAFE—the Center for Statistics and Applications in Forensic Evidence—which is funded by NIST.

Hare's algorithms are based on machine learning, which allows a computer to match patterns without being explicitly programmed how to do so. Hare "trains" his algorithms by feeding them pairs of bullets and telling the computer whether they match or not. The computer analyzes the physical features of those bullet pairs and develops a set of statistical rules for predicting whether or not a pair of bullets match.

"Once we've trained the algorithm, we give it data without telling it whether it's a match or a non-match, and we can see how well the algorithm performs," Hare said.

As the database grows in size the algorithms will become increasingly accurate. And as the database grows in variety to include different types of ammunition and weapons, the algorithms will become more broadly useful. The database already contains test fires from consecutively manufactured firearms, and Hare is testing whether the algorithms can reliably distinguish between them.

Perhaps most importantly, Hare's code is open source. That means other researchers can check for bias or error in the algorithms, and correct any that are found.

"In high-profile situations where there's a lot at stake, it would be good if everyone knew exactly what the algorithms were doing," Hare said.

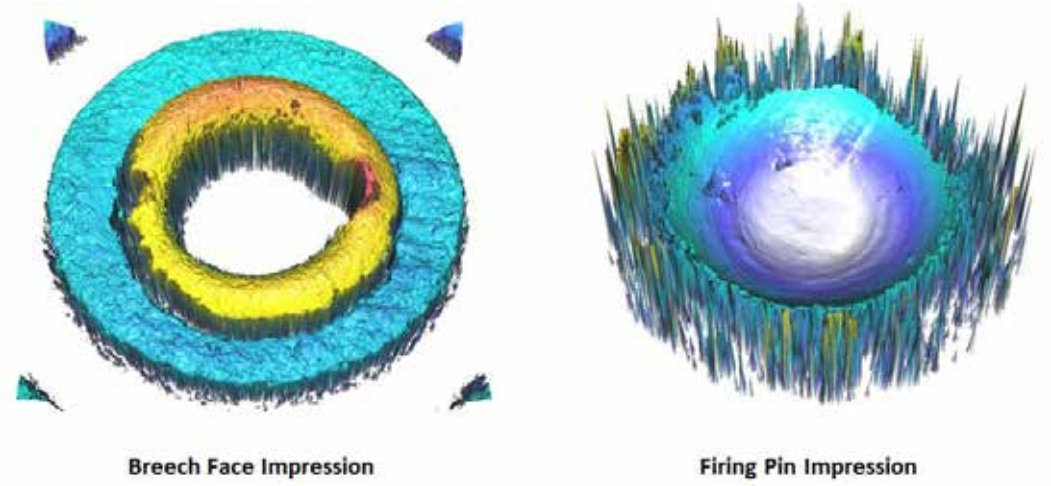
The FBI recently agreed to contribute a large dataset of test fires from its reference collection of several thousand firearms, which will greatly increase both the size of the database and the diversity of firearms it covers. Zheng hopes that other forensic labs with 3-D microscopes will start uploading their

data to the database as well. Because while the database is now available, the real work has just begun.

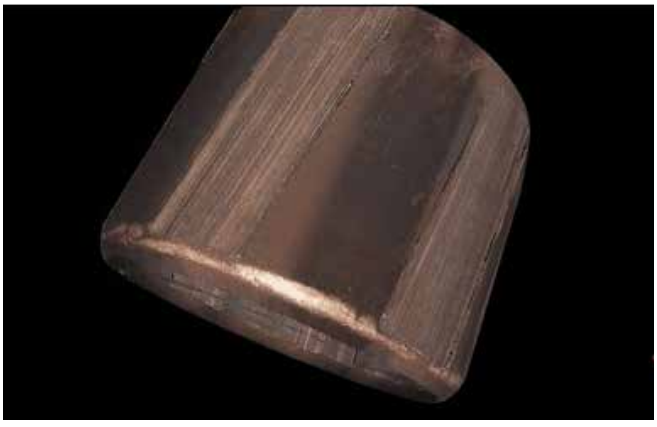
The National Institute of Standards and Technology (NIST) is an agency of the U.S. Department of Commerce.

http://www.nist.gov/pml/div683/nist-3d-ballistics-research-database-goes-live.cfm

Impressions
A fired bullet with rifling impressions from the barrel of a gun (above). A fired cartridge case and fired bullet (left, bullet and case). Experts can often identify the weapon used based on rifling impressions on the bullet, or breech face and firing pin impressions in the primer at the base of the cartridge case.
Credit: Robert M. Thompson/NIST



Firing pin impression
As with bullets, markings on cartridge cases can be used to identify the gun that fired it. This image shows 3-dimensional topographic surface maps of the breech face and firing pin impressions left in the primer at the base of the cartridge case.
Credit: NIST



3D Image
A 3D topographic surface map of the base of a fired 9 mm bullet. This visualization highlights the grooves imparted on the bullet by the barrel of the gun that fired it. These 3D surface maps produce more detailed comparison data than the two-dimensional images that are traditionally used to match bullets.
Credit: NIST

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

*Seán Ó Muircheartaigh**

Figure 1: *Griess developed thin layer plate*

Parts I[1], II of this paper detailed the circumstances of the arrest and convictions of the Maguire Seven. Other critical documents are the Court of Appeal final judgment[3] and the Guildford and Woolwich Inquiry Reports (1-3)[4] . The report of the scientific committee (under the chairmanship of Professor T. S. West) is also an important document. [Note: A video of the Griess TLC method, which is central to this paper, that produced evidence as presented to the court, is available on the website. [5]]

The format of this paper is:

1. Introduction and summary of the case against the Maguires.
2. Purpose of this paper.
3. The Crown's case in original trial 1974.
4. Forensic evidence in the Maguire case.
   (i) preliminary comments
   (ii) actual TLC results used to convict the Maguires.
   (iii) Court of Appeal (COA) documentation/judgment.
5. Transfer of nitroglycerine to hands/nails on kneading the explosive
6. Legal and scientific fundamentals.
7. Return to critical COA judgment statement
8. Chemistry of the Griess test.
9. Disappearance of nitroglycerine with time.
10. Reassessment of Professor Burn's kneading experiment as per COA
11. Conclusions.
12. Some comments on Griess TLC
13. Some final comments
14. References

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Part I of this series was reprinted in the CACNews, 4th Q 2016.

1. Introduction and summary of the case against the Maguires:

The Facts of the Maguire Trial

"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 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 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 the 23rd January 1980 Mr. Conlon died while serving his sentence."[1, 2]

2. Purpose of this Paper:

The primary objectives of this paper are to show that a proper interpretation of the evidence must lead to the conclusion that the Maguires were innocent of all charges proffered and to raise the question as to whether others may be wrongly convicted on the basis of such defective processes and procedures.

3. The Crown's Case in original trial 1974: [6]

"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 tests given 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 [substance X] which might mimic the results on the TLC….

… that NG could not have got there innocently ...that the presence under the nails of traces of NG was only consistent ... (could only have got there) ..by handling or kneading of explosive…."

…"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. "

In the original trial the jury found the Maguires guilty as charged.

4. Forensic evidence in the Maguire case:

(i) Preliminary comments

"The case really depended on the scientific evidence and as the judge told the jury they could not convict unless they accepted it [7]*…*

The evidence was to the effect that the pink spots had a similarity of colour across the plates…But as we have explained the test is not a quantitative one : similarity of colour to the standards means a quantity of approximately 200 to 1,000ng. ***After that*** *the spot becomes more diffuse and possibly will have a yellow centre."*[8]

(ii) Actual TLC results results used to convict the Maguire Seven [9]

	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	–	–	–	–	–	–	–

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.

Table 1. *(as photographed)*

Name	Ref.no.	Time swabs were taken	Left dry	Right dry	Left Ether	Right Ether	Left nails	Right nails	Paper
Conlon	LV/1	12am	–	+	+	+	+	+	+
Smyth	LV/2	12.25am	+	+	+	+	+	+	+
O'Neill	LV/3	12.45am	–	–	–	–	+	+	+
Mr Maguire	LV/4	1.10am	–	+	–	–	+	+	+
Vincent Maguire	KD/1	10.40pm	–	–	–	–	–	+	+
Patrick Maguire	KD/2	11.15pm	–	–	–	–	–	+	–
Mrs Maguire	KD/3	11.50pm	–	–	–	–	–	–	–
John Maguire	KD/4	1.00am	–	–	–	–	–	–	–

17

– 17 –

Table 1B. [10] *(as photographed)*

Table 1B shows the delay in taking samples from the Maguires. In all cases there appears to be at least four to five hours delay from the time they were arrested, to when swabs were taken.

(iii) Court of appeal documentation / judgment.:

"There were therefore two distinct factual issues at the trial: [7]

First Issue: *Was the substance on the male Appellants hands and Mrs. Maguire's gloves NG? If so could there be an innocent explanation for the presence of the NG? It is implicit in the Jury's verdict that they answered both issues against the Appellant.*

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

Discussions on First Issue by the Court:

"The key witness regarding this question in the Court of Appeal was Professor Thorburn Burns (an expert appointed by the Court). "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…"*** [11]

"…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 (defence expert and former retired head of laboratory at RARDE) with a view to determining if any other substance 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:

'Any compound having a false positive reaction ["Compound X"] must have the following characteristics: persist on hands, be ether extractable, chromatograph with an Rf 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)." [12]

Discussion of Second Issue:

Six grounds of appeal were considered but only the fourth one was considered to have any validity (See judgment)

"The convictions of all the defendants were unsafe and unsatisfactory because fresh evidence has emerged as a result of the May Inquiry shows (inter alia): …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:

'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."

5. Transfer of nitroglycerine to hands/nails on kneading the explosive:

Professor Burns carried out an experiment in which volunteers kneaded nitroglycerine and found the following masses (weights) of nitroglycerine (in ng) on the hands and under the nails of the volunteers [Table 2]. HPLC, a modern method of analysis not available in 1974 was used for the analysis.[13]

	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*

Table 2.

"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."*[14] These values are all in nanograms.

6. Legal and scientific fundamentals

Forensic evidence involves the disciplines of science and law. This paper examines crucial rules that apply to the admissibility of evidence from the viewpoint of these two disciplines, and then proceeds to assess the merit of the Maguire Seven forensic evidence.

Evidential Burden:

"Only evidence which passes an evidential burden is admissible as evidence. The evidential burden[15] *is the obligation to show, if called upon to do so, that there is sufficient evidence to raise an existence or nonexistence of a fact in issue, due regard being had to the standard of proof demanded of the party under such obligation."*[15]

In the context of forensic evidence in a criminal trial, this means that analysis results should be inadmissible unless the test procedures can be shown validly to measure the species being examined; that competent qualified staff carry out the tests; that proper sampling and handling procedures have been used, that proper calibration has been carried out and a rigid system of documentation has been adopted. The procedures for testing and accreditation have been formalized in recent years (1989), but the basic principles have been standard practice within the chemistry profession for decades. The objective of the evidential burden is to prevent accused from being tainted by association with unproven / untrue incriminating evidence. [The Birmingham Six case is the classic example of this possibility of taint by association with multiple (false) test procedures.][16]

(i) Validation of forensic results:

Starting off with the chemistry requirements, four critical parameters (from a long list) need to be investigated. These were (i) identification, (ii) accuracy, (iii) precision and (iv) range. Supplementary (but also critical) issues such as (v) chain of custody, (vi) procedural documentation and (vii) operator registration also needed to be considered.

Identification: It is established (and accepted by the authors) that nitroglycerine is converted to nitrite by alkaline hydrolysis before the Griess reagent is added. This "fact", however, would need to be confirmed for a proper validation to be effected.

Accuracy: How close the value obtained is to the true value. Specification of the standard purity is crucial.

Precision: This refers to the reproducibility of the result and is usually expressed as confidence levels or standard deviation.

Range: It was—and is—essential common good laboratory practice to establish the operational range of a test procedure, so to confirm that test results are reliable within specified concentration limits.

(ii) How would the RARDE TLC test relate to these expected operating standards?

Identification: The original trial and subsequent court cases and inquiries spent considerable time discussing how the tests were carried out and also the issue as to whether the pink spots were nitroglycerine or not. The defence scientists spent a lot of time suggesting the spots may have come from some other substance, sometimes referred to as substance "X". In the totality of the circumstances where the calibration, sampling and processing of the samples was grossly defective, this issue was irrelevant.

Accuracy: There is no mention in the court reports of the standards used or of the details of the purity of the reagents. Moreover, it is a fact that the Griess reagent goes off on standing, and actually can become coloured without the addition of a test sample. This was not mentioned either.

Precision: The simple TLC test does not lend itself to precision. Visual observation of colour is non quantitative. The simple TLC test was not and cannot be modified to give a satisfactory forensic analytical method for forensic purposes.

Range: The Court indicated that the TLC test gave a pink colour from about 200 to 1000 nanogram of nitroglycerine, and then became "more diffuse, and possibly had a yellow centre." There is no discussion of the range or the significance of the colour disappearing at higher concentrations. It is obvious to trained analysts that an acceptable validation process has not been carried out.

Moreover, no proper documentation was produced, and the laboratory notebooks and documentation were not made available to the defence, an issue criticized by the Guildford and Woolwich Inquiry.

7. Return to critical CAO judgment statement:

"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.***" [17, 18]

This is a crucial statement. To the scientific mind it rings an alarm. The principle behind a colourimetric test such as that for nitrite is that the analyte species reacts with one or more reagents (which are colourless and in excess) to form a specific colour. The more nitrite present the more intense the colour. The presence of the colour is caused by the formation of a dye. This is shown clearly in TLC plate Figure 1 at top of paper and in Figure 3 below.

The subsequent disappearance of the colour (Figure 3/3A) is extremely unusual in a test of this kind. It means that for some reason the dye is either destroyed or masked.

To investigate this further Griess TLC's were carried out on a range of nitrite concentrations, and indeed the test only worked over a very narrow concentration range. To get a better understanding of this phenomenon it is necessary to investigate the source of the colour in the Griess test and the mechanism of the reaction.

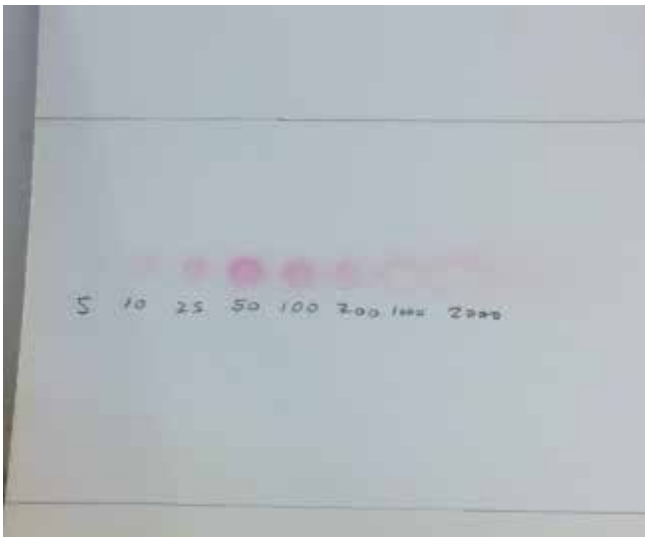


Figure 3.

Figure 3A. *(expanded view)*

8. The Chemistry of the Griess Test:

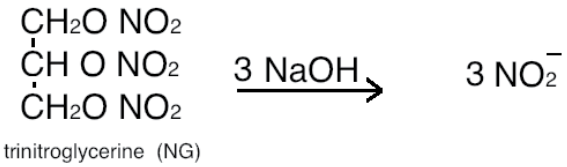
What follows is an examination of the salient points of the Griess test including experimental results obtained by the author for an explanation of the colour disappearance and the confused information which arises as a result.

The Griess Test

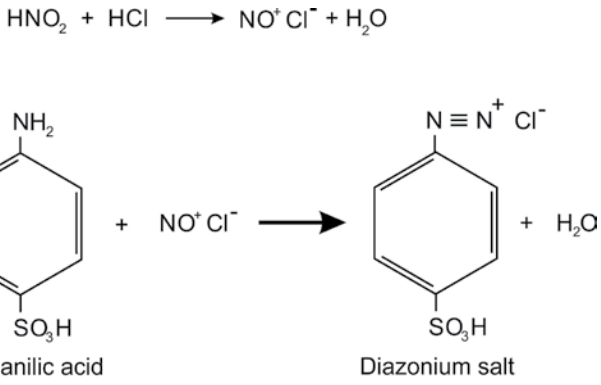
Investigation into the Griess test for nitrite [1974 reagents]—(Detection system for NG in thin layer chromatography.)

Reagents: 0.1% sulphanilic acid in 30% acetic acid and 0.1% naphthylamine in 30% acetic acid. A comprehensive description of the nitroglycerine TLC Griess test is given in Part 1. The chemical mechanism is outlined in Figure 4.

Step one: Breakdown of nitroglycerine to nitrite.



Step two: Reaction of nitrite (NO_2^-) with sulphanilic acid to form diazonium salt.



Step three: Reaction of diazonium salt ion with 1-naphthalamine to form azo dye.

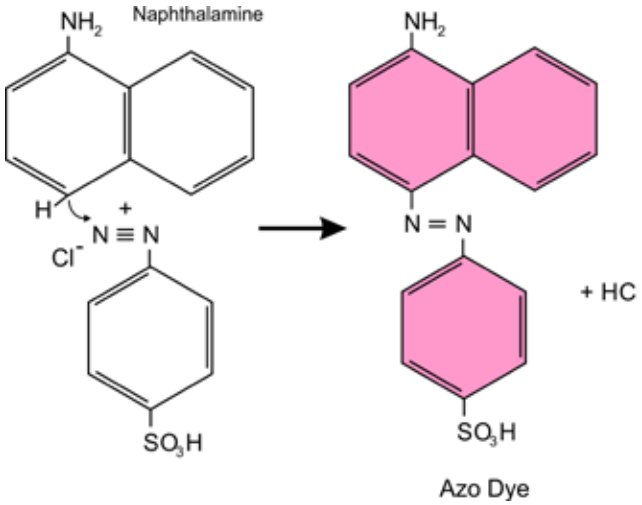


Figure 4. *Mechanism for pink color formation in TLC Greiss test for nitroglycerine*

The practical consequences of this colour disappearance merit further scrutiny. TLC is not a technique of choice for this type of investigation because of the impossibility of precision. A superior method of assessing the Griess test is the use of volumetric solutions, which can be readily quantified. It might be noted that the operational range for Griess TLC is about 0 to 2000 ng of NG and that for volumetric solutions is 0 to 100 ppm nitrite approximately.

In the 0 to 1 ppm (nitrite) range a proportional increase in colour was obtained by the author as shown:

Figure 5.

However, when 0 to 1000 ppm is used, the colour increases at first and then disappears! In other words the colour seen (or not seen) is not a measure of the amount of nitroglycerine on someone's hands **:**

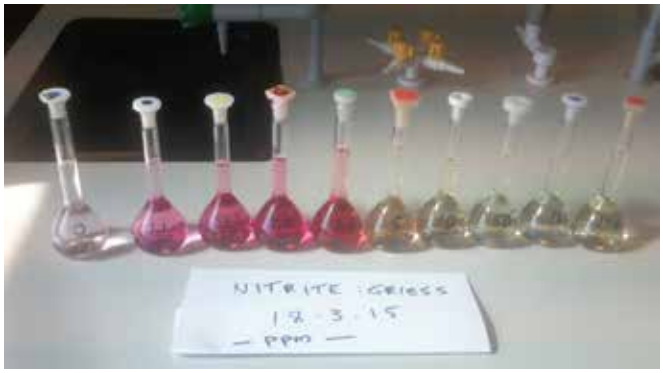


Figure 6.

Clearly this is an unexpected result. However, there is a likely cause. The azo dye thus formed still has a free aromatic amine (NH_2) group. It is suggested that at higher nitrite concentrations this group is diazotized attracting some of the electronic - cloud from the molecule and thus destroying the colour (figure 7):

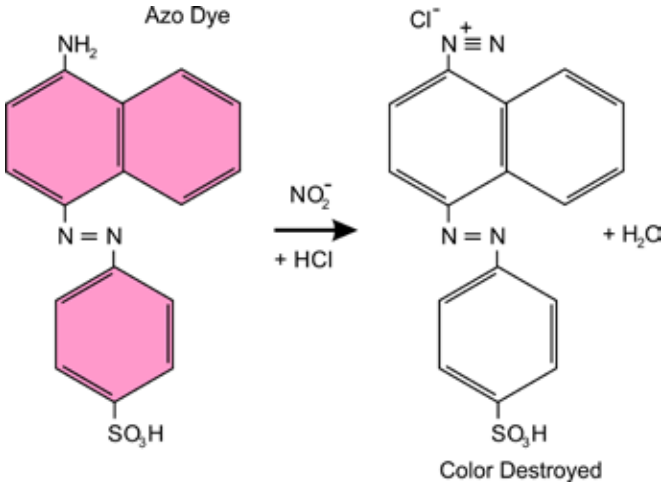


Figure 7.

The corresponding TLC plate (Figure 3 above) shows that if one is to get spots of similar pink colour intensity, it is necessary that the nitrite or nitroglycerine levels need to be very similar—within about a 1x to 3x ratio at the most. A further consequence of these observations is that a person with a very high level of nitroglycerine contamination would be found to give a negative TLC result. ***It is quite clear from this that the TLC test is not suitable even as a screening test as it cannot distinguish between persons who have zero and very high explosive contamination!*** Had a more thorough validation exercise been carried out, this fact would have been noticed by the defence or expert witnesses, and the Maguires would never have been charged let alone convicted.

The following statements from the Guildford and Woolwich Inquiry interim report are also interesting. (Mr. Higgs was the Head of the explosives laboratory at RARDE).

"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 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 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."* [19]

9. Disappearance of nitroglycerine with time.

The author was able to carry out this approximation using values from report of the scientific committee of the Guildford and Woolwich Inquiry. The results tie in nicely with various statements from court and Inquiry documents. This gives an indication of how rapidly nitroglycerine disappears. The phrase 'They do not allow for the effects of delay' in the court of appeal's description of Professor Burn's experimentation above (Table 2) is an understatement of considerable importance. It is hard to construct a credible scenario in which one could ignore the effect of time in the case of a species which is well known to be highly volatile. In fact, this author was able to derive an approximate curve for the disappearance of NG based on values in the West report[20], and then estimate the NG remaining after certain periods of time.

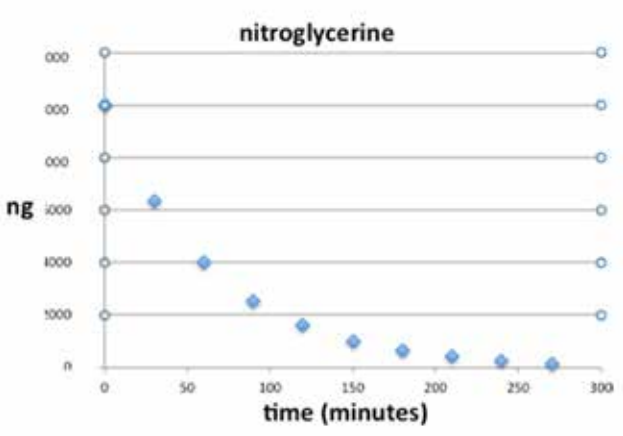


Figure 2. *Nanogram nitroglycerine with time.*

10. Reassessment of kneading experiment as per COA judgment

0 minutes		RIGHT HAND	NAILS	LEFT HAND
	C	24,900	717	17,300
	D	13,900	68	5,500
	E	5,500	388	4399
	F	6,200	93	11,200

60 minutes		RIGHT HAND	NAILS	LEFT HAND
	C	10,005	288	6,951
	D	5,585	< 200	2,210
	E	2,210	< 200	1,767
	F	2,491	< 200	4,500

90 minutes		RIGHT HAND	NAILS	LEFT HAND
	C	6,340	<200	4,406
	D	3,540	< 200	2,201
	E	2,210	< 200	1,102
	F	2,241	< 200	2,852

0 minutes		RIGHT HAND	NAILS	LEFT HAND
	C	24,900	**717**	17,300
	D	13,900	68	5,500
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90 minutes		RIGHT HAND	NAILS	LEFT HAND
	C	6,340	<200	4,406
	D	3,540	< 200	2,201
	E	2,210	< 200	1,102
	F	2,241	< 200	2,852

Table 3. *Estimated values from Table 2 estimated using formula from decay curve in Fig 2.*

Bearing in mind that <200 ng and more than 1000ng of nitroglycerine gives zero colour, only two values are pink immediately; one after 60 minutes and none after 90 minutes. Moreover, far higher concentrations on the hands would be shown up as negative. **The results do not support the suggestion in the COA judgment that there is a distinct possibility that the Maguires had been contaminated by a towel as suggested below in the COA judgment**. Scrutiny of the scientific committee (West report) of the Guildford and Woolwich Inquiry similarly can be interpreted to undermine the suggestion. Furthermore it seems to the author that it was misleading to suggest values determined by HPLC indicated positive nitroglycerine, when the colourimetric Griess procedure used by prosecution scientists would have given negative readings. **Some major research was carried out by the scientific[20] committee set up by the Guildford and Woolwich Inquiry under the chairmanship of Professor T. S. West.**

Their scientific report showed that in every single volunteer there was no nitroglycerine detected on paper swabs after three hours. Moreover, the vast bulk of samples gave NG values which would have been negative using the TLC analytical procedure, and the concentration on the hands was far greater than under the nails. This is the opposite of the five of the Maguires (Table 1 above).

The evidence in the Maguire case was that some twenty three samples analysed from the Maguires were positive as per Griess TLC test (Table 1, above). That means they were all in the narrow 200 to 1000 ng of nitroglycerine range. Ten of these were from under the nails of the six men convicted. This evidence is completely contrary to the evidence produced in Court. The latter found a vast spread of values in all its experiments, with substantially more nitroglycerine on the hands as compared to the nails in most cases. After three hours only a minority of samples had nitroglycerine detectable by the Griess TLC test.

11. Conclusions

1. Nitroglycerine (NG) was not found on the Maguires because there was no evidence that the samples were taken and processed correctly. The description of NG being found on the Maguires is scientifically and legally incorrect.
2. There was no close causal connection between the gloves and Mrs. Maguire. Even if NG had been on the gloves, (which of course it was not) there is no evidence of its source.
3. The TLC Griess test was not validated and was therefore legally and scientifically inadmissible. Using this as evidence was in breach of the best evidence rule.
4. Because of no proper documentation, the chain of custody was inadequate and the result was there was no close causal connection between the samples tested and the Maguires.
5. There is no scientific or legal basis for the suggestion that there was contamination on a towel (which was never produced—contaminated or otherwise), and therefore the inference that an unknown person (presumably an associate of the Maguires) caused this is not sustainable. The towel evidence was hearsay and inadmissible.
6. The evidence in this case, when properly investigated, shows the Maguires were not contaminated by nitroglycerine.
7. ***"The evidence does not enable us to conclude who the person or persons were who so contaminated the towel or the gloves."***[3] **It is this conclusion of the COA that there was proof of nitroglycerine contamination in the Maguire household and the implication that it may have been due to**

one of the Maguires or their associates is unfounded and totally unacceptable.

12. Some comments on Griess TLC

(2017): Comment from US forensic science chemistry expert with 40+ years experience:

I believe that the TLC test was/is a valid test providing very strong evidence of nitroglycerine on the hands and gloves of the Maguire 7. The strongest evidence that the Maguire 7 were innocent lies in the fact that no bulk explosives or bombs were found in the Maguire house.

(1974): Statement of Facts as submitted for original trial:

The expert evidence will be that the method of testing employed in this case—involving the use of dry and ether swabs and the examination by means of thin layer chromatography of material distilled from those swabs and from the dislodged debris—is scientifically well established, is used all over the world, and has been published and has not been the subject of any known scientific criticism.

13. Some final comments:

Was there contamination (as indeed suggested by the defence forensic scientists)? If so it is most likely it took place in the laboratory because of the closeness of all the TLC values. Given (i) the high volatility of nitroglycerine, (ii) the very short operational range of the TLC Griess test, (iii) the positive values under the nails, on paper and on the hands and on the gloves of the accused—all collected at random intervals of time after possible contamination with the explosive—**there seems to be no doubt, but that the evidence against the Maguires spectacularly failed the evidential barrier and was inadmissible in chemistry and law.**

The author acknowledges with thanks the many discussions he had with Eoin O'Neill, over many years, on the issues raised in the course of the author's research on this paper.

Much of the background information for this paper is to be found in Paper 1 (references 1 and 2 online)

14. References:

1 *Irish Chemical News,* 4th Issue, 2016: www.chemistryireland.org

2 *CACNews* 4th quarter 2016: www.cacnews.org/news/4thq16.pdf

3 COA - draft judgment R v Maguire and others. (It is emphasized that this report was specified as unrevised); http://netk.net.au/UK/MaguireFull.asp

4 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

5 http://www.bbc.co.uk/programmes/p00hvb6q

6 COA draft judgment *R v Maguire* and others Part 1; P22. (unrevised).

7 COA judgment unrevised, Part 1, P23

8 COA Part 2, P3, unrevised.

9 Interim Report on the *Maguire* case, Rt Hon John May, 12 July 1990: Section 7.1 [https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/228724/0556.pdf]

10 COA, unrevised Part 2; P17.

11 Court of Appeal, unrevised, Part 1; P30

12 Court of Appeal, Part 2 P 32.

13 Court of Appeal, unrevised judgment, Part 3, P6.

14 In attempting to give people an appreciation of the confidence one could have in the statement *"It is clear however that substantial quantities can be transferred to the hand of those subjects from the towel", referring to 24,900 ng, if one million people were each carrying this amount the total amount being carried would be 24.9 gram.*

15 Cross on evidence, Butterworths sixth edition, 1985 page 107.

16 *R v Callaghan, et al*, S. O'Muircheartaigh, April 1990 (Birmingham Six case submission) which contributed to the release of the Six

17 Court of Appeal unrevised, Part 2; P3

18 **[Note 1: 'After that**' may be taken to mean that if a higher concentration of nitroglycerine is present, the colour intensity decreases and as the concentration increases the pink colour eventually disappears. Note: A suspect with a more significant amount of nitroglycerine on his hands may be shown by the test as having clean hands—very strange!

19 Interim report May Section 7.4, page 23.

20 Guildford and Woolwich scientific committee report (West Committee, August 1992)

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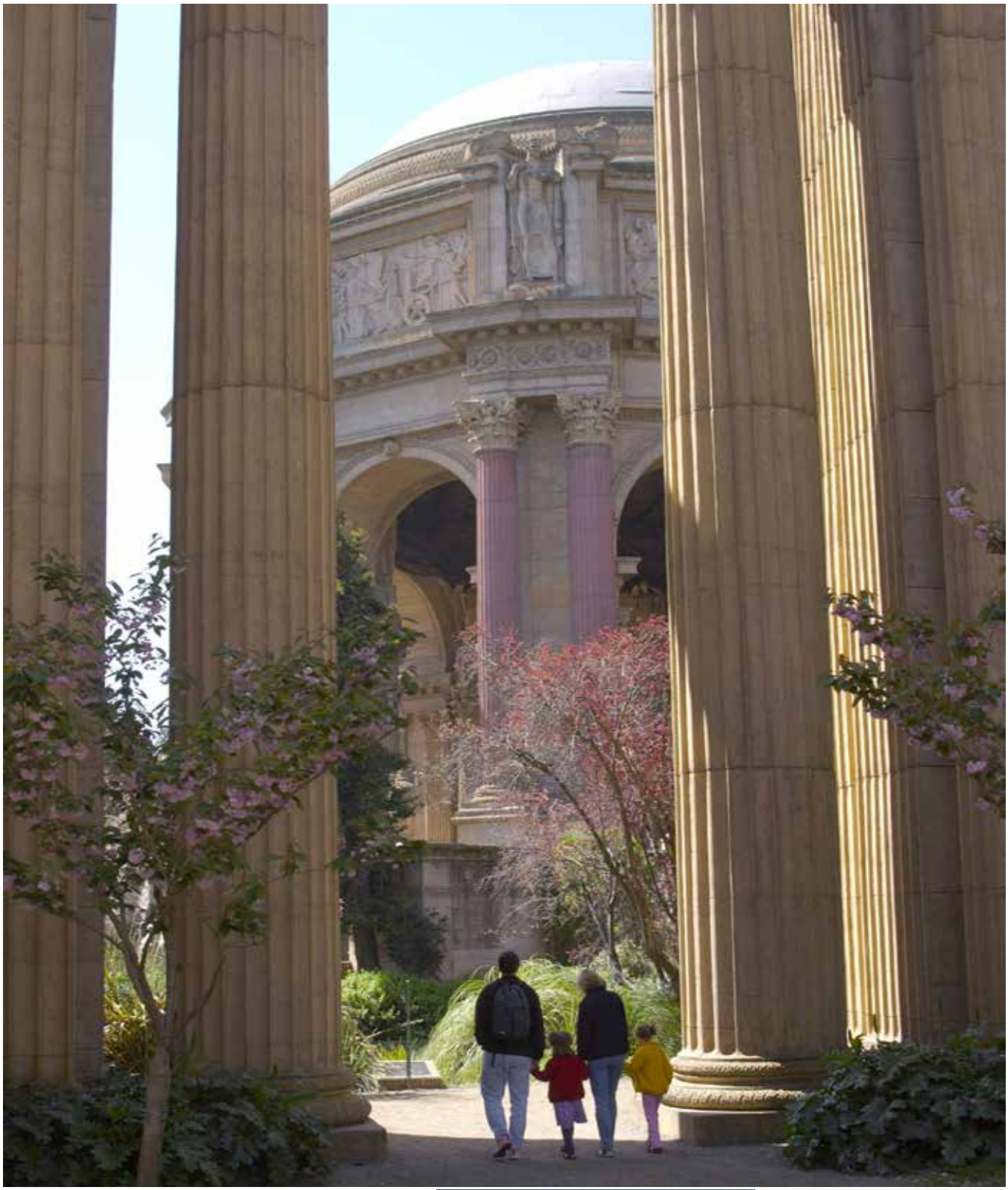

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