

# the Analytical Scientist

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# Online this Month



## *The Power List 2015 –Online*

You can find The Power List 2015 on page 31; however, space limitations have prevented us from sharing everything our Power Listers had to say.

Online, you can find The Power List in all its full glory, with responses that range from most important life lessons to encounters with serendipity and views on the future of groups, niche areas or even analytical science as a whole.

Is one of your analytical heroes on The Power List – check online to read more.

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## *Tea With Rich*

What's better than a nice cup of tea and a chat? "Tea With Rich" – an ongoing series of informal interviews with key analytical scientists in glorious settings around the globe – makes a comeback from HPLC 2015 in Geneva with six scientists that feature on The Power List.

First up is Gérard Hopfgartner, who reflects on the responsibilities of chairing the ever-successful HPLC

conference. Gérard then discusses his current research: multidimensional chromatography and its utility in finding answers to global and complex problems, before considering HPLC 2025...

We're also treated to more "drone" footage and left wondering what Rich Whitworth has been doing, as the final shot captures his departure...

Watch the video now:  
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## *It's time for the TASIAs!*

Do you have a piece of transformative technology or a brand new instrument that significantly raises the bar? Our December issue will showcase the greatest analytical innovations of 2015.

To nominate, email  
[rich.whitworth@texerepublishing.com](mailto:rich.whitworth@texerepublishing.com) with:

- i. Name of innovation
- ii. Brief description (~10 words)
- iii. Detailed description (50-150 words)
- iv. The potential impact of the innovation (50-100 words)
- v. One image (if applicable)

Nominations close November 10



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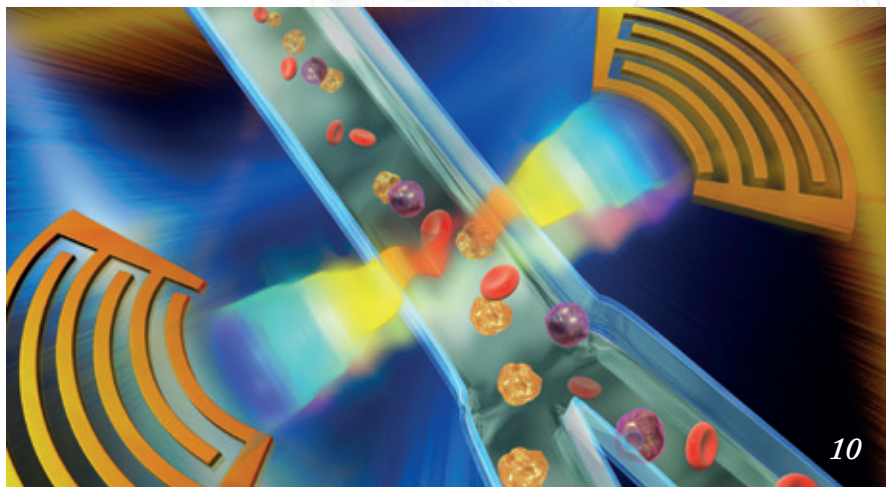
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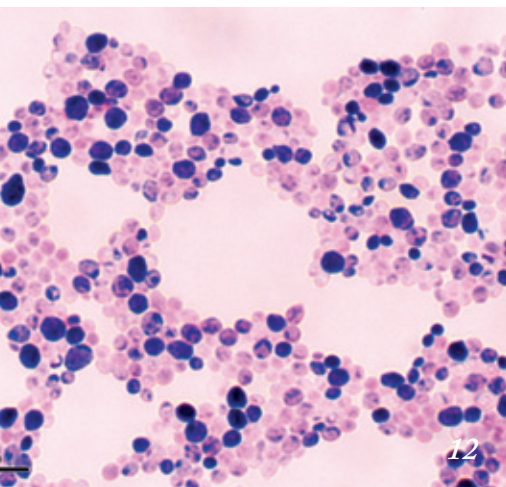
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by Rich Whitworth

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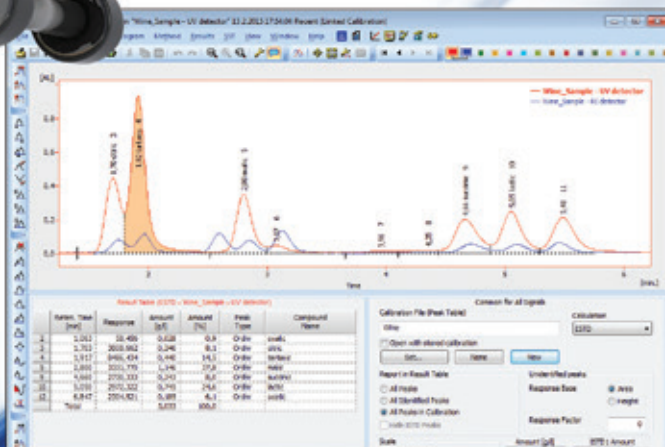
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1	1/1/2011	1	1-A-1000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	✓	✓	✓
2	1/1/2011	2	1-A-1000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	✓	✓	✓
3	1/1/2011	3	1-A-1000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	✓	✓	✓
4	1/1/2011	4	1-A-1000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	✓	✓	✓
5	1/1/2011	5	1-A-1000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	✓	✓	✓
6	1/1/2011	6	1-A-1000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	✓	✓	✓
7	1/1/2011	7	1-A-1000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	✓	✓	✓
8	1/1/2011	8	1-A-1000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	✓	✓	✓
9	1/1/2011	9	1-A-1000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	✓	✓	✓
10	1/1/2011	10	1-A-1000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	✓	✓	✓





the Analytical Scientist

Power List

2015

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Welcome to what is perhaps the most anticipated issue of the year – if not for The Power List itself, then to find out how we could possibly live up to our 2013 Sgt. Pepper’s Lonely Hearts Club Band cover... We hope you will agree that our pastiche of Klaus Voormann’s artwork for The Beatles’ 1966 album “Revolver” hits the right note – and emphasizes that The Power List should be about having fun first and foremost.

As I indicate with the opening lyrics of Revolver’s final track – Tomorrow Never Knows – I hope that the majority of you are able to “turn off your (analytical) minds” and view The Power List as a source of entertainment (or inspiration) rather than a reason to become upset (or angry). As with our 2013 Power List, we do not pretend that our ranking is definitive or absolute. Rather, we want it to be a celebration of the analytical sciences, promoting the importance of the whole field to the wide world in a bid to raise the profile of the excellent and valuable work you do.

Of course, many important and influential scientists are not present on the list. Why are they missing? Primarily, because you didn’t nominate them (or they didn’t nominate themselves). You see, The Power List represents more than just the influential people within. It stands as a testament to a wider community of analytical scientists that wants to get involved and join in with our cries for recognition. The Analytical Scientist itself is inclusive (not exclusive). And the reason we have an open nomination process for The Power List is so that everyone and every niche area is given the opportunity. In other words, we want it to be your list, not ours.

Once the nominations are in, our judges have the final daunting task of selecting their Top 100. Yes, this process is subjective – but the averaged views of five experts of the field limits any unwitting (or otherwise) bias.

The result? A list of 100 names that truly showcases the diversity – and this year, particularly – the personality of the people that make up the critical field of measurement science. Indeed, in 2015 our Power Listers explore topics such as serendipity and share some of their funniest or most unexpected moments (see page 31).

Who will be on the 2016 or 2017 Power Lists? In the immortal (and incomprehensible) words of Ringo Starr: “Tomorrow Never Knows.”

*To do list:*

1. *Enjoy The Power List while listening to “Tomorrow Never Knows” by The Beatles (followed by the rest of Revolver).*

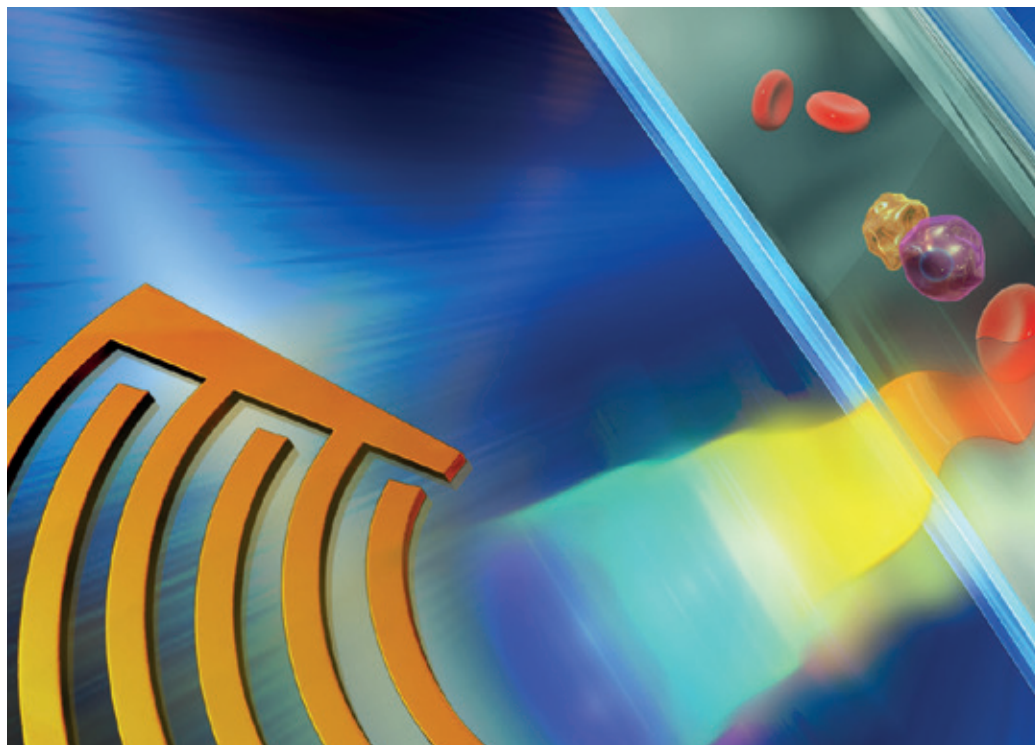
**Rich Whitworth**  
*Editor*

# Upfront

*Reporting on research, personalities, policies and partnerships that are shaping analytical science.*

*We welcome information on interesting collaborations or research that has really caught your eye, in a good or bad way. Email:*

*rich.whitworth@texerepublishing.com*



## Fast Cell Sorting – on a Chip

**A dime-sized microfluidic device harnesses acoustic waves to efficiently sort cells**

Flow-cytometry based cell sorters aid in both medical diagnosis and biological studies, but commercial systems tend to be expensive (both to purchase and maintain), large, and complex. Moreover, according to Tony Jun Huang, associate professor of engineering science and mechanics, Pennsylvania State University, USA, they have been reported to significantly reduce cell viability, especially when sorting fragile or sensitive cells such as neurons, stem cells, and sperm cells.

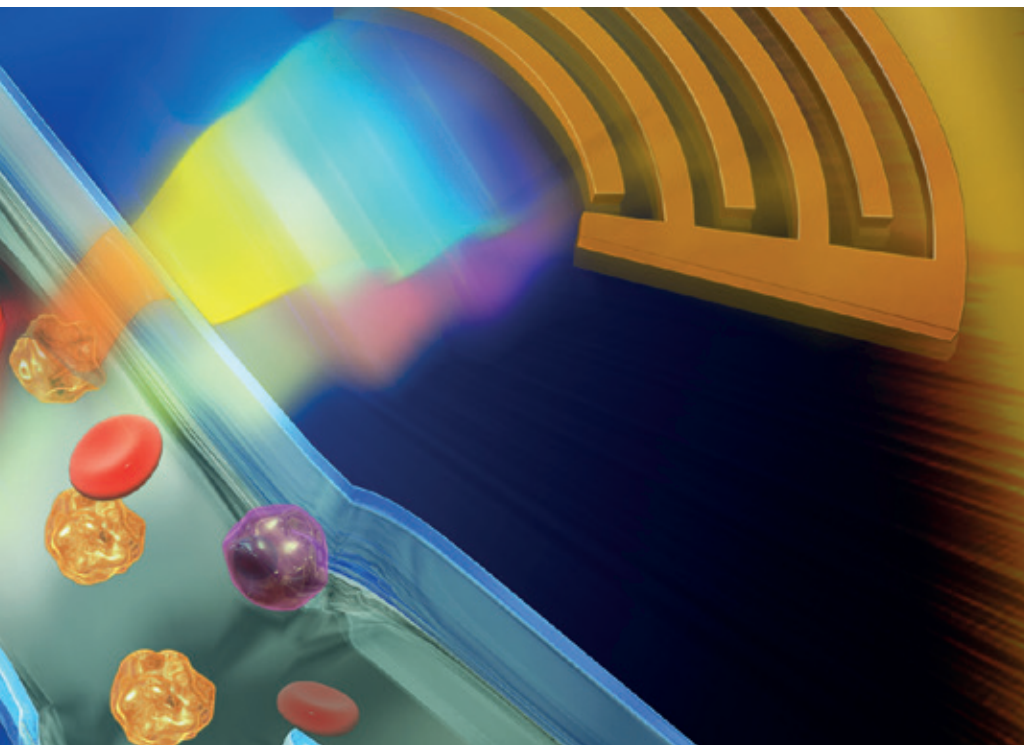
And although lab-on-a-chip devices typically struggle to keep up with their

benchtop or floor-standing counterparts, one such device now rivals fluorescence cell sorters with its efficiency. The device, developed by a team of researchers led by Huang uses acoustic waves to rapidly sort a continuous flow of cells on a dime-sized chip (1).

“In recent years, microfluidics has emerged as a promising platform for developing low cost, portable and disposal equipment, says Huang. “Meanwhile, the biosafety of acoustic waves has been proved in many applications such as ultrasonic imaging. Thus, an acoustofluidic – the fusion of acoustics and microfluidics – cell sorter has great potential to overcome the drawbacks of fluorescence cell sorters.”

How does it work? According to Huang, the acoustic wave cell-sorting chip uses two focused interdigital transducers (FIDTs) to generate two surface acoustic waves (SAWs) propagating in opposite directions. The two SAWs interfere





with each other, forming a standing SAW (SSAW) as well as pressure nodes and antinodes. “The cells/particles in the SSAW area experience an acoustic radiation force and are sorted to the nearest pressure node,” says Huang. Like a lens focuses light, the team used circular-shaped electrodes to focus the acoustic waves. “We were so excited to figure out that the performance of the FIDTs is highly dependent on the angle of the circular-shaped electrodes. The 20° arc had the best focusing performance and could achieve a focal beam with a similar size to that of the acoustic wavelength – this was the most critical step of the project,” adds Huang.

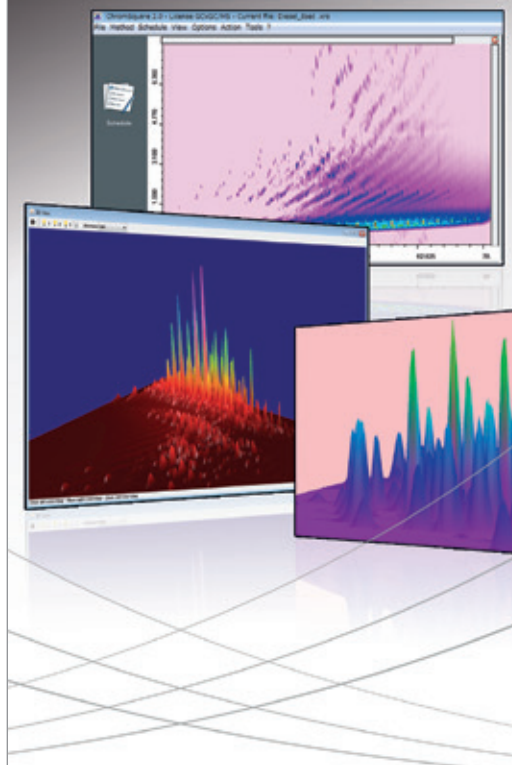
Many acoustic cell sorters have been developed in the past, but none have rivaled the efficiency of commercial instrumentation (103-104 events per second). Huang has already demonstrated error-free sorting at a throughput of 3300 events/s, but says, “Our device has

a theoretical maximum throughput of 13,800 sorting events/s, comparable to commercial cell sorters”.

One limitation of the prototype is that it can only sort cells into two channels, compared with commercial cell sorters, which are capable of multi-channel sorting. In previous work, Huang has demonstrated multi-channel sorting using frequency-tunable IDTs and believes that this could be applied in this case too: “We plan to integrate the sorting unit with a laser-induced fluorescence detection system to develop a high-performance fully functional fluorescence-activated acoustofluidic cell sorter. We will also apply this system in the sorting of fragile cells, such as stem cells and sperm cells, to prove the biosafety,” adds Huang. *VB*

#### Reference

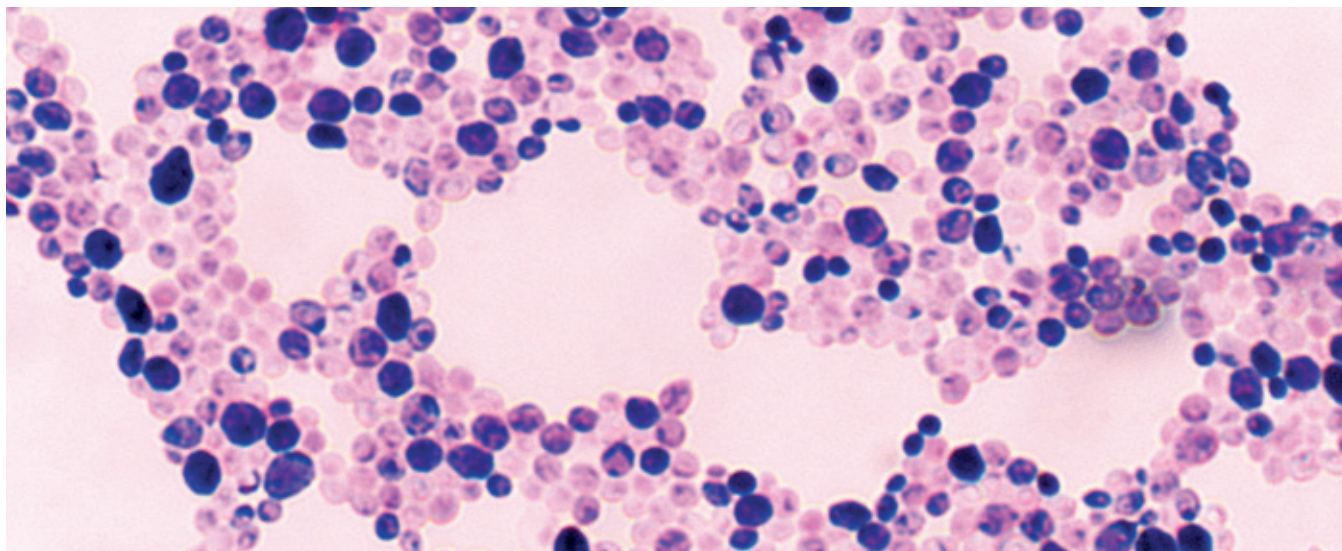
1. *L. Ren et al., “A high-throughput acoustic cell sorter”, Lab Chip, 15, 3870–3879 (2015). DOI: 10.1039/C5LC00706B.*



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## Pathogen Identity Parade

**Two-dimensional photonic crystals combined with spectroscopy shines a light on microbial culprits**

The best way to treat an antibacterial infection is to target the root cause. So why don't we do it more often? "Detecting bacteria is a fairly lengthy process, so physicians tend to give patients a broad-spectrum antibiotic that wipes out all the bacteria as soon as possible instead of waiting to see which pathogen is actually causing the problem," explains Xinyu Liu, assistant professor at the University of Pittsburgh, PA, USA. Liu, Sanford Asher, and their respective research groups, decided to develop a new method to identify pathogens by combining 2D photonic crystals with spectroscopy (1).

Liu decided to target carbohydrate structures found on the cell surfaces of microbial organisms: "We envisioned that if we could come up with a way to rapidly sense these microbial carbohydrate

structures in a user-friendly manner, we could have a broadly applicable sensor for microbial pathogens," says Liu.

The sensor relies on a selective protein hydrogel coated with spatially-defined 2D photonic crystals (PC) – the latter being an area in which the Asher group has significant expertise. In the proof-of-concept paper, the hydrogel was embedded with Concanavalin A (ConA), a lectin protein that multivalently and selectively binds to poly-mannose (mannan) – a carbohydrate structure that is found on the cell surface of *Candida albicans* (the fungus responsible for oral thrush). Liu says, "While there are many ways to make a protein-engineered hydrogel, we simply used the protein as the polymeric backbone and cross-linked it to glutaraldehyde. This worked out fantastically well (to my surprise at least)! The cross-linked Con A protein retains its secondary structure and was still able to recognize mannan efficiently."

When *C. albicans* is present, Con A binds to mannan to form crosslinks that shrink the protein hydrogel, which reduces 2D PC particle spacing, causing a blue-shift in diffracted light. The diffraction shifts can be

visually monitored, measured with a spectrometer, or determined from the Debye diffraction ring diameter, and offer sensitivity of about 40 CFU/mL for *C. albicans* in aqueous solution.

Although the platform is sensitive, a key limitation is the lack of true selectivity – the sensor detects any microbial organism with mannan on its cell surface. To that end, the team is working towards achieving absolute selectivity – by integrating antibodies, for example, with a focus on *E. coli* O157 for food poisoning, and MRSA – a persistent scourge of hospitals.

Moreover, they are also working on increased response time, portability and reusability. Liu and Asher certainly have big plans for the future of their next-generation sensor: "If we can reduce the cost of its manufacture, it can be distributed to those in resource-poor countries, where the sanitation of water and food is problematic," adds Liu. *VB*

### Reference

1. S.A. Asher et al., *A photonic crystal protein hydrogel sensor for Candida albicans*, *Angew. Chem. Int. Ed.* (2015). DOI: 10.1002/anie.201506205



## A Nose for Quality

**Sniffing out 'off smells' in drinking water with a bioelectronic sensor**

It's clear that researchers Seunghun Hong, Hwi Jin Ko, and Tai Hyun Park, and the team at Seoul National University, South Korea, all have a nose for sensing; they have already developed several human nose-like biosensors for different applications, such as disease diagnosis and food quality assessment. Park explains why drinking water was next on the agenda: "Recently, a severe green algal bloom has wreaked havoc on the water supply in Korea. So we started to develop a bioelectronic nose for monitoring the quality of drinking water."

Even the purest of water contains compounds that contribute to its smell or flavor – and the human nose is extremely sensitive to two small, odorous molecules that often slip through the water treatment process. "The bioelectronic sensor was able to selectively detect geosmin and 2-methylisoborneol in drinking water down to 10 ppt," says Park. "Although these compounds are completely safe at this concentration, the result is an earthy, musty-smelling water, which is off-putting to drink – so the challenge was to find the human olfactory receptors that bind specifically to geosmin and 2-methylisoborneol," Park added.

Current methods, such as GC-MS, are labor-intensive and time-consuming, but the bioelectronic nose can analyze water samples in real-time. "This makes the sensor suitable to real applications through integration into a portable device that we are currently developing," says Park.

Hong, Ko, Park and the team of researchers first screened a number of human olfactory receptors to find

out which ones bind the odor-causing molecules. Once identified, a single-walled carbon nanotube field-effect transistor was functionalized with olfactory nanovesicles. The human olfactory receptors afford the bioelectronic nose higher selectivity compared with any other sensing material, which allows it to detect odor molecules in various water samples without any pre-treatment process.

But the approach is not without its limitations, as Park explains: "Unfortunately, because nanovesicles are biological materials, they do have a shelf-life – we are currently developing more stable and reusable alternatives to

nanovesicles, such as olfactory receptor proteins, nanodiscs containing olfactory receptor proteins and peptides, and so on."

The researchers also have plans to take their nose into the digital world: "Our next step is to integrate the bioelectronic nose with a smartphone application by applying multi-channel sensing and wireless transport technologies," adds Park. *VB*

### Reference

1. M Son et al., "Real-time monitoring of geosmin and 2-methylisoborneol, representative odor compounds in water pollution using bioelectronic nose with human-like performance", *Biosensors and Bioelectronics*, 74, 199–206 (2015).

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## The Emotive List?

**The 2015 Power List will likely thrill, disappoint and annoy in (possibly) equal measures – but what does it mean to the people on it? In short: don't take it too seriously...**

“The Power List is great fun – and I like to think that it doesn't really matter that much! But I also know that I will probably be mildly disappointed when I eventually – and inevitably – fall off it when I am displaced by much abler analytical scientists. With apologies to Oscar Wilde: “There is only one thing worse than being on The Power List, and that is not being on it.” – *IW*

“It is an interesting exercise, but I think for every person on this list who's happy and appreciative, there's an unhappy one who feels he or she ought to be listed!” – *HKL*

“Anything that draws attention to the profound influence analytical science has on our lives is a very good thing. By sheer accident, this corner of science, which frankly underpins most of modern life, has found itself in something of a corner, vital but somehow too reliable, essential yet bizarrely undervalued. If The Power List helps raise the profile of work in the field, then its a good thing, whether that be with users, industry, agencies that fund research or early career researcher thinking of entering the field. If smart people don't enter the field then we are globally in big trouble.” – *AL*

“The thing I like most about The Power List is that it raises awareness of not only analytical science but also some of the tremendous science done in that field.” – *JG*



“I could paraphrase Groucho Marx – do I want to trust a list that includes me among its members? It's certainly a difficult job to come up with such a list and quantify the influences of analytical chemists, especially with all the subfields around the world. You have to include a balance between research topics, geography, gender and so on. Such lists always ignite controversy – and when a group is under represented on the list – it promotes conversation, which is a good thing. But – as with any list – it will include some important individuals while others are left out. It's important to make it clear that no one should take it too seriously!” – *JS*

“The Power List is fun and flattering – but shouldn't be taken too seriously.” – *CF*

“I think it is a great effort – and being on it means huge peer recognition. The fact that the ranking is based on expert opinions lends credibility and transparency.” – *RA*

“I like that The Power List has got people talking about the analytical sciences in general and that it highlights the importance the development of the

technology that underpins measurements made in other more high profile fields.” – *EH*

“Obviously I love it, if I keep moving up! Actually, I think it is a little uncomfortable to be ranked in such a dramatic fashion; however, my latest thoughts are that it shouldn't be taken too seriously and instead should be considered a bit of fun and a conversation piece for those of us in the field.” – *BK*

“It is always very nice to have a high ranking in The Power List and this obviously caresses your ego. For those involved in drawing up the list, it must be a big challenge to maintain credibility and remain unbiased.” – *PS*

“It is an interesting exercise and a bit of fun (and it's nice to be included). However, the list is very subjective.” – *PH*

“The Power List is a measure of scientific impact convoluted with personal popularity and visibility. That said, it might be important to recognize impact on the scientific community other than strictly via ‘H-index.’” – *JP*



“It is a bold move to publish such a list, as there is any number of ways to find fault in the method used to generate it. It is a challenging – maybe impossible – task to accurately generate this list. It is easy to think of people that you think are missing or should be in the Top 20 – but at the end of the day, it’s just one list. It generates discussion and it’s probably good for people to think about who has contributed to our field.” – *MR*

“No doubt The Power List helps promoting the analytical sciences and adds great prestige to the field. On the other hand, scientists are already continuously compared and ranked by their citations, number of PhD students, h-index, and so on... Yet another type of ranking maybe not what this field

needs – especially if it relates to such an ill-measurable quality as “power”. Conclusion: great advertisement for the field, but the individual ranking of somebody – or the mere fact that she or he is in the list or not – should be taken with the largest possible grain of salt.” – *GD*

“I’m honored to be included with such a talented group of individuals, but emphasize that this has only happened because of the great team that I work with.” – *DS*

“It is rather nice to be recognized by your peers. Even if there might be some bias in the list. It is quite an exclusive group of scientists to belong to after all...” – *AF*

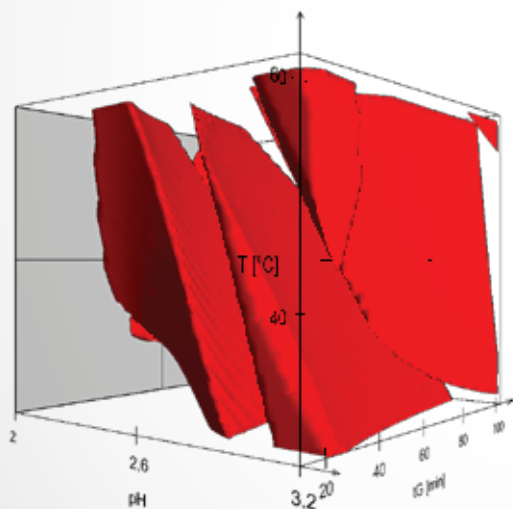
“To be honest, I personally do not take lists very seriously. However, my colleagues actually recognized me on The Power List 2013 and informed me, so there are a lot of people who do take lists very seriously! Since then, I feel very honored of course to be on the list. I really appreciate that this list is alternated with a young scientist list, such as the Top 40 Under 40. After all, they are the boys and girls who will take over and continue to boost analytical science and technology in the future!” – *MN*

“A good idea. It gets noticed by my colleagues, who have been known to part with money to buy me a beer...” – *CP*

*Make up your own mind about the 2015 Power List on page 31.*

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## A Light Boost for Water Treatment

**Exploring fluorescence spectroscopy's ability to monitor quality – and reduce operating costs in wastewater treatment works**

Thanks to substantial investment, the EU has seen considerable improvements in the collection and treatment of wastewater. The downside? It has also increased pressure on current wastewater treatment technologies. Enter FLUORO-BOOST (Fluorescence-

Based Optimization Of Sewage Treatment) – a project that aims to “provide the water industry with a robust yet straightforward technique, based on novel developments in the field of fluorescence spectroscopy, to optimize wastewater treatment works performance, to reduce energy consumption and to monitor final effluent quality in real time”. Elfrida Carstea, a researcher at the University of Birmingham, UK, has been working on the project, which comes to a close in October 2015 (1).

“From the beginning of my research career, I was interested in applying fluorescence spectroscopy to water monitoring,” says Carstea. “The technique is fascinating. Its beauty lies in its simplicity; it can provide a quick and effortless view

on the composition and characteristics of a particular water sample.”

John Bridgeman, a professor of environmental engineering at Birmingham initially came up with the idea for the project following positive preliminary studies (2). “The topic fitted my expertise so we submitted a proposal under the Marie Curie Intra-European Fellowship programme in 2012,” Carstea says, “Not only does the project bring research on wastewater monitoring a step forward, the prestigious fellowship also gives my career a boost!”

One current method used for monitoring at wastewater treatment works is the offline five-day biochemical oxygen demand (BOD5) test, which measures the amount of oxygen consumed during the microbiological decomposition of



organic material in water. Lower values signal cleaner water; for example, pristine rivers may give a reading of 1–2 mg/mL, whereas untreated sewage could be several hundred mg/mL. Although BOD5 is very commonly used, it is labor intensive, slow to yield data, and insensitive and unreliable at low concentrations, all of which make it unsuitable for online monitoring and process control. Indeed, with an uncertainty in accuracy of 10–15 percent, wastewater treatment works tend to “over treat” water to ensure compliance with regulations – and that’s where potential savings can be made. Replacing the BOD5 method with fluorescence spectroscopy could enable real-time control and adjustment of plant performance, which could in turn cut energy costs by up to 40 percent.

To investigate the relationship between

BOD5 and fluorescence spectroscopy data, Carstea and the team collected both treated and untreated wastewater samples from five plants at different points along the process train. “We measured BOD5 for all samples and recorded the fluorescence using different bench-top and portable instruments. The large dataset was essential in establishing a good correlation between fluorescence data and BOD5,” says Carstea. “The analysis of the data is in progress, but from what we have seen so far, it challenges our current knowledge about these two parameters. We now know more about the limitations of both techniques and on how to improve fluorescence.”

Carstea also discovered that the use of spectroscopy in this atypical application presents its own challenges. Biofilm formation on sensors can affect

the fluorescence signal, but can be significantly mitigated by regular cleaning and anti-fouling copper tapes, according to Carstea. And temperature also has a big impact on readings – Carstea applies a correction factor to the data.

Despite the challenges, Carstea believes the project has been a success. The speed, sensitivity, accuracy and relatively inexpensive nature of the technique offers the potential for a more modern approach to water quality monitoring. *VB*

#### Reference

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## Quis Custodiet Ipsos Custodes

**Conducting an autopsy of the flaws of comparative bullet lead analysis in forensic practice.**



*By Clifford Spiegelman, distinguished professor of statistics, Texas A&M University, College Station, Texas, and William Tobin, forensic metallurgist and failure analyst, Forensic Engineering International LLC, Lake Anna, Virginia, USA.*

Back in the 1960s, civilian research scientists at Gulf General Atomic (GGA) studied the feasibility of using compositional comparisons of questioned (crime scene) and known (suspect) bullets and bullet fragments to determine putative source. The scientists were on contract from the US Atomic Energy Commission (AEC, now the Department of Energy, DoE), which was seeking commercial applications for its considerable capital (nuclear reactors) and intellectual resources. The research actually ascended to high profile forensic significance during the JFK assassination investigation after one of the original researchers on the GGA team testified before the US Senate Subcommittee on Assassinations to the results of the JFK analyses.

The US Federal Bureau of Investigation (FBI) Laboratory seized the opportunity to expand its forensic services by adopting the methodology used by the GGA scientists for comparative bullet lead analysis (CBLA). The original GGA team used three analytes (antimony, copper and arsenic) in efforts to characterize bullet

lead, and concluded – in a 1970 contract report to the AEC – that three analytes were insufficient to uniquely characterize lead sources (known as “pots” in lead smelting parlance).

It took almost two decades of forensic application using the three original analytes before the FBI Laboratory added silver, bismuth, tin, and eventually cadmium. The FBI Laboratory then confidently, but misguidedly, intuitively concluded that six (and eventually seven) analytes, coupled with the precision of sophisticated instrumental analysis of neutron activation analysis (NAA) and/or optical emission spectroscopy (OES) to parts per million (ppm) levels, surely must be sufficient to “fingerprint” a molten source of lead. For nearly forty years, FBI laboratory examiners testified that crime scene bullets and defendant (suspect) bullets “originated from the same source of lead produced on the same day.” Eventually examiners became emboldened to claim (and testify) source attribution as the “same box of bullets.”

The curiosity of forensic metallurgist William Tobin and his subsequent research team was piqued in the late 1990s because the underlying premises required for efficacy of forensic CBLA practice contradicted well-established metallurgical principles. Three underlying premises – or assumptions – are logically required to validate opinions offered in criminal trials by CBLA examiners: i) 50–60 mg samples used for forensic analyses are representative of their sources, ii) the “sources” were compositionally uniform (homogeneous), and iii) that each of the “sources” was unique.

In 1998, out of scientific interest and an attempt to reconcile the apparent contradiction to long-established metallurgical principles and phenomena, the forensic metallurgy team began to research the scientific and legal underpinnings of the practice, including secondary lead smelting and refining, the



complete domain literature, and transcripts of testimonies from judicial proceedings. The team was shocked at what they found.

Although there was extensive peer-reviewed literature on the analytical chemistry methodology of neutron activation analysis (NAA) and inductively coupled plasma atomic (and later optical) emission spectroscopy (ICP/OES) for generating precise compositional data for bullet lead, there was not a single comprehensive or meaningful publication establishing or corroborating the validity of the three required underlying assumptions for the practice. Worse still, researchers in a subsequent study of retail product distribution in the USA found shocking geographic concentrations of same-composition bullets in local and regional areas, dealing a fatal blow to forensic and probative utility of the practice.

If everyone owned bullets of the same composition in a geographical locale of a shooting homicide, a finding of “analytically indistinguishable” bullets in the possession of a suspect compared to those recovered from a victim should never be presented to courts as incriminating evidence. In such a hypothetical scenario, there is no probative value of a claimed “match” between bullets recovered from a crime scene and those recovered from a suspect. Therefore, unless comprehensive and meaningful studies have been conducted and presented as to rarity or prevalence of analytically indistinguishable bullets in a regional population of bullets at the time of a shooting crime, such evidence should not be used to determine guilt or innocence in judicial proceedings.

Based primarily on flaws demonstrated by the metallurgical research, consequent

publications, and court testimonies of forensic metallurgical and statistical research team members, a consequent study by the National Research Council (NRC) of the US National Academy of Sciences (NAS), publications by the NRC statisticians, and reporting by the media, the following objectionable aspects of the forensic practice were exposed:

- The forensic practice was developed almost exclusively by forensic examiners and analytical chemists. There was no evidence of vital cross-discipline input from metallurgists or statisticians;
- No comprehensive or meaningful study existed of the assumption that each pot (‘source’) of lead was unique in composition;
- No comprehensive or meaningful

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study existed of the assumption that each forensic sample was representative of its original source;

- No comprehensive or meaningful study existed that each source was compositionally homogeneous;
- No study existed as to whether or not bullet composition “matches” had any probative value for criminal trials, largely because there existed no study of retail product distribution in the USA;

- There had never been any true (mainstream) scientific oversight during development of the forensic practice;
- Papers promoting the practice had been “peer-reviewed” only by the very insular community of CBLA practitioners themselves and/or only by chemists relating to the analytical chemistry methodology, which was never under challenge. The actual underlying assumption for the

practice, that “same composition = same source” (the legal “task at hand”) was never tested.

As it turns out, the FBI practitioners had established themselves as “the world’s CBLA experts” based on nothing more than speculative and intuited assumptions that were eventually shown to be false, perpetuating probably the most sophisticated “junk science” that ever deluded jurisprudence in North America.

## The Isotopic Doctor

**High-precision isotopic analysis of essential metals is beginning to show real promise for medical diagnoses. Here, I share some of the progress in this exciting application area.**



*By Frank Vanhaecke, professor, Department of Analytical Chemistry, Ghent University, Belgium.*

The lightest elements vary in their isotopic composition due to isotope fractionation; this is something we’ve known for quite a while. It occurs when the isotopes of an element do not take part with exactly the same efficiency in a physical process or (bio)chemical reaction. Differences in reaction rates (kinetics) and in equilibrium (thermodynamics), therefore, occur – for example, the lighter of two isotopes will react more quickly,

while the heavier will prefer the strongest bonding environment.

In ‘traditional’ isotope systems (hydrogen, nitrogen, carbon, oxygen and sulfur), variations can be studied using gas source isotope ratio mass spectrometry (IRMS). But for heavier elements, the relative difference in mass between the isotopes was initially thought too small to result in a measurable variation in the isotopic composition. However, with the advent of improved instrumentation – especially that of multi-collector inductively coupled plasma-mass spectrometry (MC-ICP-MS) in the early 1990s – it is now generally accepted that all elements with two or more isotopes show natural variation in their isotopic composition because of isotope fractionation effects.

Before the introduction of MC-ICP-MS, only thermal ionization mass spectrometry (TIMS) provided sufficient precision for studying natural variation in the isotopic composition of heavier elements. However, its widespread use was hampered because of low sample throughput capability and the limited ionization power of its source (only elements with an ionization energy up to 7 eV are efficiently converted into M<sup>+</sup> ions). With the ICP providing a much more powerful ionization source at atmospheric pressure, MC-ICP-

MS can analyze a broader range of target elements. Indeed, geochemists welcomed MC-ICP-MS with open arms for studying non-traditional isotope systems in various application areas.

Today, a few institutions around the world are using MC-ICP-MS for high-precision isotopic analysis of metals in body fluids as a potential new tool for medical diagnosis. In a NASA-funded study, a research group at Arizona State University, USA, discovered that natural changes in the isotopic composition of calcium in urine indicate bone loss in bed rest patients. In follow-up work, they demonstrated that the approach could also signal multiple myeloma disease activity. In a pilot study, researchers at the École Normale Supérieure de Lyon, France, showed that the isotopic composition of serum copper in breast and colorectal cancer patients reflected response to chemotherapeutic treatment more quickly than traditional biomarkers.

Ghent University, Belgium, is among these pioneering institutions. In the work performed so far, we have shown that Wilson’s disease, a hereditary illness that interferes with the excretion of excess copper into the bile, leads to a significantly lighter isotopic composition of serum copper. In liver cirrhosis sufferers, we have revealed that the



*“We have shown that Wilson’s disease leads to a significantly lighter isotopic composition of serum copper.”*

isotopic composition of serum copper reflects the severity of the disease. This breakthrough is potentially useful for prioritizing liver transplant patients.

Another promising application is isotopic analysis of whole blood/serum iron, as pioneered by researchers at

ETH-Zürich, Switzerland. The serum concentration of ferritin is the clinically most useful measure of iron storage. Low serum ferritin levels indicate depleted iron, whereas increased levels may indicate overload. Inflammatory conditions (or infections, cancer and liver disorders) will also influence ferritin concentration; as a result, a large number of patients remain at risk from iron depletion or overload. We have seen a link between iron status and the isotopic composition of whole blood iron. This is a potentially better marker for iron status and it has the benefit of offering access to both short term (via serum iron) and longer term (via red blood cells or whole blood iron) information.

Despite the relatively high cost of an MC-ICP-MS analysis, the medical world is interested in the approach for

earlier and non-invasive diagnosis and prognosis of diseases. Are we there yet? Not exactly. Several issues, such as the specificity and reproducibility of the shift in the isotopic signature of the target element(s), need assessing, and we need a more thorough understanding of the underlying causes of the changes we observe in isotopic composition. However, we are working on this, experimenting in vitro and in vivo to gain greater insights.

In a biomedical context, the isotopic analysis of non-traditional isotope systems is, therefore, intriguing, particularly as it shows real potential for clinical practice. I am glad that my research group and I – and our colleagues from the Ghent University Hospital – can contribute to progress in this exciting area.

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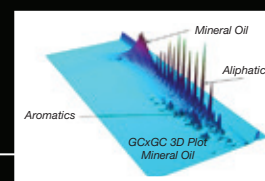
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## Letter to the Editor: Supplied but not Supported

**The gift of analytical capability is welcomed with open arms, but needs to go beyond core instrumentation.**



*By David Essumang, Professor,  
Department of Chemistry, University of  
Cape Coast, Cape Coast, Ghana.*

Rich Whitworth's editorial "How Do You Measure Success?" last month struck a chord with me. He posed a question: "Is your nation successful because it has assured the safety of its citizens with high-quality food and drugs (or simply shelter) or because it is rolling out more charitable and advanced programs to help resource-poor nations do the same?" I believe Whitworth was indicating that countries with advanced analytical capability could do more to aid nations that are less fortunate in that regard. And he is half right. But in my country of Ghana, the difficulty for analytical chemists goes beyond the simple lack of analytical equipment.

It is a known fact that science in most developing countries is not so advanced despite several efforts by governmental and non-governmental agencies to support it. In some cases, charitable organizations support governments in their efforts to develop science by financing the purchase of analytical equipment. Equipment that is very much in demand includes gas chromatography-mass spectrometry (GC-MS), high-performance liquid

chromatography (HPLC) and Fourier transforms infrared spectroscopy (FTIR). Receiving help to buy such equipment is certainly a great start, but some of the suppliers who sell the equipment don't always follow in the same charitable footsteps; for example, by refusing to supply an accessory that renders the equipment unusable through its absence. Indeed, there are currently several types of instrumentation that have become 'white elephants' in several laboratories in the developing world. In doing so, they are denying laboratories the full benefit of the contribution of donor agencies and their efforts to support quality research and development in Africa – and they are still failing to line their own pockets in many cases.

Sadly, I have come to the conclusion that it is illogical to ask for new equipment from donors when the ones supplied earlier sit untouched, having never performed a single analysis. I remember in 2004, the chemistry department at the University of Cape Coast received some analytical equipment to boost research and development in the university. The equipment included GC-MS, FTIR and atomic absorption spectroscopy (AAS) detector and was supplied through the vendor's African agent in Egypt. But we never received the full complement of accessories and the instrumentation has never been used. In fact, we do not even know what to do with it. In such cases, it is clear that we are not getting value for (our charitable donor's) money. And so here, I would like to kindly ask both donors and suppliers to ensure that any equipment – and all accessories – are supplied in full and supported with proper training; otherwise, all the effort – and financial support – is for naught.

The lack of adequate maintenance schemes for analytical equipment is another serious challenge to raising our scientific game. When equipment fails, the lack of technical know-how makes it very difficult for us to attempt a repair. We've experienced substantial periods of instrument downtime

*"We've experienced substantial periods of instrument downtime just because a fuse needed changing."*

just because a fuse needed changing. I also remember a time when we had some ion-selective electrodes, but once the calibrating solutions ran dry, the set-up was not used again. Why? Because there was no clear method that indicated how we could prepare more solution.

Certainly, some of these difficulties may seem trivial to someone in a well-stocked laboratory with easy access to technical support and almost limitless resources. But their combined affect on the development of analytical chemistry in the developing world is very real.

To that end, I would like to make a passionate appeal to the international community for continued help. Our doors are wide open to any organization that is prepared to support the development of analytical chemistry in Ghana and other developing nations. It is my sincere hope that better analytical capability will help us to identify most of the human health risk factors that result from the presence of numerous emerging chemicals in our environment. It would also afford us the opportunity to give proper training to our students and start a more positive cycle. But there is a small caveat: simply throwing financial resources at a problem does not always make it go away; we also need support in terms of accessories, consumables and training to ensure that the big investments do not go to waste.



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## Critical, Constructive or Crass?

**The somewhat imperfect peer review process has a long way to go before it could be considered 'standardized' – but at least we should be heading in the same direction.**



By Victoria Samanidou, professor of analytical chemistry, Department of Chemistry, Aristotle University of Thessaloniki, Greece.

Upon completion of research, scientists typically want to communicate their findings to the scientific community, with the greater goal of driving science forward. There is no doubt that publication in peer-reviewed journals is currently the most acceptable way of sharing the outcome of scientific investigation. No surprise then that a great variety of journals, with high, medium or low impact factor, have jumped to the demand, offering the opportunity to present their work to audiences in the same niche or broad field.

The journals' editors, who essentially decide whether the work deserves publication or not, must handle all manuscripts at some point. Initially, the task of accepting or rejecting was solely the role of the editors-in-chief or editorial committees. But the sheer volumes of manuscripts flying around our increasingly electronic and interconnected world have demanded the need for hordes of so-called referees or reviewers. Reviewers evaluate

manuscripts and provide a report that notes weak points or suggests improvements, generally maintaining standards of quality and reliability. The role is advisory and the editor has no obligation to accept the opinion of the referee, though it is often used and adapted. Peer reviewers are qualified experts of the same or relevant scientific field – a valuable resource indeed.

But recruiting referees is a difficult task, as they offer their time and expertise on a voluntary basis. Sometimes they are suggested by the authors, but with restrictions; they should typically not be from the same university, country, research team, and so on. In the case of any conflict of interest, editors are informed.

The peer review process is usually anonymous (single-blind review), where the names of the reviewers are hidden from the author. In some cases, both the reviewer and the author remain anonymous, which further ensures fair judgment (double-blind review). Open reviews are rare, but possible.

The peer review process should promote integrity in research publications. Unfortunately, the system is often biased, unjustified, incomplete – and sometimes plain insulting, unfair, ignorant, or incorrect. I suspect that most scientists have faced, at some time, a criticism that was not scientifically accurate. I recall one reviewer who wondered if QuEChERS was referring to a German car! Irony, ignorance, arrogance – or all of the above?

And so here is my question: can peer reviewing be harmonized or standardized by standards organizations? Manuscript reviewing is based on the volunteer work of scientists who spend time and effort giving editors advice and also helping authors to improve the presentation of their work – and this is undoubtedly highly appreciated. But harmonized procedures are essential when it comes to offering unbiased judgment. Are all parties – journal editors, authors and referees – ready to work together to aim for such standardization?

*“Unfortunately, the system is often biased, unjustified, incomplete – and sometimes plain insulting, unfair, ignorant, or incorrect.”*

For example, International Standards exist in the food industry that set out the requirements to harmonize existing methods through an internationally recognized system to ensure that food is safe for the consumer. International Standards guarantee that products and services are safe, reliable and of good quality. They are developed using a consensus-based approach and comments from all experts are taken into account. Could all publishers be in a consensus and guarantee the same degree of integrity and reliability for the authors?

The Committee on Publication Ethics, which is a forum for editors and publishers of peer reviewed journals that provides advice on all aspects of publication ethics, helps steer us in the right direction, but still is not enough. In my view, the reputation of a scientist alone is not sufficient to prove integrity of judgment.

Perhaps there is long way to go before all parties involved can agree upon standards of expected ethical behavior in the world of publishing. Clearly, we cannot apply standards as strictly as other more rigorous ISO systems, but I do believe the principles could and should be adapted and adjusted to fit the needs of a scientific community that wants to share the fruits of its labor.



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## From Analysis to Synthesis

**Using saturation-transfer difference (STD) NMR and in situ NMR spectroscopic analyses of biocatalyzed reactions to optimize application of enzymes in organic synthesis.**



By Lothar Brecker, Department of Organic Chemistry, University of Vienna, Austria.

Sustainability in chemistry and the concept of green chemistry has become an important topic in modern synthetic applications over the last two decades. Nowadays, the chemical industry checks their production processes with respect to sustainability, and several companies are seeking novel and sustainable solutions in synthesis.

One important and widely used approach in this development is the application of biocatalyzed reactions to synthesize organic compounds. The biocatalysts are easily available from microbial growth and combine a couple of properties that are important for performing sustainable chemical synthesis. Notably, they distinctly reduce activation energy in the catalyzed reactions and allow product formation with an excellent chemo- and stereo-selectivity at ambient temperature. Ordinary water is the solvent of choice in these transformations, and consequently the synthetic processes do not lead to formation of problematic side products, avoiding formation of excessive waste.

However, biocatalysts evolved through a long process of mutations before human

civilization came to our planet, and so enzymes are not at all optimized for biosynthetic applications in chemical synthesis of artificial products. The development of usable biocatalyzed synthetic processes demands the selection of a suitable enzyme as well as optimization of the molecular interaction between enzymes, co-factors, substrates and the desired product. Indeed, we must apply a complex combination of wet chemical synthesis and analysis in addition to in silico simulation to guide such a process. During development, it is necessary to gain detailed analytical information about the catalytic process at a molecular level, including kinetics of the biotransformation as well as concentrations and structural data of all molecules involved in the catalytic event. Furthermore, detailed knowledge of the binding processes is indispensable.

Such data can be recorded using several labor-intensive and costly analyses. However, NMR spectroscopy is an alternative versatile analytical method that allows fast and accurate determination of reliable information about catalysis at a molecular level. In particular, <sup>1</sup>H-NMR is good at monitoring biocatalyzed reactions, as the proton is ubiquitous in organic molecules and has a high sensitivity of the NMR active nuclei. To that end, on-line monitoring can be performed to measure spectra in situ at any stage of enzyme catalyzed reactions without sampling the reaction mixture, which makes manipulating the biotransformation much more accessible. All the data about molecular structures and compound concentrations are taken directly from the spectra. And H<sub>2</sub>O or HDO signals can be managed using known pulse sequences. Most importantly, the results gained are not influenced by extraction, separation, chromatography or derivatization caused by additional sample preparation and separate analysis.

In addition, STD NMR spectroscopy can be applied as a time and labor efficient

*“NMR spectroscopy is an alternative versatile analytical method that allows fast and accurate determination of reliable information about catalysis at a molecular level.”*

technique to determine complete mapping of ligand/enzyme binding in a global as well as in-site specific way. The determined binding patterns allow analysis of the specific substrate, intermediate and product binding to enzymes on a molecular basis. And a concomitant specific co-substrate and co-enzyme binding can be determined, including detailed analysis of ternary enzyme/co-enzyme/substrate complexes. All of the resulting binding patterns can be studied during catalysis as well as under binding-only conditions, meaning that this NMR-based analytical technique is particularly suited to performing a comparison of wild type and corresponding mutant enzyme binding.

In summary, the combination of both STD NMR and in situ <sup>1</sup>H NMR techniques enables comprehensive studies of mechanistic details of biocatalyzed reactions, which can be supported and visualized by in silico molecular docking. Indeed, these powerful techniques facilitate sustainable and target-oriented optimization of synthetic approaches that allow us to benefit from – and reduce our impact on – the natural resources around us.

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## Living in a Material World

**Research into migration of packaging materials into food began decades ago. And despite the relatively inconspicuous nature of this niche area, it is characterized by some of the most significant modern-day challenges in food analysis.**

*By John Gilbert, Director at FoodLife International, York, UK.*

I first got involved in analysis of food contact materials back in the mid-1970s, when it was recognized that vinyl chloride monomers could migrate into foods. Needless to say, subsequent investigations led to regulations being introduced that controlled monomer levels both in plastic and in food, and a new aspect of food analysis was born, expanding into other food contact materials.

Today, a food contact material is, by definition, one that is approved for food applications – the EU, for example, has a positive list of starting materials and plastics additives restricted to substances that are deemed safe for food packaging. Polyolefins (HDPE, LDPE and PP), PET and polystyrene are probably the most important plastics in common use in bottle, sheet and film formats. Films can be particularly complex in construction, involving multiple laminate layers to achieve the desired properties, sometimes with adhesive between layers, and printing on the outer surface. Coated paperboard is also widely used; for example, in drinks cartons.

Although polymers are generally inert, high-molecular weight, cross-linked substances that don't migrate – the residual monomers used to prepare them can, and since it's not possible to get a complete



conversion to the polymer, oligomers may remain. Moreover, as indicated above, plastics need numerous additives to make them suitable for packaging – antioxidants, heat stabilizers, UV absorbers, plasticizers and colorants, and so on – there are literally hundreds of potential substances, which represents a significant analytical challenge.

It's fair to say that food-packaging analysis is very niche compared with, for example, pesticide residues, but there is a lot of awareness within the packaging industry – and the food industry certainly realizes it must comply with regulations.

### Analytical drivers

Over the years, a great deal of food packaging regulation has actually been driven by developments in analytical techniques. Going back to the 1970s, MS and GC-MS were around, but the techniques were relatively specialized. People were using headspace GC with FID, and LC-MS was yet to be developed. As instrumental techniques have become more sensitive – and as costs have come down – methods have been developed and regulations established using the techniques available. Indeed, today's regulations were beyond the realms of possibility back in the 1970s because the technology simply wasn't available.

Substances of below 1000 daltons in molecular weight are of particular interest, but can vary from simple volatile chemicals like vinyl chloride, acrylonitrile, vinylidene chloride through to complex mixtures of

substances of much higher molecular weights like mineral oils. Migrants range in polarity from highly polar to non-polar organic molecules through to classical metals, as well as metal nanoparticles. Therefore, the full range of analytical tools must be employed in migration testing, including headspace GC-MS for volatiles, LC-MS/MS, LC-high-resolution accurate mass (HRAM) MS (Orbitrap) through to AAS and ICP-MS. Even DART-Orbitrap MS has been investigated for direct analysis of both plastics materials as well as extracts from plastics without any clean up.

### NIAS work

In 2011, Commission Regulation (EU) No. 10/2011 brought together numerous previous regulations, and introduced the concept of non-intentionally added substances (NIAS). The new regulations place responsibility on food producers to demonstrate due diligence for untargeted substances – a challenging feat. With NIAS, the substance could be a decomposition product from additives used in the plastic packaging or an adventitious contaminant – there is a huge range of possibilities. And that has led to a real interest in non-targeted analysis using LC-HRAM (Orbitrap-based) systems, where the ability to gain full-scan data at accurate mass is extremely useful.

Right now, NIAS regulations are very general; they simply state that not only are you responsible for showing compliance to the positive list of substances, you also



have to prove you have considered other potential contaminants, which by NIAS definition are unknown. It's very typical in the regulatory world to begin with an indication of intention and then firm up on the detail of compliance later on. In time, someone might suggest an approach for providing assurance, and someone else will suggest it is validated. If CEN adopts it, it will become a definitive CEN standard for NIAS measurement. But, of course, these things take time...

Right now, I would say that the industry is largely self-policing – especially given that food control or public analysts have limited resources. But that doesn't mean it isn't being proactive. The big worry for the food industry is a sudden scare and the resultant damage in reputation – and there have been several related to packaging. Photoinitiators represent a recent scare – especially as they decompose into free radicals when exposed to sunlight. Bisphenol A is also on the list, as it can migrate into food from the epoxy resin coating on the can or from polycarbonate food containers in certain circumstances.

I believe that in due course, contract labs will offer comprehensive analysis using HRAM mass spectrometry for migrating substances from food packaging, just as they do for other residues and contaminants.

The future of food contact materials  
Packaging never stands still; innovation is continual. Take nanotechnology – the industry is looking for ways to improve the performance of packaging with nanoclays and other materials, such as nano-silver.

There's also a great deal going on in active packaging, where examples include 'moisture absorbers' used in meat trays, 'scavengers' found in small sachets used to absorb residual ethylene or oxygen, or 'releasing systems' that slowly release antimicrobial agents to extend shelf-life. There is also interest in whether it's possible to incorporate antimicrobial substances into the packaging itself. Clearly, the food

cannot be contaminated in the process.

Indeed, all of these innovations represent new analytical challenges. And with nanomaterials, unlike other contaminants, it is not simply a case of measuring compound concentrations – particle size and particle size distribution are also important. There's a good paper that uses Thermo Scientific ICP-MS to look at the migration of silver nanoparticles incorporated into plastic chopping boards into chicken meat (1).

The regulators have to balance food safety (from a contaminant point of view) on one hand, but on the other, limit controls that get in the way of packaging innovations that are advantageous to the producer, retailer and consumer. Indeed, it is all too easy to think negatively about packaging when you consider substance migration and contaminants. But the reality is that packaging has made a huge difference to the food chain in terms of extending shelf life and availability; we no longer have to rely on locally available food products, and I would say the advantages far outweigh the disadvantages – it's just a question of striking the right balance and using the right analytical tools and techniques to ensure safety.

In my opinion, the push for sensitivity has largely ended (which was getting a little ridiculous in terms of identifying miniscule amounts of anything and everything). I believe specificity is also adequate – as long as the analysis is performed properly. What the food and packaging industries want is the ability to cover more analytes, at lower cost – and with greater speed. And as attention turns increasingly to non-intentionally added substances, we'll see a concomitant growth in untargeted analyses.

#### Reference

1. RJB Peters et al., "Development and validation of single particle ICP-MS for sizing and quantitative determination of nano-silver in chicken meat", *J Anal Bioanal Chem* 406 (16), 3875–3885 (2014).

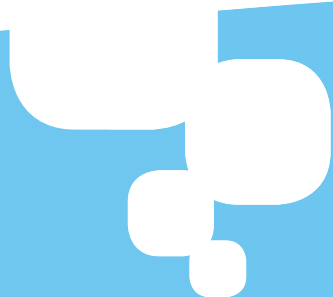


## Analytical Challenges in Food Contact Materials

John Gilbert worked at the Central Science Laboratory (CSL) as research director for 15 years until 2009, when it was renamed Food and Environment Research Agency (Fera; now Fera Science Ltd). In 2009, John took up a teaching position at the University of Natural Resources (BOKU) in Vienna, Austria, and at the same time, with a colleague, set up a consultancy company – FoodLife International Ltd ([www.foodlife.com](http://www.foodlife.com)) –. John has also been editor-in-chief of Food Additives and Contaminants for the past 15 years.

John has always maintained an interest in food contact material analysis, and chaired the ILSI Europe Packaging Task Force for many years, and was also involved in one of the scientific panels undertaking evaluations. John also helped to develop packaging recycling guidelines for PET, and is currently working on a new project called "Better Training for Safer Food," which is funded by the EU, and plans run courses for inspectors of plastic recycling plants from 2016.

To watch John Gilbert's comprehensive webinar on: 'Analytical challenges in measuring migration from food contact materials' – register here: [tas.txp.to/1015/FCMwebinar](http://tas.txp.to/1015/FCMwebinar)



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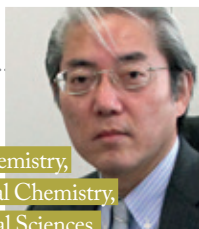
[info@pss-polymer.com](mailto:info@pss-polymer.com)



the Analytical Scientist  
*Power List*  
**2015**

Welcome to The Power List 2015 – our second foray into the Top 100 most influential people in the world of analytical science. Though we realize our list can (and should) never be definitive, who can argue that the faces within – both familiar and new – do not beautifully highlight the brilliance and diversity found within our sometimes undervalued field? Here, we celebrate 100 reasons to be proud of analytical science.

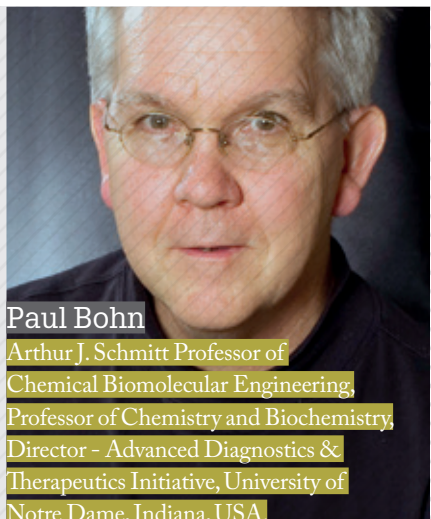




### Yoshinobu Baba

Professor of Physical Chemistry,  
Department of Medicinal Chemistry,  
Faculty of Pharmaceutical Sciences,  
University of Tokushima, Japan.

Research Human genome analysis,  
functional genomics, and proteome analysis.



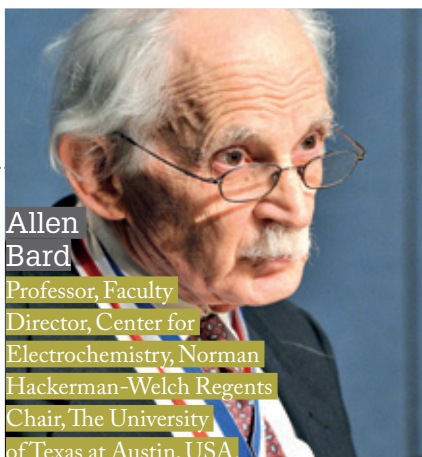
### Paul Bohn

Arthur J. Schmitt Professor of  
Chemical Biomolecular Engineering,  
Professor of Chemistry and Biochemistry,  
Director - Advanced Diagnostics &  
Therapeutics Initiative, University of  
Notre Dame, Indiana, USA.

Most important lesson It's not about us –  
it's about the students and young colleagues  
(courtesy of Peter Beak, UIUC).

Encounters with serendipity Yes - in a  
stunning pedagogical example from the  
research lab, back in the late '90s. We  
were injecting currents into chemically  
modified thin films and measuring  
molecular electrochemical effects on  
conduction. The whole experiment hinges  
on making  $\mu\text{A}$  current measurements in  
the presence of a mA (injected current)  
background. Fortuitously, even though  
the background was 1000x larger than the  
signal, the noise in the background was  
 $10^4$  to  $10^5$  smaller than the background, so  
the signal to noise ratio was respectable.

It was the exceptional and wholly  
unanticipated character of the fluctuations  
in the injected current (near the Johnson  
noise limit in most experiments) that  
made this possible.



### Allen Bard

Professor, Faculty  
Director, Center for  
Electrochemistry, Norman  
Hackerman-Welch Regents  
Chair, The University  
of Texas at Austin, USA.

Research Electrochemical methods  
applied to chemical problems,  
conducting investigations in electro-  
organic chemistry, photoelectrochemistry,  
electrogenerated chemiluminescence, and  
electroanalytical chemistry.

### Lutgarde Buydens

Professor and Head, Analytical  
Chemistry/Chemometrics, Radboud  
University Nijmegen, The Netherlands.

Research Chemometrical techniques for  
optimization of molecular structures with  
respect to (bio) chemical activity and for  
the processing/interpretation of (medical)  
multivariate images.

### Purnendu (Sandy) Dasgupta

Jenkins Garrett Professor of Chemistry and  
Biochemistry, University of Texas at  
Arlington, USA.

Most unexpected outcome Early in my  
career, a researcher from abroad visited  
my lab. She had adopted a technique we  
developed and, in fact, was already doing  
far better than we had accomplished.  
Her boyfriend accompanied her and saw  
something unrelated that we were doing.  
He said he was extremely interested in its  
implications (but delicately avoided telling  
me what his program was about!) Later, I  
received a fully-funded invite from him to  
put up one of our trace gas measurement  
instruments on a blimp for an extended  
period. Even now, I have no idea why it was



### Perdita Barran

Professor of Mass Spectrometry, Director of  
the Michael Barber Centre for Collaborative  
Mass Spectrometry, University of  
Manchester, UK.

Research Gas-phase ion chemistry and  
the application and development of mass  
spectrometry for complex chemical and  
biological problems.

### Marc Casper

President and Chief Executive  
Officer Thermo Fisher Scientific,  
Massachusetts, USA.

Revenue: US\$17 billion  
Employees: >50,000  
[www.thermofisher.com](http://www.thermofisher.com)



important and what he did with the data!  
Eye on the horizon Analytical science is  
simultaneously diverging in two directions:  
i) simpler, cheaper formats (for example,  
paper-based assays) – my heart lies in this  
direction, and ii) increasingly sophisticated  
instrumentation that provides heretofore  
unattained performance levels – my intellect  
admires this direction. Of course, the elusive  
ideal is when you can combine the two,  
perhaps with a completely new paradigm  
– in some parlance: disruptive technology.  
Rarely is the latter merely a result of  
systematic and methodical research.



### Andrew DeMello

Professor of Biochemical Engineering, Institute for Chemical and Bioengineering, Department of Chemistry and Applied Biosciences ETH Zürich, Switzerland.

Most important lesson Trust the opinions and instincts of young scientists and graduate students!

Encounters with serendipity I encounter serendipity all the time. I remember applying to Rich Mathies at Berkeley to postdoc in the area of photochemical

reaction dynamics area. At the time, he didn't have funding but offered me the chance to work with him on a new area: making chip-based devices to analyze DNA. It was an incredibly fulfilling time and complete luck that I began working with microfluidic technology.

Funniest moment The funniest is most definitely not repeatable here! That said, turning round to see one of my colleagues (when I was student) covered from head to toe in two liters of rhodamine 6G in ethylene glycol (from a dye laser) did raise a rather large smile.

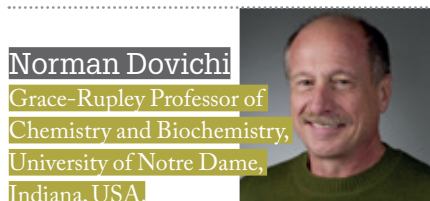


### Monika Dittmann

Principal Scientist, R&D, Agilent Technologies, Germany.

Most important lesson The need for patience and persistence.

Funniest moment During development an instrument started a life of its own, throwing microfluidic chips around the lab. We had to install webcams to find out what it was doing at night and got some very funny videos showing the robotics going crazy due to a firmware bug.



### Norman Dovichi

Grace-Rupley Professor of Chemistry and Biochemistry, University of Notre Dame, Indiana, USA.

Research Developing tools to study the proteome with two-dimensional capillary electrophoresis, coupled to either laser-induced fluorescence or mass spectrometry for detection.

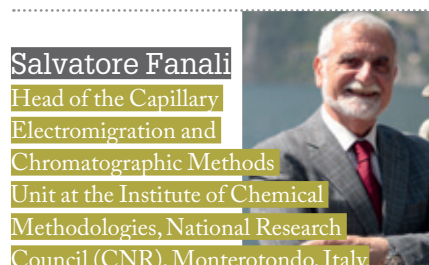


### Paola Dugo

Professor of Food Chemistry, University of Messina, Italy.

Most important lesson It is better to be together than alone

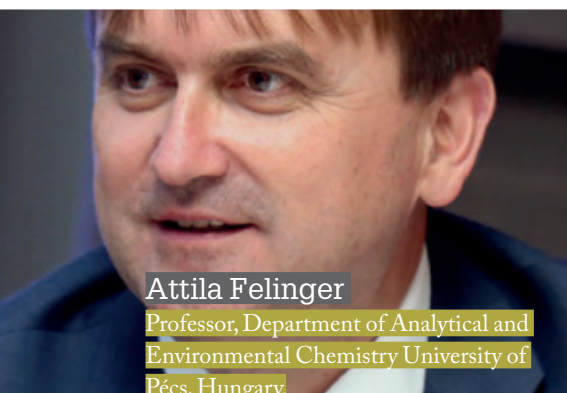
Encounters with serendipity During my masters degree, I was working on the synthesis of some 3-deoxyflavilium salts, potentially useful as color additives. Only by serendipity, a 4-styrylflavilium cation with a remarkable hyperchromic effect with respect to the other 3-deoxyflavilium salts was obtained.



### Salvatore Fanali

Head of the Capillary Electromigration and Chromatographic Methods Unit at the Institute of Chemical Methodologies, National Research Council (CNR), Monterotondo, Italy.

Most important lesson Be honest in obtaining results (useful in both science and one's career). It is also very important to have great respect for all. Funniest moment Back in 1991, I was delivering a lecture on CE and suddenly, there was a power failure... I continued my talk in the dark without any aids.



### Attila Felinger

Professor, Department of Analytical and Environmental Chemistry University of Pécs, Hungary.

Most important lesson Never stop looking beyond the frontiers of your specific area. Engineers, physicists, or biologists may have an answer to many fundamental problems of analytical chemistry, but first you have to understand their languages.



### Catherine Fenselau

Professor of Chemistry & Biochemistry, Department of Chemistry & Biochemistry, University of Maryland, USA.

Most important lesson Science progresses as a global team effort; rapid communication is critical.

Most unexpected outcome The most unexpected thing that happened to me in my scientific career was that I met a fellow with a big smile in the lab who eventually became my husband!



### Justin Gooding

ACS Sensors Editor-in-Chief, Scientia Professor, ARC Australian Laureate Fellow and founding Co-Director of The Australian Centre for NanoMedicine, University of New South Wales, Australia.

Most important lesson To be persistent. Eye on the horizon The sensing field is really blossoming; there seems to be a move away from electrochemical to optical methods with nanoscale materials. For me, the really exciting direction is towards digital assays that count single molecules.





### Christian Griesinger

Director and Scientific Member,  
Max Planck Institute for Biophysical  
Chemistry, Göttingen, Germany

**Most important lesson** Listen to your co-workers. Don't ignore mice since they could become elephants.

**Encounters with serendipity** When a co-worker of mine – Jürgen Schleucher – was experimenting with recently published pulse sequence and magnetic field gradients, he noticed that half of the scans were empty. This led to a general approach to coherence selection in NMR and later to theoretical investigations that could be solved with the help of the mathematician Sieveking.



### William Hancock

Editor-in-Chief, Journal  
of Proteome Research;  
Bradstreet Chair in Bioanalytical  
Chemistry, Northeastern University,  
Massachusetts, USA

**Research** Applying new analytical technology to current problems in the biotechnology industry as well as cancer proteomics and the plasma proteome.

### Amy Herr

Lester John & Lynne Dewar  
Lloyd Distinguished Professor  
of Bioengineering, University  
of California, Berkeley, USA

**Most important lesson** Thoughtful persistence pays off. Never give up, but be adaptable in light of new learnings, approaches, and ideas.

**Eye on the horizon** Biology and biomedicine are becoming more quantitative, so I see an exciting and perhaps even more central role for the analytical sciences in tackling grand challenges in the 21st century.



### Davy Guillarme

Senior lecturer, School of  
Pharmaceutical Sciences,  
University of Geneva, Switzerland

**Most important lesson** “We are stronger together than we are alone”. This quote applies very well in analytical sciences, where people should work together as a team to attain a fixed objective.

**Eye on the horizon** I'm now strongly involved in the analytical characterization of biopharmaceuticals, which is highly demanding for analysts and requires a wide range of analytical techniques (electrophoresis, chromatography, mass spectrometry, spectroscopy...). There are always new challenges to solve in this research area.

### Albert Heck

Chair, Biomolecular  
Mass Spectrometry and  
Proteomics Group,  
Utrecht University,  
The Netherlands



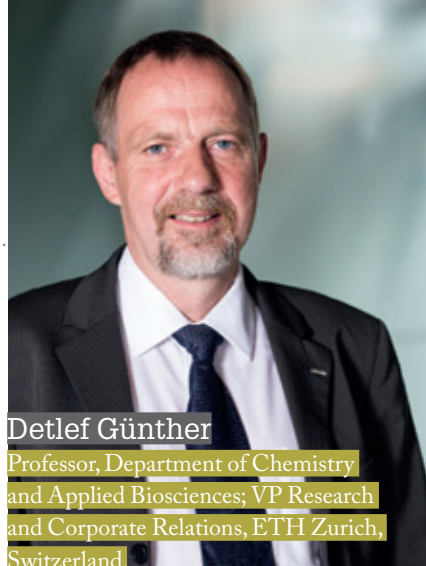
**Research** Technology development for proteomics and structural biology.



### Gary Hieftje

Distinguished Professor; Robert and  
Marjorie Mann Chair in Chemistry;  
and Group Leader, Laboratory for  
Spectrochemistry, Indiana University, USA

**Research** Investigation of basic mechanisms in atomic emission, absorption, fluorescence and mass spectrometric analysis, and the development of instrumentation and techniques for atomic methods of analysis.



### Detlef Günther

Professor, Department of Chemistry  
and Applied Biosciences; VP Research  
and Corporate Relations, ETH Zurich,  
Switzerland

**Research** Trace element characterizations of different samples using inductively coupled plasma-mass spectrometry (ICP-MS) and laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS).

### Ron Heeren

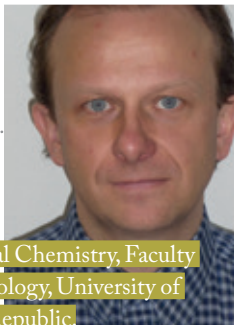
Co-director of the Maastricht  
MultiModal Molecular Imaging  
(M4I) center, Maastricht  
University, the Netherlands

**Most important lesson** Have fun in the science we do. Enjoyment brings the creativity needed to solve complex problems and allows people to think without boundaries or restrictions.

**Funniest moment** My daughter unexpectedly asked me to help her on a topic that we just proposed to the National Science Foundation (and got funded). She analyzed the hairs of her fellow high school students for drug content with unexpected results on numerous levels. Best of all, she won the prize for best thesis of the year.





**Michal Holcapek**

Professor, Analytical Chemistry, Faculty of Chemical Technology, University of Pardubice, Czech Republic.

**Most important lesson** The curiosity to understand the principles is a driving force for scientists. This scientific enthusiasm is a natural attribute of any scientist. Talent must be accompanied by hard work and patience to attain success.

**Funniest moment** By far the most fun can be encountered during the examination of students. The winning answer: the nucleus of a hydrogen atom contains half of proton and half of neutron, because the nucleon number is equal to one.

**Eye on the horizon** The field of lipidomics is growing and will continue to do so, because lipids are connected to many biological processes, including those associated with disease.

**Elizabeth Holmes**

CEO and Founder, Theranos

*Company valuation: US\$ 10 billion*  
([tas.txp.to/1015/Theranos](http://tas.txp.to/1015/Theranos))  
[www.theranos.com](http://www.theranos.com)

**Klavs Jensen**

Warren K. Lewis Professor of Chemical Engineering, and Professor of Materials Science and Engineering, Massachusetts Institute of Technology, USA.



**Research** Understanding and controlling the interaction of reaction and transport processes in the realization and testing of functional micro- and nano-structured materials and devices for chemical, biological, optical, electronic and energy applications.

**Emily Hilder**

Director, ARC Training Centre for Portable Analytical Separation Technologies, University of Tasmania.

**Most important lesson** Never stop learning new things, keep your interests as broad as possible and don't be afraid to ask what you think are stupid questions. I've seen many big breakthroughs come from those who are able to challenge the 'right way' of doing things, and often just because they approached the problem from a totally new perspective.

**Gérard Hopfgartner**

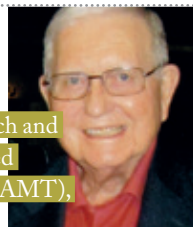
Professor in Analytical Sciences and Mass Spectrometry and Head of the Mass Spectrometry Platform of the Sciences Faculty, University of Geneva, Switzerland.

**Research** Bioanalysis, metabolism, miniaturization of sample preparation, multi-components analysis, ultra-high throughput and high sensitivity analysis, as well as studies on the rationalization of fragmentation mechanisms for the identification of metabolites.

*Sitting Down With interview:*  
[tas.txp.to/1015/Hopfgartner](http://tas.txp.to/1015/Hopfgartner)

**Joseph (Jack) Kirkland**

Vice-President, Research and Development, Advanced Materials Technology (AMT), Delaware, USA.



**Most important lesson** During my R&D career, the most important lesson learned is perseverance. This is a needed quality if difficult problems are to be solved. Along with perseverance, patience is required, and that was difficult for me to accept and develop.

**Eye on the horizon** I expect some significant changes for my group in the future with my upcoming move to the University of South Australia in Jan 2016 as the Director of the new Future Industries Institute. Separation Science may appear to be a mature field, but there is still plenty to be done. Developments in detection technology, in particular mass spectrometry, have already had a big impact and will continue to demand new separation technologies.

**Pavel Jandera**

Professor, Department of Analytical Chemistry, Faculty of Chemical Technology, University of Pardubice,

**Most important lesson** It is impossible to avoid mistakes when searching for new solutions to problems; I cannot count mine. However, the failures may be very useful and we often can turn them into an advantage.

**Michael Laemmerhofer**

Professor, Pharmaceutical Analysis and Bioanalysis, University of Tuebingen, Germany.

**Most important lesson** Research demands hard work, persistence, and stern discipline to pave the way for success. In this endeavor, ambition to make small achievements represents a useful motor. Encounters with serendipity In biomarker analysis, serendipity happens all the time; molecules that you weren't looking for often pop up – the hope is that they are real...



**Frank Laukien**

Chairman, President and Chief Executive Officer, Bruker Corporation, Germany

Revenue: US \$1.84 billion (2013)

Employees: >6000

www.bruker.com



**Milton Lee**

H. Tracy Hall Professor of Chemistry, Department of Chemistry and Biochemistry, Brigham Young University, Utah, USA

Research Development of new instrumentation and supporting technology in the fields of capillary and micro/nano fluidic separations and mass spectrometry.



**Alastair (Ally) Lewis**

Professor, National Centre for Atmospheric Science, University of York, UK

Most important lesson Analytical science is amazingly broad, innovative and flexible, so that someone, somewhere, has probably already solved your problem (even if they don't yet know it).

Encounters with serendipity In 1993, I had a chance encounter with John Phillips who described a new method called GCxGC. I subsequently managed to build the best part of a career out of his technique by applying it to atmospheric and pollution science.

Funniest moment It's strange that different countries deliver gases in different colored bottles. I once spent a week trying to light an FID in Portugal that was fed with nitrogen rather than air. I never even thought to ask.



**Hian Kee Lee**

Professor, Department of Chemistry, National University of Singapore

Most important lesson A few lessons, actually: Not to be deterred by setbacks, have a sense of humour, cherish the support of the family and the friendship of colleagues, be grateful for the opportunity, and to students, and never stop learning (see next item).

Funniest moment When our son was in his first year of primary school, he was asked by his teacher to write something

about his family. Of his father, he wrote: "Daddy is a professor in the university, he's learning to be a scientist." Which basically sums it up.

Eye on the horizon More focus on automation and onsite applications: "The environment is your lab".

**Susan Lunte**

Ralph N. Adams Distinguished Professor of Chemistry and Pharmaceutical Chemistry; Director, Adams Institute for Bioanalytical Chemistry, The University of Kansas, USA



Research Microanalytical methods for the investigation of the transport and metabolism of peptides across the blood-brain barrier; separation-based sensors employing on-line microdialysis coupled to microchip electrophoresis; Cell-based assays on chips; and microchip-based diagnostics for cardiovascular and metabolic diseases.

**Fasha Mahjoor**

Founder, President, and Chief Executive Officer, Phenomenex, California, USA

Revenue: unlisted

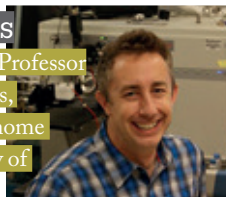
Employees: >700

www.phenomenex.com



**Mike MacCoss**

Michael MacCoss, Professor of Genome Sciences, Department of Genome Sciences, University of Washington, USA



Most important lesson Be persistent and consistent.

Funniest moment Becoming a tenured professor from the same department that I was rejected admission for graduate school.



**Ron Majors**

Retired, former Senior Scientist Agilent Technologies, Delaware, USA





### Matthias Mann

Director, Department of Proteomics and Signal Transduction, Max Planck Institute of Biochemistry, Munich, Germany

Research Developing and applying methods of mass spectrometry-based proteomics in a variety of biological areas.

### Hans Maurer

Full professor, Toxicology and Pharmacology; Head, Department of Experimental & Clinical Toxicology, Saarland University, Homburg/Saar, Germany

Most important lesson If you have a new scientific idea, don't wait for funding – start directly with your available resources.  
Most unexpected outcome I received a fax the day before Christmas 2006, informing me that the Rector of the University of Ghent in Belgium would be presenting me with an Honorary Doctorate.

### Chad Mirkin

Director, International Institute for Nanotechnology; George B. Rathmann Professor, Chemistry; Professor, Chemical and Biological Engineering, Biomedical Engineering, Materials Science & Engineering, and Medicine. Northwestern University, Illinois, USA.

Research Anisotropic nanostructures, on-wire lithography (OWL), dip-pen nanolithography, organometallic chemistry, spherical nucleic acids.



### Andreas Manz

Head of Research, Korea Institute of Science and Technology (KIST), Saarland University, Saarbrücken, Germany.

Research Lab on a chip, microfluidics, miniaturized total analysis systems (microTAS), biomimetic microfabrication, clinical diagnostics and the Human Document Project.

### David McCalley

Professor in Bioanalytical Science, University of the West of England, UK.

Most important lesson The communication skills of scientific researchers are inversely proportion to their intelligence.  
Funniest/most unexpected moment Being mistaken for “Mr. Bean” on my first visit to Japan to attend a scientific conference. And being amazed that 99 percent of the citizens of Kyoto could actually understand the basic Japanese that I had learned but (perhaps unsurprisingly) disappointed that I could not understand 99 percent of their responses.



### Luigi Mondello

Full professor of Analytical Chemistry Chemical, Biological, Pharmaceutical, Environmental Sciences Department, University of Messina, Italy.

Most important lesson Always love what you are doing; only with enthusiasm and hard work can you reach recognition.



### Alan Marshall

Professor of Chemistry and Director, National High Magnetic Field Laboratory ICR Program, Florida State University, USA.

Research Continuing development of new theory, techniques, and analytical/biological/environmental applications of Fourier transform ion cyclotron resonance (FT-ICR) mass spectrometry.

### Michael (Mike) McMullen

President and Chief Executive Officer, Agilent Technologies

Revenue: US\$4 billion  
Employees: ~12,000  
[www.agilent.com](http://www.agilent.com)



Encounters with serendipity I was at the ISCC meeting in 2006, and together with my co-worker Peter Tranchida, we showed the benefits (in terms of resolution) of using a split-line in comprehensive GC experiments to Leonid Blomberg. Leon took a look at the data (later published in *Anal. Chem.* 2007, 79, 2266-2275) and immediately made the following observation “...apart from the split line, there must be some other factor contributing to such a great gain in resolution”. He was right. But it took us about six years to find the other factor (*J. Sep. Sci.* 2013, 86, 212-218).





### Royce Murray

Kenan Professor, Chemistry The University of North Carolina, USA

Research Electrochemistry, molecular design, sensors.



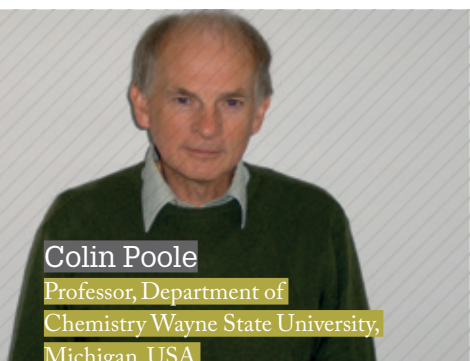
### Christopher O'Connell

President and Chief Executive Officer, Waters Corporation, Massachusetts, USA

Revenue: US\$1.99 billion (2014)

Employees: ~6,000

[www.waters.com](http://www.waters.com)



### Colin Poole

Professor, Department of Chemistry Wayne State University, Michigan, USA

Most important lesson Patience. Laboratory work takes time and hustling does not get it done any faster.

Encounters with serendipity While waiting to talk to the Dean I

casually picked up a magazine that contained a short article suggesting that ethylammonium nitrate had physicochemical properties that resembled water. It proved to be far from the truth but commenced a 35-year investigation into the synthesis and characterization of ionic liquids in my research group.

Most unexpected outcome Presenting a 45-minute lecture without visual aids or access to a blackboard because of a projector failure.



### Michel Nielen

Professor, Special Chair on Analytical Chemistry at Wageningen University; Principal scientist, RIKILT Wageningen UR, Scientific director of COAST, Amsterdam, The Netherlands

Most important lesson Think outside of the box ("what if?"), the impossible is possible! Most unexpected outcome In the late eighties, we tested professional kites for their ability to carry air samplers in a weekend trial. All kites crashed – but how to tell the boss?



### Michael Quilliam

Principal Research Officer, Biotoxin Metrology, Measurement Science and Standards, National Research Council, Nova Scotia, Canada

### Milos Novotny

Distinguished Professor Emeritus, Adjunct Professor of Medicine, Director of the Institute for Pheromone Research, Director of the Novotny Glycoscience Laboratory, Indiana University Bloomington, USA

Research Improving resolution of complex biological mixtures and identification of the separated compounds through techniques such as electrospray mass spectrometry (MS) and matrix-assisted laser desorption/ionization MS.

Most important lesson I have learned that it is always best to try to help other researchers when they need help to solve a problem – it always pays off with future opportunities and collaborations, as well as lifelong friendships.

Most unexpected moment As a summer student in an analytical lab, I was asked to help the police investigate a case. A man believed his wife was trying to kill him – and claimed his vermouth tasted "funny". I discovered that the drink was adulterated with N,N-diethyl-m-toluamide, more commonly known as DEET – the insect repellent. Apparently the wife thought her husband was a real pest!

### Susan Olesik

Dow Professor and Chair, Department of Chemistry and Biochemistry, Ohio State University, USA

Most important lesson Hard work always pays off. Eye on the horizon My group intends to contribute strongly in advancing the speed of analysis using separation science and mass spectrometry.



### Jeanne Pemberton

Professor, Chemistry, The University of Arizona, USA

Research Chemistry at interfaces in electrochemistry and electrochemical devices, chromatography, organized molecular assemblies, and environmental systems.





### Marja-Liisa Riekkola

Professor of Analytical Chemistry, Head of the Laboratory of Analytical Chemistry, Department of Chemistry, University of Helsinki, Finland.

Most important lesson Believe in your scientific ideas and instincts, and take advantage of opportunities when offered. Look rather into the future than into the past.

Eye on the horizon I see very positive

future for my research group because analytical atmospheric chemistry (with very good knowledge of separation science and mass spectrometry) offers an excellent basis for the development of new sampling techniques, portable instruments and other equipment to tackle fundamental climate change issues. In addition, the same expertise helps to develop new miniaturized systems for human biomolecule studies. The topics mentioned are so important and actual that I do not see any major problems in getting funding although the economic situation is getting worse.

### Fred Regnier

John H. Law  
Distinguished Professor of Chemistry, Purdue University, Indiana, USA



### Alison Rodger

Professor, Head of Department of Chemistry, University of Warwick, UK



Research Biomacromolecule structure and function including DNA, membrane proteins and fibrous proteins including application to bacterial cell division. Intermolecular interactions. Developing new polarized spectroscopy techniques for biomacromolecules. Particular expertise in circular and linear dichroism, fluorescence.

### Wilhelm Schaezler

Head, Institute for Biochemistry, German Sport University Cologne, Germany.



[www.dopinginfo.de](http://www.dopinginfo.de)



### Peter Roepstorff

Professor, Department of Biochemistry and Molecular Biology, University of Southern Denmark, Denmark

Research Development of methodology for mass spectrometric protein analysis with focus on post-translational modifications including protein oxidation as function of aging and also the use of mass spectrometric protein analysis in the biotechnological and pharmaceutical industry.

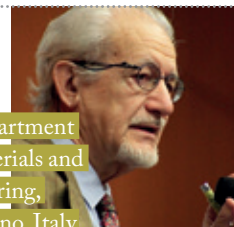
### Hamish Small

Retired Chemist/Research Scientist, Dow Chemical, Oregon, USA.



### Pier Giorgio Righetti

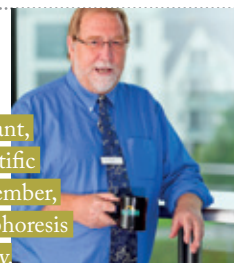
Full professor, Department of Chemistry, Materials and Chemical Engineering, Politecnico di Milano, Italy.



Research Proteomics, combinatorial peptide ligand libraries, biomarker discovery, cancer research, red blood cell pathologies, allergen discovery in food stuffs, cerebrospinal fluid analysis.

### Gerard Rozing

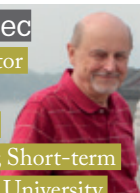
Technical Consultant, Rozing.com; Scientific Advisory Board member, Advanced Electrophoresis Solutions, Germany.



Encounters with serendipity Serendipity occurs in our environment naturally and is part of it. Grabbing the unexpected potential to perform liquid chromatography in a CE capillary and instrument (capillary electrochromatography) is an example from my own career. Nevertheless, not all discoveries make it – if asked for a “killer application”, an inventor or engineer will find it difficult to answer since the technology is new.

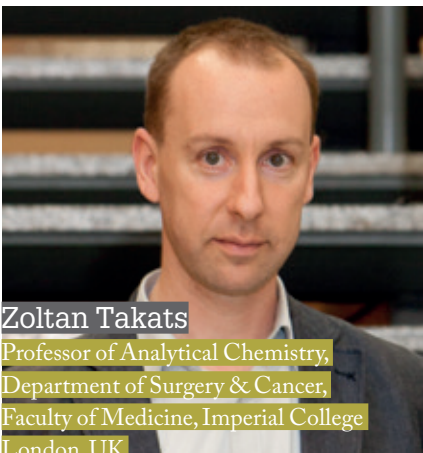
### Frantisek (Frank) Svec

Lead Scientist; Facility director at the Molecular Foundry, Lawrence Berkeley National Laboratory, California, USA; Short-term Principal Researcher, Beijing University of Chemical Technology, International Research Center for Soft Matter, China.



Most important lesson Be patient. Good results do not occur overnight. Also, wide ranging teamwork is imperative. Encounters with serendipity Audaces fortuna iuvat (fortune favors the bold); one must be prepared to discover something new.





**Zoltan Takats**  
 Professor of Analytical Chemistry,  
 Department of Surgery & Cancer,  
 Faculty of Medicine, Imperial College  
 London, UK

Research Ambient mass spectrometry.

**Sarah Trimpin**

Associate Professor,  
 Department of Chemistry,  
 Wayne State University,  
 Michigan, USA.

Research Developing a fundamental understanding of a newly discovered process that brings into question what is currently taught relative to ionization methods in mass spectrometry.

**Jean-Luc Veuthey**

Professor, School of pharmaceutical sciences,  
 University of Geneva, Switzerland.

Most important lesson The importance of the scientific collaborations between colleagues from different domains to achieve relevant results.

Most unexpected moment My nomination as a full professor while I was a young scientist working in a pharmaceutical company.

Eye on the horizon We will not modify our main area of research (development of separation methods dedicated to pharmaceutical compounds), but the importance of new biopharmaceuticals will certainly increase in the coming years, inducing the implementation of new

**Koichi Tanaka**

Core Researcher/General  
 Manager, Koichi Tanaka Laboratory  
 of Advanced Science and Technology,  
 Shimadzu Corporation, Japan.

Research Developing next-generation ultra-high-sensitivity mass spectrometry systems to contribute to medical and pharmaceutical fields, and a wide range of other sciences and technologies.

**Teruhisa Ueda**

President & CEO,  
 Shimadzu Corporation, Japan

Revenue: ~US\$2.63 billion (2014)

Employees: ~10,800 (2015)

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techniques for these complex compounds. The size of the group will remain the same but we must begin new partnerships with the industry, especially to face the analytical challenge of biopharmaceuticals. I see the development of new stationary phases in LC for increasing analytical performance (for example, monolithic materials, pillar array) and the miniaturization of equipment.



**Nobuo Tanaka**  
 Professor Emeritus, Kyoto Institute of  
 Technology, Japan.

**Albert van der Berg**

Professor, MIRA and  
 MESA+ Institute,  
 University of Twente,  
 The Netherlands.

Most important lesson That research is full of hurdles... but also unexpected bypasses! Keep your eyes open for the unusual. Encounters with serendipity The awarding of the Dutch Spinoza prize opened a new world of science for me – and also a totally unanticipated collaboration with a migraine expert and a mathematical expert on tipping points.



**Joseph Wang**  
 SAIC Endowed Chair, Distinguished  
 Professor, Chair of Nanoengineering,  
 University California San Diego, USA.

Most important lesson Keep up the creativity and passion!  
 Eye on the horizon We will endeavor to be at the cutting edge of analytical research.



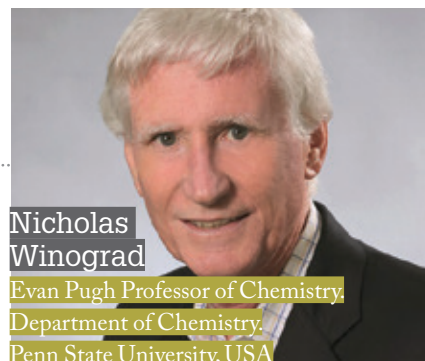


### Ian Wilson

Professor, Chair in Drug Metabolism and Molecular Toxicology, Department of Surgery & Cancer, Faculty of Medicine, Imperial College London, UK

Most important lesson Depressingly, I've found that persistence matters more than inspiration (though inspiration helps!).  
Most unexpected outcome That my career happened at all...

Eye on the horizon Now is undeniably the best time in all of human history to be an analytical scientist given the speed and power of the technologies available to us. The only problems are the expense of modern equipment and the difficulty of thinking up good enough questions to answer with them.



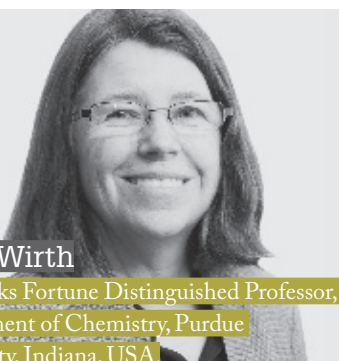
### Nicholas Winograd

Evan Pugh Professor of Chemistry, Department of Chemistry, Penn State University, USA

Most important lesson Perseverance. Don't follow the crowd.

Funniest/most unexpected moment Funny events are usually provided by the students – like hooking up a vacuum pump backwards. The most unexpected thing was winning the Texas Instruments prize in 1984.

Eye on the horizon I have been at this for 45 years; it is time to let the younger researchers take over. Analytical sciences, since they depend heavily upon exponentially growing technology, has a terrific future...



### Mary Wirth

W. Brooks Fortune Distinguished Professor, Department of Chemistry, Purdue University, Indiana, USA

*Pushing the limits of LC: [tas.txp.to/1015/Wirth](http://tas.txp.to/1015/Wirth)*

### Kurt Wuthrich

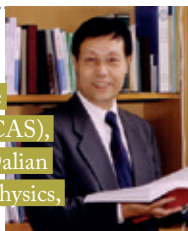
Professor of Biophysics, Institute of Molecular Biology and Biophysics, Zürich, Switzerland; Cecil H. and Ida M. Green Professor of Structural Biology, Scripps Research Institute, California, USA



Nobel Prize in Chemistry: “for his development of nuclear magnetic resonance spectroscopy for determining the three-dimensional structure of biological macromolecules in solution.”  
Research Molecular structural biology, protein science and structural genomics.

### Yukui Zhang

Member of the Chinese Academy of Sciences (CAS), Research professor of Dalian Institute of Chemical Physics, CAS, China

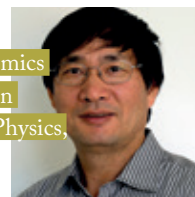


Most important lesson If your research cannot meet practical needs, you will be kicked out of the game.

Most unexpected moment To obtain the life-time achievement award at HPLC 2015 in Beijing. To be honest, I think without the support of my friends, colleagues, and students, I could not win this award.

### Guowang Xu

Director for Metabonomics Research Center, Dalian Institute of Chemical Physics, Chinese Academy of Sciences, China



Most unexpected moment From 1995-1997, I worked in the University Hospital Tuebingen, Germany. When I returned to China, I continued researching the relationship between urinary metabolic products and health. I didn't know this was metabonomics until 2001, when someone told me. Later, I found that Professor Nicholson defined metabonomics in 1999; my group had been pioneers in a brand-new field, but I didn't even realize!

### Ed Yeung

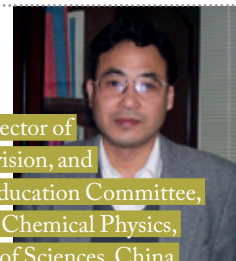
Distinguished Professor of Liberal Arts and Sciences, Iowa State University, USA



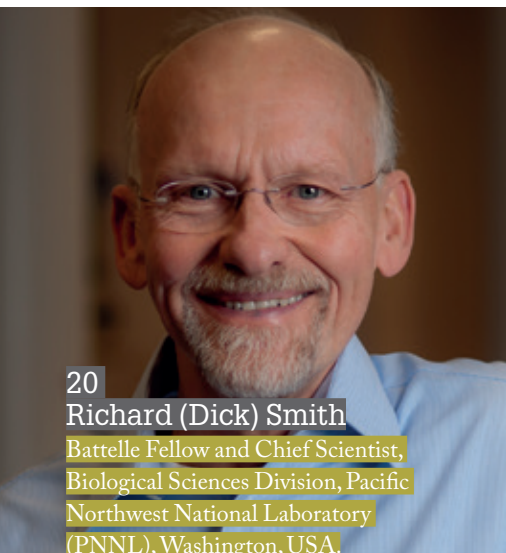
Most important lesson To be observant – often scientific discoveries are in plain sight but only the few who take the time to examine the data in detail are rewarded.  
Encounters with serendipity I was weighing various options for a thesis topic when a second-year graduate student was suddenly drafted into the army. His research project became available and I stepped right in. If not for this turn of events, I might not have taken up an academic career in analytical chemistry.

### Hanfa Zou

Professor, Vice Director of Biotechnology Division, and Vice Director of Education Committee, Dalian Institute of Chemical Physics, Chinese Academy of Sciences, China



Research Analytical biochemistry

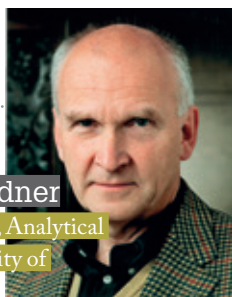


**20**  
**Richard (Dick) Smith**  
 Battelle Fellow and Chief Scientist,  
 Biological Sciences Division, Pacific  
 Northwest National Laboratory  
 (PNNL), Washington, USA.

**Most important lesson** Not to be constrained by conventional wisdom, and to try to think beyond the next step – for example, if an experiment or study works out as hoped or expected, then what?

**Encounters with serendipity** Back in the early 1980s, I thought it would be really fantastic to couple capillary zone electrophoresis (CZE) with mass spectrometry, but there was no real option to do so. Later, in 1984, I happened to listen to a talk by future Nobel Laureate John Fenn, who was speaking on some of his early work with electrospray ionization-MS. I immediately wondered how CZE might be used with it, and ultimately developed an ESI-MS interface that allowed this – and actually had broader utility. In 1988, Fenn reported how ESI enabled the effective analysis of proteins by MS for the first time, and while everyone in the MS community was suddenly interested in the approach, instrumentation was lacking. We'd already published our initial explorations into CZE-MS, and our research was able to move forward much faster than others in a number of important new directions. Certainly some luck; perhaps even serendipity!

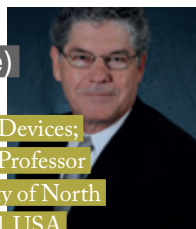
*Sitting Down With interview:*  
[tas.txp.to/1015/Smith](http://tas.txp.to/1015/Smith)



**19**  
**Wolfgang Lindner**  
 Professor Emeritus, Analytical  
 Chemistry, University of  
 Vienna, Austria.

**Most important lesson** Stay curious throughout your life and don't be afraid to enter new fields and to learn the language of these fields. By doing so, one can gain new insights that otherwise one could only dream of. Never give up and "dig deep" in science in order to meet far-reaching goals.

*Sitting Down With interview:*  
[tas.txp.to/1015/Lindner](http://tas.txp.to/1015/Lindner)



**17**  
**J. Michael (Mike) Ramsey**  
 Scientific founder, 908 Devices;  
 Goldby Distinguished Professor  
 of Chemistry, University of North  
 Carolina at Chapel Hill, USA.

**Encounters with serendipity** I always say it's better to be lucky than good. I am a great believer in the adage: "The harder I work, the luckier I get."

**Eye on the horizon** Smaller, faster, better, cheaper!

*Feature article:* [tas.txp.to/1015/Ramsey](http://tas.txp.to/1015/Ramsey)



**16**  
**Jeremy Nicholson**  
 Chair in Biological Chemistry,  
 Head of the Department of  
 Surgery & Cancer, Faculty  
 of Medicine, Imperial College  
 London, UK.

**Most important lesson** To ignore the opinions of so-called thought leaders and do my own thing.

**Encounters with serendipity** Too many times to call – I find the whole of life a continuous series of stochastic events.

*Feature article:* [tas.txp.to/1015/Nicholson](http://tas.txp.to/1015/Nicholson)



**18**  
**Gert Desmet**  
 Professor and Faculty of  
 Sciences Vice-dean, Vrije  
 Universiteit Brussel (VUB), Belgium.

**Most important lesson** That the joy and fun of being in science and research is the people you can work and share with – be it on a daily basis with students (who I prefer to call co-workers, by the way) or cooperating or discussing at conferences with colleagues.

*Feature article:* [tas.txp.to/1015/Desmet](http://tas.txp.to/1015/Desmet)



**15**  
**Alexander Makarov**  
 Director Global Research Life Science Mass  
 Spectrometry, Thermo Fisher Scientific, Germany.

**Most important lesson** Play fair with people and nature; with people that simply means following normal moral maxima (like "treat others as you would like to be treated"), for nature it means that you should not try to obtain anything from it using brute force (or "try and see what happens") – instead we must gain deeper understanding and modeling of the underlying principles, complications and pitfalls, followed by a long-term and systematic effort to reach our goals.

**Funniest moments** When I started working for HD Technologies in Manchester, there were only few of us but it was like being a crew in a U-boat, working long hours in a close proximity. Learning the great British art of understatement was very amusing during those times. As was my colleague's inability to remember I drank tea without milk.

*Feature article:* [tas.txp.to/1015/Makarov](http://tas.txp.to/1015/Makarov)  
 See page 48 for more.

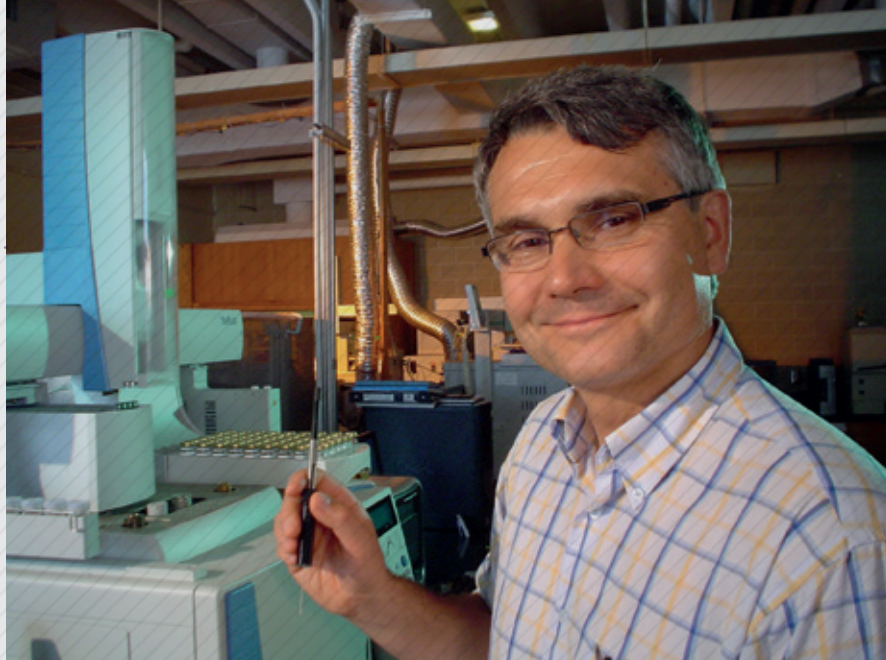


14

### Janusz Pawliszyn

Professor, Department of Chemistry,  
University of Waterloo, Ontario, Canada.

Most important lesson I learned that it is helpful when developing new science ideas to work with scientists who share the passion for the particular research direction. Encounters with serendipity Early in my career I discovered the significance of concentration gradient detection while investigating photothermal effects at the electrode interface. This work eventually led to development of microfluidics systems for capillary electrophoresis based on single point and whole column imaging detectors. Eye on the horizon Further development of mass spectrometry instrumentation will



have a dramatic impact on the practice of analytical chemistry. The number of new approaches based on rapid chromatography/MS, direct sample preparation/MS and direct sample introduction/MS will grow. Miniaturization of MS and front end

devices will result in devices facilitating on-site multicomponent analysis, resulting in rapid diagnostic tools in hospitals, rapid screening methods for food quality determinations, and monitoring approaches for environment.



13

### Paul Haddad

Emeritus Distinguished  
Professor, Australian Centre  
for Research on Separation Science,  
University of Tasmania, Tasmania, Australia.

Most important lesson To be persistent in your endeavors and goals, even when things are not working out the way you had hoped. Encounters with serendipity Serendipity was a common occurrence when we regularly consulted paper copies of journals rather than electronic versions. With the paper copy you sometimes encountered an article that was on the adjacent page to the one you were reading and that article then turned out to be pivotal in your future research directions. Sadly, with electronic databases you find only what the search engine provides and the magic of serendipity is lost.

Feature article: [tas.txp.to/1015/Haddad](http://tas.txp.to/1015/Haddad)

11

### Barry Karger

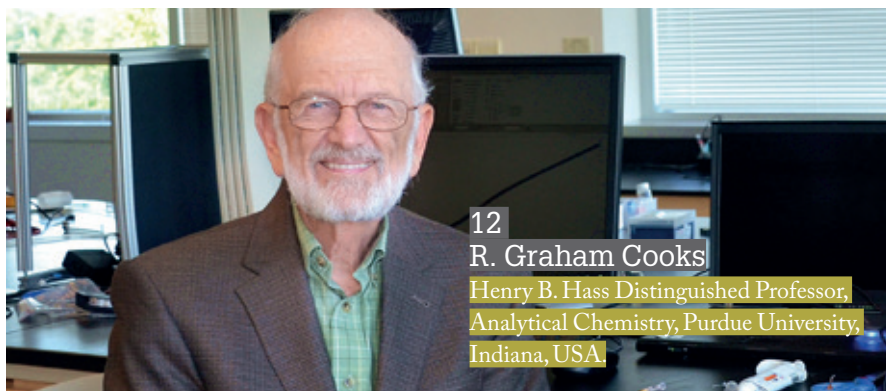
Director, Barnett Institute;  
Distinguished Professor and  
James L. Waters Chair in Analytical  
Chemistry, Northeastern University,  
Massachusetts, USA.



Most important lesson There are many lessons learned, but perhaps the most important is that science continually changes, and we have to change with it. We can't be afraid of going in new directions, in

fact, that prevents us from getting bored. Most unexpected outcome In the Human Genome Project, Molecular Dynamics used a linear polyacrylamide polymer we developed for sequencing by CE. They designed the instrument with a maximum column temperature of 43 °C, which was unfortunate; they could have sequenced 200-300 more bases per run at 70 °C. It's an example of where (not) understanding the fundamentals of a process can have a major effect.

*Sitting Down With interview:*  
[tas.txp.to/1015/Karger](http://tas.txp.to/1015/Karger)



12

### R. Graham Cooks

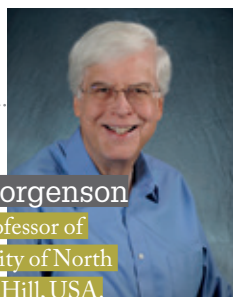
Henry B. Hass Distinguished Professor,  
Analytical Chemistry, Purdue University,  
Indiana, USA.





10  
**Richard Zare**

Marguerite Blake Wilbur Professor in Natural Science, Stanford University, California, USA



9  
**James (Jim) Jorgenson**

W. R. Kenan, Jr. Professor of Chemistry, University of North Carolina at Chapel Hill, USA

Most important lesson Relax, be patient, and enjoy the journey.

Encounters with serendipity I cannot think of a significant instance of serendipity, which is surprising, as I certainly feel that I have been very fortunate in my work.

Eye on the horizon It's time for a shocking, blockbuster, paradigm-shifting development in chemical separations. Such a development is overdue. That's no doubt wishful thinking on my part, but I would love to see it happen. Right now, I am most impressed with trends in miniaturization. The ability to easily carry (not lug) truly sophisticated analytical instrumentation to just about any location could have amazing consequences.

Feature article: [tas.txp.to/1015/Jorgenson](http://tas.txp.to/1015/Jorgenson)



8  
**Daniel Armstrong**

Robert A. Welch Distinguished Professor, Department of Chemistry and Biochemistry, University of Texas at Arlington, USA

Most important lesson If you have imagination and work harder (and more effectively) than others, you are likely to be successful. Create fads rather than following them.

Most unexpected outcome Most unexpected was the fact that our initial work in chiral molecular recognition rapidly morphed into a practical commercial technique (enantiomeric separation) that changed the pharmaceutical industry and regulatory focus. Even more surprising was that, over a decade later, billions of dollars were being spent in lawsuits between generic and more "mainstream" drug companies.

Sitting Down With: [tas.txp.to/1015/Armstrong](http://tas.txp.to/1015/Armstrong)



7  
**Peter Schoenmakers**

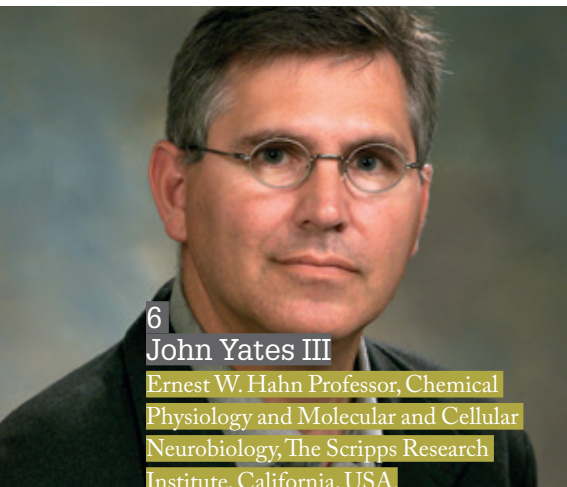
Education Director COAST; Editor, Journal of Chromatography A; Professor, Analytical Chemistry/Forensic Science, van't Hoff Institute for Molecular Sciences, University of Amsterdam, The Netherlands

Most important lesson Expected results are pleasing, but unexpected results are much more interesting. Of course, the correct application of analytical science requires that most of our experiments are performed in a repeatable manner. However, in scientific research, unexpected results herald progress. Encounters with serendipity My best unplanned project came about on the way back from Vienna from a conference. A Philips plane was returning from Vienna half empty, and I got rescheduled from an airline flight to the company plane. At the time, I was interested in artificial intelligence – we were working on expert systems – and I bumped into Frans Sijstermans (who was similarly rescheduled) and found out that he was into parallel computing. We got some manpower from Lutgarde Buydens' group in Nijmegen, used half of the nodes in a parallel computer (without anyone noticing), and obtained really nice results on neural networks...

Funniest moment The funniest thing I ever came across was the most-sensitive LC detector ever - the Post-column Explosion Detector (it was meant to be a post-column-reaction detector, but the reaction was a bit too fast.) It worked only for one peak (and after rebuilding, one more peak, so it proved repeatable). The details of this highly exciting experiment in Barry Karger's group were, unfortunately, never published.

Eye on the horizon My field, analytical separations, is far from mature. There is a great need for better separations of all kinds of complex mixtures – and we need breakthroughs to fill these needs. My group is in a good position because we have three candidates for the next "Top 40 Under 40" Power List; we need excellent young scientists to bring the field further. Indeed, the Top 40 under 40 is perhaps more important than The Power List...

Sitting Down With interview: [tas.txp.to/1015/Schoenmakers](http://tas.txp.to/1015/Schoenmakers)



**6**  
**John Yates III**

Ernest W. Hahn Professor, Chemical Physiology and Molecular and Cellular Neurobiology, The Scripps Research Institute, California, USA.

Most important lesson Tenacity is most important.

Encounters with serendipity Maybe, but there have been many more “aha” moments. One of the first was when I first tried to search tandem mass spectra through a set of sequences and it worked well. I expected it not to work.

Most unexpected moments It’s always interesting to see famous people on airplanes. I was once flying to Germany on a business class ticket and, as I was alone, I was upgraded to first class and ended up sitting behind the actor Nick Nolte. I’ve sat next to G. Gordon Liddy of Watergate fame and across the aisle from the US Supreme Court justice John Paul Stevens on flights. For the Star Trek fans, I was once on a flight with Seven of Nine...

Eye on the horizon I expect there to be a push to make proteomic technology better so that it can tackle increasingly complicated problems – in particular, I think proteomics needs to develop a capability for massively parallel analyses.

Feature article: [tas.txp.to/1015/Yates](http://tas.txp.to/1015/Yates)

**5**  
**George Whitesides**

Woodford L. and Ann A. Flowers University Professor, Department of Chemistry and Chemical Biology, Harvard University, Massachusetts, USA.



Feature article: [tas.txp.to/1015/Whitesides](http://tas.txp.to/1015/Whitesides)



**4**  
**Pat Sandra**

Emeritus Professor, Organic Chemistry, Ghent University; Founder and President, Research Institute for Chromatography, Kortrijk, Belgium.

Most important lesson Never go in (scientific) competition with colleagues or organizations that are stronger or have more possibilities than yourself... try to collaborate.

Encounters with serendipity Stir bar sorptive extraction was invented (by accident) through a controversial discussion in the literature on the absorption-adsorption properties of polydimethylsiloxane (PDMS). Our observations on the partitioning mechanism between water and PDMS were called into question. Solid phase microextraction with a PDMS fiber of polychlorobiphenyls spiked in water indicated that adsorption was taking place because the log P value controlling the PDMS/water distribution was not followed. However, repeating the experiment, we came to the conclusion

that most of the PCBs were adsorbed on the Teflon stir bar used in the experiment. Within a minute, we came up with the idea to coat stir bars with PDMS, resulting in a very sensitive new sample preparation method. Thousands of stir bars, commercialized as Twister, have been sold since that time.

Most unexpected moment By far the most unexpected thing that happened – and which was, in the end, of utmost importance in my career development – was the Belgian dioxin crisis in 1999. I was able to prove the link between dioxins present in our food and contamination with transformer oil or polychlorobiphenyls (PCBs). The result was that analysis of food could be restricted to PCB analysis rather than the very expensive, time-consuming and ultra-trace dioxin analysis via capillary gas chromatography hyphenated to high-resolution mass spectrometry. Just imagine more than 50,000 samples being analyzed by the latter technique!

Sitting Down With interview: [tas.txp.to/1015/Sandra](http://tas.txp.to/1015/Sandra)





3

### Jonathan Sweedler

Editor-in-Chief, Analytical Chemistry; James R. Eiszner Family Endowed Chair in Chemistry and Director of the School of Chemical Sciences, University of Illinois at Urbana-Champaign, USA

Most important lesson I think one of the most important lessons I haven't learnt is how to say "no" to the many requests I receive. I do try, but it never seems to work for me. My colleagues and friends tell me I do too much – but I think it's simply that I have too many things on my plate. However, one of the important things I have learnt is that I will pick important but difficult research goals and I keep moving towards them no matter the intervening challenges or obstacles, which clearly keeps me on target.

Encounters with serendipity I didn't expect to become editor of Analytical Chemistry. The job fell into my lap without any advanced thought or preparation – it just happened! I'm really enjoying the job, although it takes up a lot of my time.

My whole career is really just a collection of what seem to be fairly random events. My passion for analytical chemistry was ignited by working at the LBNL for

three consecutive summers. Had I not gone there, I may have ended up doing something completely different. Most people could say something similar, and I think that I got to where I am now through random events and mentorship by great people like Richard Zare and Richard Scheller at Stanford University. I see people like them as the hallmark for the rest of my career. Research is different though and I don't think serendipity has much of place; I consider research to be a continuous effort to solve problems.

Eye on the horizon There are a number of areas that are getting a lot of press attention and are obviously important; for example, the integration of various techniques with nanoscience, portable analysis through microfabrication, the advances in mass spectrometry instrumentation, and informatics driving new types of analysis. And then there's the big data problem...

2

### Robert (Bob) Kennedy

Hobart H. Willard Distinguished University Professor of Chemistry, Chair of Chemistry, College of LS&A; Professor of Pharmacology, Medical School, University of Michigan, USA

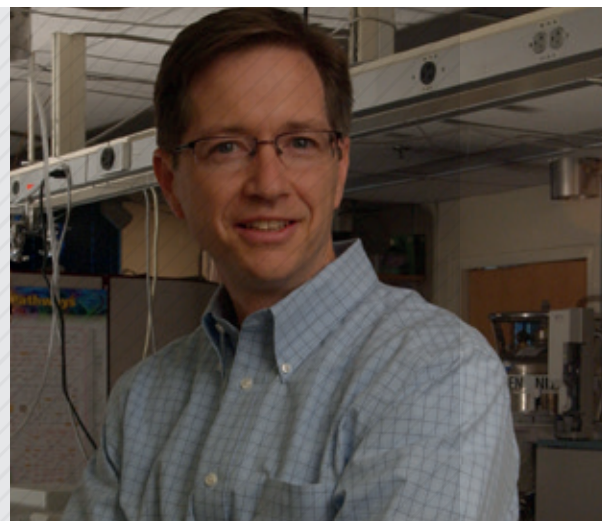
Most important lesson The most important product of my research is not my papers or patents but trained people who can go off and achieve what they want to achieve.

Another practical lesson is that there is no such thing as an "easy" starter project. I used to think that it was good to have people start on projects that eased them into doing research, but actually those took just as long as the more ambitious sounding projects. So now we just start on what we really want to do.

Funniest moment I'm not sure it is funny, but I was stunned at how quickly I got

pushed out of the lab by the quality of my own student's work. I specifically remember showing Lan Huang, one of my first students, how to use an electrode we had developed to measure insulin secretion from single cells. Lan worked on it over the weekend and on Monday morning she said something like, "I don't think I'm doing this right. Here is what I got." And of course she had beautiful signals. They were so much better than mine that she thought she was doing something wrong. That was it for me in the lab.

Of course, we've had many funny things happen in the lab and at conferences over the years. One amusing "Spinal Tap" moment happened when my student Zech designed a light-tight box to cover a laser induced fluorescence detector he built. He sent the order to our shop but apparently they didn't get the message



that it was drawn 1:10 scale. We received a perfect miniature box, complete with little hinges and latches. The craftsmanship was excellent – if only it had been the right size. I'm not sure how they thought this would hold a complete LIF detector...

*We Sit Down With Bob Kennedy on page 50.*





**1**  
**Rudolf (Ruedi) Aebersold**  
Deputy Head, Department of Biology,  
Institute of Molecular Systems Biology,  
ETH Zurich, Switzerland.

Most important lesson Understanding the importance of the research environment, specifically the colleagues around you, which includes your immediate lab group, but also the scientists in the broader environment. Great colleagues are an inspiration, judges of ideas, a resource for innovation – and they make work pleasant and fun.

Encounters with serendipity I never really had a master plan for my career. Great job opportunities came about from unexpected angles and new lab members brought ideas or skills that greatly enriched our research portfolio or drove our research in new directions. Such an occurrence was

the opportunity to recruit the first group members with a computational background from the Institute for Systems Biology in Seattle. They have transformed our work, the group structure, and our research approach. Most unexpected outcome I was trained as a cell biologist at a time when computers did not really matter in biology. So perhaps the most unexpected outcome is that some of the significant achievements of our group are algorithmic/computational. The early computational work was based on urgent needs and serendipity. We recognized the demand for new algorithms for data analysis and we were able to recruit, largely through the philosophy at the ISB, a terrific initial cadre of computational scientists into our group. Eye on the horizon I will continue to work with my relatively large group of around 30 members for another four years, but

then the labor law in Switzerland demands that I retire.

I think that my field will continue to rapidly grow in size and significance because we finally have very robust proteomic technologies to learn new biology and make headway in the translational arena. I see a broader dissemination of proteomics, outside the traditional proteomics groups and I see a significant development of computational and data management systems in the cloud, further democratizing large-scale proteomics.

In general, I think that the current tough funding climate will favor advances in analytical sciences that can demonstrate a relatively timely impact via their application to urgent problems.

*Sitting Down With interview:*  
[tas.txp.to/1015/Aebersold](https://tas.txp.to/1015/Aebersold)

## Orbitrap™: Ten Years Young

**Coupling gas chromatography with Orbitrap™ technology wasn't easy, but the outcome – the introduction of the Thermo Scientific Q Exactive™ GC – represents a big step towards bringing full-scan, high-resolution, and accurate mass data into routine labs around the world. And my dream of an “Orbitrap in every lab” inches ever closer.**

*By Alexander Makarov, Director, Global Research Life Science Mass Spectrometry, Thermo Fisher Scientific, Germany.*

We started thinking about GC Orbitrap technology a long time ago – very soon after the dust had settled following the launch of the first commercial instrument at the June 2005 ASMS Conference in San Antonio, Texas – the LTQ Orbitrap tandem mass spectrometer. But back then it was clear that one or two second peaks were too narrow for the wide application of Orbitrap technology in GC. Nevertheless, Joshua Coon (a professor at the University of Wisconsin-Madison) expressed an interest and we initiated a research project to look at the potential. Originally, the project was simply a continuation of the mainstream work in his lab, which focused on electron transfer dissociation (ETD) for the LTQ Orbitrap instrument. At that time, ETD utilized anions that essentially came from the ion source of a GC quadrupole system, and so the connection was relatively straightforward. Indeed, the work resulted in the first rudimentary GC Orbitrap system. The initial data proved that there was high potential, but also indicated some challenges.

Amelia Peterson (from the Coon Research Group) came to the Thermo Scientific research lab in Bremen, Germany to continue work on the GC-MS-LTQ Orbitrap instrument and, on her return to UW-Madison, presented several applications in high-impact journals. Although the projects were only exploratory in nature, they proved invaluable in allowing us to gauge interest in GC-Orbitrap technology – and a number of customers began asking for more information.

### An essential confluence

In reality, we were not able to communicate any fixed date about GC Orbitrap technology to our customers. We needed to fully assess what was needed in the market and put together an entire development team – and Orbitrap technology was still not ready for GC.

Over the next few years, information was gathered and the potential became clearer – but, more importantly, Orbitrap technology development continued. By 2011, we had increased the speed of the Orbitrap by a factor of four, by combining two innovations: i) enhanced Fourier transform algorithms, which doubled resolving power, and ii) the high-field “compact Orbitrap” (where an increase from 3.5 kV to 5 kV boosted frequency by 20 percent and the smaller trap provided a factor of 1.8 increase in speed.) Finally, we had an Orbitrap analyzer that was completely compatible with GC separations. At the same time, a talented development team became available in Austin, Texas, which could take on the not insignificant challenge of giving GC its first new mass analyzer in half a century.

Without these streams coming together, we could not have moved forward; the confluence of user demand, increased Orbitrap capability (in terms of speed, sensitivity, mass accuracy and selectivity), and the necessary resources gave us the critical mass we needed to



begin in earnest. At which point, the ball started rolling very quickly.

What Orbitrap technology means for GC – and vice versa

At ASMS 2015, exactly 10 years after the introduction of the LTQ Orbitrap system, we launched the Q Exactive GC – an excellent way to celebrate Orbitrap's anniversary. What does Q Exactive GC offer the world of GC-MS? The real breakthrough is the combination of accurate mass with high sensitivity. Imagine a triangle of mass accuracy, sensitivity and speed – traditionally, optimization of mass accuracy comes at the sacrifice of the other two factors. Instruments that were not constrained by mass accuracy – triple quadrupoles, for example – were far ahead of the game in terms of sensitivity and speed. On the other hand, the only accurate mass instruments – time-of-flight systems – suffered from a severe compromise in other features. In other words, the size of the triangle is limiting. Orbitrap technology expands the triangle so drastically that we can now match the speed and sensitivity of triple quadrupoles, but at the same time provides high mass accuracy and resolution.

Since its launch, I've been pleased to see an extremely enthusiastic reception to the Q Exactive GC from the community. People are excited to learn how their

samples behave; we've already shared stories from Hans Mol in pesticide analysis, Karl Burgess in metabolomics, and Jana Hajšlová in food authentication in this article series – and I think there will be many more interesting stories to be told as the technology is adopted in labs around the world.

GC is an interesting addition to Orbitrap technology as it combines high resolution GC separation (with its large peak capacity) with the high resolving power (and mass accuracy) of the Orbitrap mass analyzer. The combination allows us to look deeper into the volatile and semi-volatile end of the analytical spectrum than we have done before – and with high clarity. Moreover, classical GC-MS with electron ionization reduces the need for MS/MS analyses, making straightforward full scan a routine mode of operation, without losing vital fragment information.

Indeed, we were surprised how far simple full-scan MS analysis could take us, using a combination of spectral library matching (with the vast, commercially available nominal mass libraries) and high resolution-accurate mass filtering. Acquisition using MS/MS is still important, but is typically used with chemical ionization mode in the search for further structural information about a compound for higher level confirmation – or, of course, to help us build an understanding of a compound that is not known and does not appear in libraries. The point is that, even though the technology appears to be more complex, the high resolution and accurate mass gained actually make analyses simpler, reducing the need for tedious method development. I think that has surprised a number of experienced analysts.

Clearly, Orbitrap brings something very new to GC – but the innovation also means that our technology is stepping outside its more traditional setting in life

science applications. For me personally that means a lot, because I believe that the combination of easy mass accuracy and sensitivity could benefit many other types of analysis – we just need to look further into where unique advantages can be gained.

We also learned a lot in the development process, for example, how to reduce or completely eliminate ion molecule reactions, which were not present in electrospray produced ions, but were visible for ions produced by electron impact ionization. And we have now adopted a modular approach – the Orbitrap is one module that can be combined with a number of different front-end modules (ion sources). And excitingly, we now have two product development lines – one for LC and one for GC. Though the Q<sub>Exactive</sub> GC is an important milestone in Orbitrap history, rather than considering that it completes the story, I like to believe that it is the beginning, with more expansion ahead.

#### Orbitrap trajectory

I can foresee several different trajectories for Orbitrap technology; for example, analysis of aerosols and other ion sources. And we have even discussed the potential of sending Orbitrap technology into space with various agencies – Orbitrap in orbit! Certainly, we are keen to investigate any area where the combination of analytical qualities that Orbitrap technology provides can add real value – and that takes time. But where serious opportunities exist, we will be pushing the boundaries of what is possible.

I would consider Orbitrap game-changing or even disruptive technology – especially now that we've entered into the world of GC with the Q<sub>Exactive</sub> GC – but I don't think all other MS technology will (or should) retire just yet. If we look back at the history of mass spectrometry, even some of the earliest examples of hyphenated analyzers, such as magnetic

sector instruments, are still leading in those areas where they confer a distinct advantage – and there are probably more magnetic sector instruments produced today than 30 years ago. Yes, we will see expansion and contraction of market share, but each will retain its own niche – and it really depends how attractive those niches are. Certainly, LC and GC applications are growing rapidly, with thousands of instruments worldwide, so this area often gets all the limelight – and here I expect Orbitrap technology to continue expanding at a higher rate than other analyzers. Why? Because it is fundamentally simple technology; it uses three electrodes with one voltage and its data system is a conventional PC. As a result, it has the potential to be competitive to quadrupole instruments in terms of investment.

We're not quite there yet – after all, we are working at the edge of what humanity can provide in terms of electrode accuracy and electronics stability – but the simplification trend has already begun; for example, if you consider the evolution from LTQ Orbitrap with five turbomolecular pumps to Q<sub>Exactive</sub> with two, you can see the tendency to use acquired knowledge and advances to decrease complexity and increase accessibility. Another example is the introduction of the Q<sub>Exactive</sub> Focus – specifically for heavy workloads in environmental and food safety – at a price that is comparable with high-end triple quadrupoles. In other words, Orbitrap is on a continually shifting pathway – and I hope that will continue for years to come.

In the end, the simplicity of the Orbitrap analyzer's design will be key to the future simplification of the technology – at that point, my dream of an "Orbitrap in every lab" starts to sound realistic.

*Video interview with Alexander Makarov: [tas.txp.to/1015/MakarovGC](http://tas.txp.to/1015/MakarovGC)  
To find out more: [thermoscientific.com/QExactiveGC](http://thermoscientific.com/QExactiveGC)*



## A Taste of the Other Side

**When Richard Fussell still worked at the UK's Food and Environment Research Agency, he was the first customer to see the Thermo Scientific Q Exactive™ GC in action – well ahead of its official launch at ASMS 2015. The latest Orbitrap™ innovation made him wonder – not for the first time – if the grass was greener on the other side.**

Take us back to your pre-Thermo Fisher Scientific days...

I worked in government laboratories for a very long time before moving to Thermo Fisher Scientific – latterly at the Food and Environment Research Agency in York, UK, working on a diverse range of projects, spanning many research areas, techniques and applications. Throughout those years, I very often found myself working in close collaboration with different manufacturers, helping to guide new and emerging technologies. As an analytical scientist, I always found it very exciting to be involved in such developments, contributing to advances and progress in the instrumentation we used on a daily basis.

My entry into the world of analytical chemistry, which actually began in the 1970s, was a little unconventional. I come from a working-class family of electricians, carpenters, plumbers, and so on. I was never great (or perhaps interested enough) at school and when I left, I went into the building trade. I remember one particularly nasty day in winter when my van broke down and I was late for my own birthday party. The very next day, I applied for – and got – a job in a laboratory.

From there, I moved into a government laboratory – who paid for my education up to MSc level, and the rest is history.

So much has changed since those early days. I remember when I first started doing chromatography, we used a hacksaw and a file to cut and polish stainless steel tubing when building our own LC systems...

Why jump the fence?

Over the years, I received quite a few tempting offers from instrument companies – even as far back as the 1980s. I was always intrigued by the prospect, but never quite attracted enough to make such a leap of faith. But when the recent opportunity to join the team at Thermo Fisher Scientific ahead of the launch of an exciting new addition to the portfolio came along, the timing seemed right. Why Thermo Fisher Scientific, specifically? I honestly believed that Orbitrap technology was the best in the field, so it seemed like the winning team.

And that was confirmed when I visited Austin, Texas, to see the pre-launched Q Exactive GC. I was amazed; the performance of the instrument was almost unbelievable. Aside from the technology, one of the things that really impressed me was how open they were. We had such great discussions – and it really felt invigorating to be involved. Furthermore, it was a really nice atmosphere, and it seemed to me that I could learn a lot – not just in terms of the technology, but other skills as well. When you've worked in a particular environment for a long time, you have to be careful that you don't get stale. Looking back, maybe I should have challenged myself at an even earlier stage, but that's just the way it worked out...

How has GC-MS changed?

I remember when GC-MS was first introduced into our laboratory (when it had finally become affordable enough). We started with GC-single-quadrupole MS, which had certain limitations but



was the best we had at the time. And in the early 2000s, GC triple quadrupole MS systems came along, which added a lot of advantages, both in terms of the selectivity and the signal to noise we could obtain for pesticides residue analysis. We could suddenly analyze more pesticides in even more difficult matrices, just because of the extra selectivity.

But despite the advantages, I guess I wasn't alone in hoping for a full-scan acquisition technique that would allow us to capture as much information as possible. That is possible with single quadrupole instruments, but the problem is sensitivity – and the selectivity isn't great either.

It seems the Q Exactive GC was highly anticipated in your field?

Absolutely. GC Orbitrap technology takes us a big step forward by essentially combining the advantages of all techniques in one platform: much better sensitivity in full-scan acquisition mode, and better selectivity because we've got high resolution combined with high mass accuracy. Back in the days when we were using single quadrupole systems, I don't think anybody could have predicted we would get this far – that we would develop cutting-edge instrumentation to the point where it could become a routine technique.

Certainly, concurrent developments in computer science and electronics have been crucial... The first computer I used in a laboratory was a ZX Spectrum, so to get to where we are now, there really have been quantum leaps on many levels.

What makes QExactive GC so attractive for food analysis?

You have to remember that the whole area of residues, contaminants, and food safety has changed dramatically over the years – and there are a lot of other changes going on at the moment. For example, interest in authenticity and food integrity is burgeoning – looking at the bigger picture is becoming increasingly important. Orbitrap technology not only gives us the capability to look at residues and contaminants, but allows us to tap into other aspects. A good example is the whisky profiling and characterization work described by Jana Hajšlová last month ([tas.txp.tp/1015/jana](http://tas.txp.tp/1015/jana)).

How quickly will it be adopted?

It won't happen immediately, of course. Introduction of new technology is an evolutionary process. The bigger research laboratories are often the first adopters; they often want to investigate the potential of the technology – and also push extra development. The smaller labs will follow. Years ago, we were one of the first labs to use an LC-MS/MS method, and I remember giving a presentation on the multi-residue analysis of about 30 pesticides. People couldn't believe it could be a robust, routine technique – now everyone's using LC-MS/MS. It's hard to believe that the same won't happen with GC-HRAM technology. You can take your sample; do the quantification, the identification – and the screening – all in one single analytical run.

As with any new technique, affordability will be perhaps the biggest barrier. But that too will change. As Alexander Makarov notes on page 48, Orbitrap technology is

constantly evolving, which increases the knowledge base and reduces cost. For example, on the LC side we now have the Thermo Scientific QExactive Focus, which is an Orbitrap-based instrument intended for routine implementation at a more competitive price.

What about the future of food analysis?

New instrumentation empowers people to do and look at things differently. It's already the case that labs are trying to combine different analyte classes in analytical methods; for example, looking at pesticide residues and mycotoxins in the same analysis. Traditionally, these areas have been separated; I suppose the laboratories become compartmentalized – constrained by the instrumentation and methods available.

I see a future trend where, for certain samples, you'll be able to look for multiple analyte classes in the same method, or perhaps test for pesticide residues at the same time as collecting data for characterization or authentication. Similarly, there is a growing interest in looking for environmental contaminants – I've looked at the uptake of pharmaceuticals in plants caused by the use of treated sewage effluent on land, for example. It's surprising how many pathways exist for contaminants to get into food. And let's not forget food contact materials – John Gilbert goes into much more detail on page 28, but it is yet another separate world of contaminant analysis. The real driver for moving in this direction is the capability of the instrumentation available.

Another trend I see developing is using full-scan instruments to detect markers to help food manufacturers ensure product consistency from a quality control point of view. With global food trade, raw ingredients come from many different sources and are difficult to track. The use of chemicals varies over the world – as do the potential routes of contamination. I believe food

manufacturers will increasingly want to screen their raw ingredients to ensure that the whole finished product is consistent over time. They certainly don't want any surprises that would undermine consumer confidence.

Do you feel like instrument manufacturers are leading the charge?

Many of the potential trends I've indicated above would really not be possible without HRAM technology – so it does appear that in some aspects, analytical laboratories are very much dependent on the development of new instruments to be able to move forward in new directions. Certainly, not everybody recognizes that fact, but even if you consider something as simple as the QuEChERS method, would it really have become so successful without the introduction of LC-MS/MS?

And is the grass greener?

I've seen a lot of changes over my career – and many of the big ones came from instrument manufacturers. I think that's one of the reasons I recently decided to make a pretty big change for myself when I joined Thermo Fisher Scientific. Luckily, people from my old world still talk to me, even though I've crossed over to the "other side". And that's important – I made some great friends over the years on the conference circuit and beyond. Now, I've been on both sides of the fence – and I consider myself a mediator of sorts. In my current role, I can make sure we are communicating effectively with our customers and perhaps facilitate the kinds of collaborations I enjoyed in my previous life. I'm very happy to be where I am at this exciting time, and as for whether the grass is greener – well, that would be telling...

*Video interview with Richard Fussell:*

[tas.txp.tp/1015/Fussell](http://tas.txp.tp/1015/Fussell)

To find out more: [thermoscientific.com/QExactiveGC](http://thermoscientific.com/QExactiveGC)



# Supercharging Correlative Microscopy

## Solutions

*Real analytical problems  
Collaborative expertise  
Novel applications*

Equipping scanning electron microscopes with Raman imaging to create a 2014 Innovation Award-winning universal microscopy solution.

*By Olaf Hollricher*

### The problem

Efforts to combine different high-resolution imaging techniques to provide the most comprehensive material property characterization are on the increase. For example, it is possible to show the structure of a sample with scanning electron microscopy (SEM) and determine its molecular composition with a Raman microscope. As these methods require separate instruments, an inevitable complication is sample transfer and re-identification of the investigated area. Is there a way to dispense with this tedious procedure and replace it with a simple – ideally, one-click – operation?

### Background

Correlative microscopy involves using two or more microscopy technologies on the same sample area. Over the past decade, the need to describe nanometer-scale samples in full detail has elevated the importance of this combined approach. High-performance analytical techniques relevant to correlative microscopy include, among others, optical microscopy, SEM, atomic force microscopy (AFM), tomography, energy dispersive X-ray (EDX), focused ion beam (FIB) and secondary ion mass spectrometry

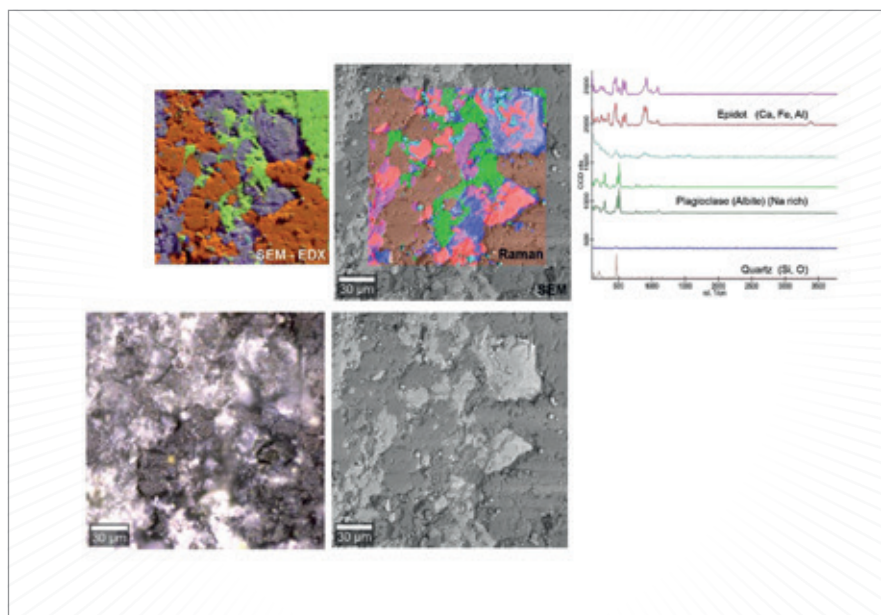


Figure 1. RISE microscopy investigation of a thin section of a drill core from the Äspö Hard Rock Laboratory (Oskarshamn, Sweden). Top: The RISE image is a composite of the SEM (bottom right) and Raman images. The Raman spectra indicate epidote (red), plagioclase (green), and quartz (brown) as well as four additional, unspecified minerals (top right). The elemental composition of the material was determined with EDX (top left: Ca, Fe, Al: grey; Si, O: orange; N: green). Bottom: Comparing the light image (left) with the SEM image (right) of the sample reveals that the images look completely different though they are of exactly the same area.

Image parameters: 100 µm x 100 µm, 150 x 150 pixels = 22,500 spectra, Integration time: 0.08 sec/spectrum. Sample courtesy of Christiane Heim, Geoscience Centre, University of Göttingen, Germany.

(SIMS). Linking the data sets enables the correlation of structural, morphological and chemical information, which provides

a more detailed understanding of the material investigated.

Correlative microscopy may appear

advantageous, but it has substantial technical challenges, which makes experiments cumbersome. Moreover, shuttling from one microscope to another may affect the sample's integrity. However, the primary problem is precise retrieval of a sample's area of interest, which means you have to rely on fiducial marks or feature recognition. Both procedures are painstaking and time-consuming.

Integrating multiple technologies in a single platform to create a hybrid system has been a distinct step in the right direction. For inspecting biological samples, for example, the combination of fluorescence microscopy and SEM has proven useful. In materials science and geology, however, different combinations of optical microscopy with AFM, SEM and EDX are popular.

SEM is a very powerful technique for investigating almost any sample that can endure a vacuum environment and it is able to zoom continuously from a field-of-view up to 100 mm in diameter down to a resolution of approximately 1 nm. Despite its extremely high resolution it also has a remarkable depth-of-field, giving images that have great clarity and 3D texture. SEM, however, does not reveal the composition of a sample and, therefore, EDX is often incorporated to identify elemental constituents. Although useful, EDX cannot offer insight into the arrangement and coordination of the detected atoms and their chemical bonds – that particular characterization is best accomplished with Raman spectroscopy. Every compound has a unique Raman spectrum, thus displaying “chemical fingerprints” within the investigated material. This method is non-destructive and doesn't require labeling or other sample preparation.

Although a combination Raman/SEM product was already available, it could only perform Raman measurements at individual points and wasn't capable

of obtaining complete images. The problem with only acquiring a single Raman spectrum is that you never know from exactly which point in the SEM image the spectrum was taken. Even after a flawlessly executed calibration, the focus can move due to thermal drift and charging effects. These effects can easily result in a displacement of 5 µm or more; a distance greater than generally acceptable in correlative studies. However, now we can overlay an image linking measurements precisely and reliably, and this provides an expedient method for alleviating drift.

#### The solution

One day Jaroslav Jiruse, head of R&D at the SEM manufacturer Tescan (Brno, Czech Republic) called me to ask if WITec would participate in developing a “universal SEM” that combined several different analysis techniques with the imaging capabilities of SEM. The potential of Raman in combination with SEM was immediately apparent to me, so I was more than happy to agree to the collaboration (especially given our strong track record in correlative microscopy; for example, our Raman-AFM product was introduced in 2003). In April 2012, we officially began our three-year project (UniverSEM) funded by the EU within the FP7 framework.

Russian novelist and historian Aleksandr Solzhenitsyn once said, “The solution is always simple, one must only find it”. His words are so pertinent to research and development – and they made us think carefully about the challenges we were about to face when combining SEM and Raman microscopy. Firstly, during SEM imaging the secondary electrons scattered from the sample are detected by extremely light-sensitive photomultipliers, which are incompatible with the bright lasers required for Raman imaging. Clearly, we could not apply the techniques

## Measurement of trace organics?

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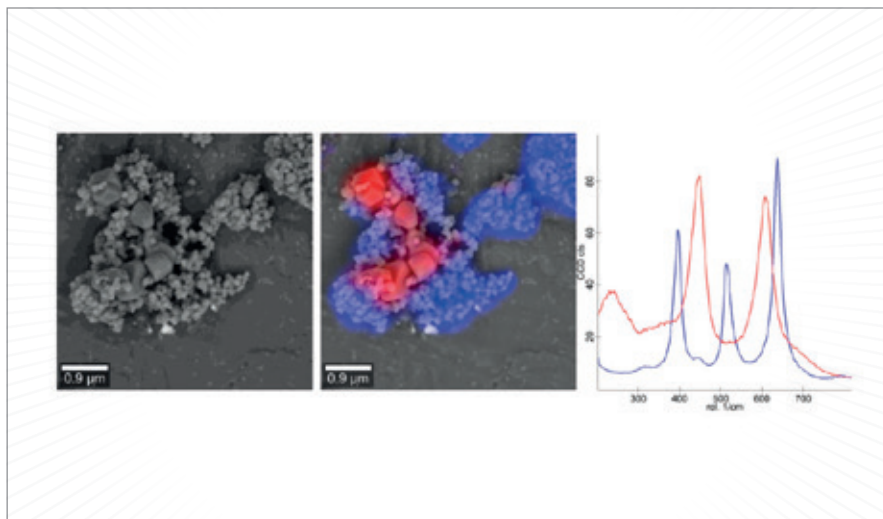


Figure 2. RISE microscopy characterization of rutile and anatase, two modifications of  $\text{TiO}_2$ . The SEM image (left) shows the size and structure of the crystals. According to their Raman spectra (right), rutile (red) could be easily distinguished from anatase (blue). Image parameters:  $12\ \mu\text{m} \times 12\ \mu\text{m}$ ,  $150 \times 150$  pixels = 22,500 spectra, Integration time: 0.037 sec/spectrum.

simultaneously. Secondly, the space inside the chamber and surrounding the SEM column is very limited; SEMs resemble abstract hedgehogs because all the tools orbiting the SEM column aim toward the same point: the sample. This is critically important because the resolution of an optical microscope is directly linked to its numerical aperture – the light cone angle of the objective available for excitation and detection. For a high-resolution objective, this angle is about 140 degrees, leaving precious little real estate for the SEM column itself, much less other detectors. Thirdly, a fully equipped Raman microscope needs several excitation sources (lasers) and spectrometers that weigh more than an SEM chamber's flanges can support (that is if space was available for attachment, which it isn't!).

We found Solzhenitsyn's simple solution to the first two problems by placing only the objective and scanner inside the vacuum chamber and changing the scanning procedure – we scan the objective rather than the sample. The location of the objective is offset from

the SEM column, freeing space for other detectors. After SEM imaging, the sample is simply transferred to the Raman position using the SEM stage. The numerical aperture of the objective can be optimized as the space above the sample is not shared with other detectors. And you can use a compact scanner because it only has to handle the objective and not samples of varying size and weight.

The modular nature of WITec Raman microscopes allowed us to overcome the third and final challenge: excitation sources and spectrometers are coupled to the instrument by flexible optical fibers, meaning that they can be placed far from the SEM chamber whilst always preserving alignment. In a system with "X" mirrors, there will "X" sources of misalignment. Moreover, modern fibers allow very efficient coupling of light, as they are more transparent than air.

Beyond the solution

We named the new technology "RISE" (Raman imaging with scanning electron microscopy) and presented it at Analytica

2014 just two years after the project was accepted for funding by the EU.

As the SEM and Raman components are essentially two systems using the same vacuum chamber, we didn't have to make any compromises regarding the respective imaging capabilities. The microscope achieves a lateral resolution of 360 nm and acquires complete Raman images with tens of thousands of data points that can be perfectly superimposed over the SEM image. This is a huge improvement over separate instruments, with shuttling executed at the push of a button and sample orientation preserved consistently. The new microscope enables software-driven quick and convenient switching between Raman imaging and SEM, transformation of the Raman spectra into an image, and the ability to overlay both images to produce a RISE image.

To explore and substantiate the capabilities of RISE microscopy we identified and imaged 2D materials, including (but not limited to) graphene and molybdenum disulphide ( $\text{MoS}_2$ ), mineral phases in sections of a drilling core, and polymorphs of titanium dioxide ( $\text{TiO}_2$ ).

We believe that correlative microscopy – exemplified by our RISE technology – will be of great benefit in solving many scientific questions when a single technology is insufficient. Others seem to agree: Photonics Media and the International Society for Optics and Photonics has recognized RISE with their Photonics PRISM Award 2015 as being the preceding year's most innovative development in metrology instrumentation. And it took a podium spot in The Analytical Scientist's Innovation Awards in December of the same year (<https://theanalyticalscientist.com/issues/1214/return-of-the-tasias/>).

*Olaf Holtricher is R&D Director at WITec, Ulm, Germany.*



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2015 Winners  
Andreas Seidel-Morgenstern (left)  
and Peter H. Seeberger (right)

**Who  
will be the  
winner in  
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**Nominations  
for the  
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## Trace LC-MS Analyses of Hormones in Potable Water and in Ultrapure Water

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Hormones are examples of contaminants of emerging concern (CEC) that have been detected in environmental and drinking waters around the world in trace amounts (1, 2). Even at very low concentrations, CECs could potentially exert ecotoxicological effects (3).

Liquid chromatography-mass spectrometry (LC-MS) is frequently used for trace hormone analysis to address concerns on environmental health and safety. These methods have very low detection limits, making it critical to avoid, or at least minimize, contamination during the experimental process. Indeed, components of the LC-MS instrument; the mass spectrometer (4); sample handling and manipulation (1); as well as the reagents and solvents used in the analyses, can all contribute to contamination issues.

Water plays an important role in LC-MS, where it is used extensively in the workflow. It is essential that the detected analytes come from the samples, and not from the water used in various steps of the experiment (such as in the preparation of samples, standards, blanks, and eluents; or rinsing/flushing of the HPLC and MS systems).

To evaluate the risk of hormone detection in the blanks and its effect on

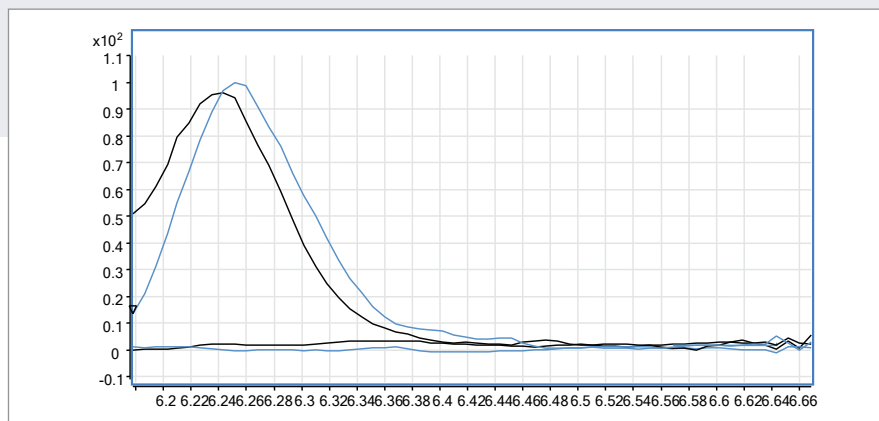


Figure 1. MRM chromatogram (ESI+) of estradiol in potable water and after purification using Milli-Q® systems.

Hormone	Concentration (ng/L)	
	Tap water	After purification
Estradiol (France, Spain)	265.40	ND
	297.92	ND
Androsterone (France, Spain)	515.33	ND
	1635	ND
Corticosterone (China)	14.91	ND

Table 1. Hormone concentrations in laboratory potable water and the product ultrapure water\*

\* All data reported are one-time, one-location data and are not representative of water in the various countries where samples were taken.

analyses, androstenedione, androsterone, corticosterone, cortisone, estradiol, estrone, progesterone, OH-progesterone, and testosterone were analysed by standard addition method in potable water as well as in Milli-Q® water produced from potable water using Elix® + Milli-Q® Advantage A10 water purification systems (China and Spain) and a Milli-Q® Integral water purification system (France). 1-liter samples were enriched by SPE prior to LC-MS/MS and analyzed in triplicate using an Agilent 1290 Infinity® HPLC coupled to an Agilent® 6420 Triple Quadrupole LC-MS system (ESI+, MRM), and using a Purospher® STAR RP-18 endcapped (2 µm) Hibar® HR50-2.1 column (EMD Millipore).

Table 1 summarizes the results of the LC-MS/MS experiment. Of the three potable water samples analyzed, estradiol and androsterone were detected in potable water in laboratories in France and Spain, while corticosterone was detected in the potable water sample from the Chinese laboratory. Figure 1 shows the MRM chromatogram of estradiol.

### Conclusion

Trace levels of hormones were detected in laboratory potable water samples using LC-MS/MS. After the potable water was purified using Milli-Q® water purification systems, the hormones were no longer detected. Milli-Q® water purification systems produce ultrapure water suitable for trace LC-MS analyses in environmental research.

### References

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# Determination of Lactose in Lactose-free Products Using HPAEC-PAD

**In many European countries, the limit of lactose in lactose-free labelled products has been lowered from 100 to 10 mg/100 g product in recent years (1).**

*Mareike Margraf and Dr. Kate Monks*

Special methods and systems are needed because classical determination of sugars in food products with RI detection is far too insensitive for this case. An HPLC method that easily reaches the required limit of detection (LOD) by using high-performance anion-exchange chromatography coupled to pulsed amperometric detection (HPAEC-PAD) is presented. After calibration, several food products were analysed to determine the lactose content.

**Method:** The system consists of a KNAUER AZURA analytical HPLC system coupled to a DECADE II electrochemical detector. A biocompatible HPLC system was used in order to eliminate the necessity of regular passivation. The mobile phase (30 mM NaOH) was continuously sparged with helium to keep it inert. The applied anion exchange column (RCX-10, 7  $\mu\text{m}$ , 250 x 4.6 mm) was stored in the tempered section of the DECADE II detector. The isocratic separation was carried out at 2ml/min and 30°C (column and flow cell). Injection volume was 50  $\mu\text{l}$ .

**Results:** A mixture of three sugars was analysed exemplarily and calibration was carried out for lactose (Figure 1).

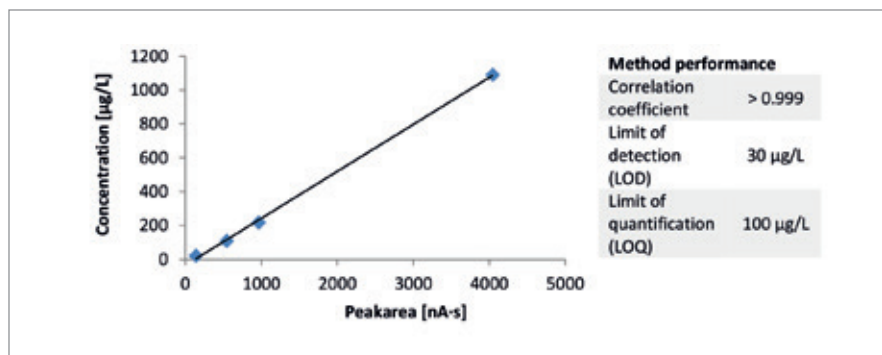


Figure 1. Calibration curve for the lactose concentrations in the range of 21.8  $\mu\text{g/L}$  to 1090.0  $\mu\text{g/L}$  and results for method performance

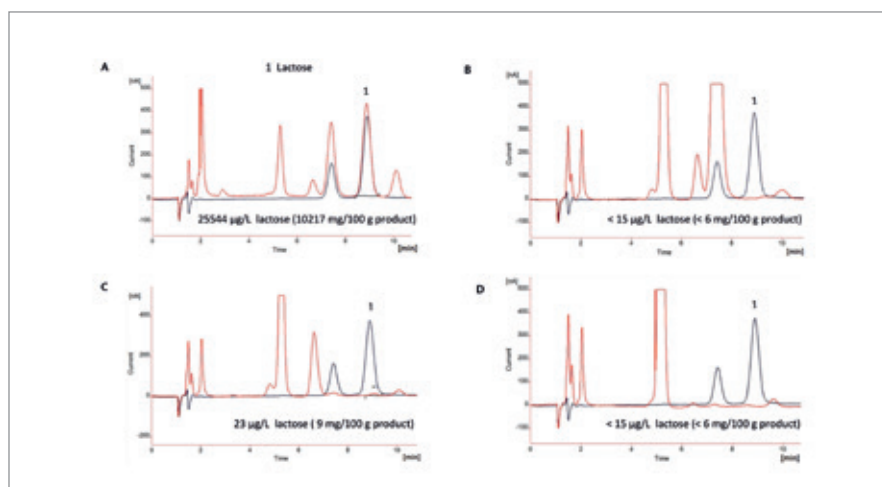


Figure 2. Chromatograms of food samples (red) with an overlay of the sugar standard (blue), samples: A: Chicken skewers, B: Meatloaf, C: “Paprika Lyoner” sausage, D: Nuremberg sausages. Calculated lactose concentrations and content per 100 grams also shown.

The analysis of four food samples from typical German food (Figure 2) shows that three of them were lactose-free even according to the new lactose limits given by the EU. The chicken skewers sample contained substantial amounts of lactose and could not be sold as lactose-free. The chromatograms show only little interfering matrix peaks, so that the analytes could be well separated and identified.

## Conclusion

The presented method of HPAEC-PAD on a KNAUER HPLC system proved to be well-suited to determine low limits of sugars in food products. The detection

principle was quite specific for sugars and only showed very little interference by matrix peaks. Using the AZURA analytical system combined with the DECADE II electrochemical detector, the analysis of lactose in lactose-free labelled products can be carried out in a robust and reproducible manner.

## Reference

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# The Bioanalytical Trendsetter

Sitting Down With... Robert (Bob) Kennedy,  
Distinguished Professor and Chair of  
Chemistry at the University of Michigan,  
Ann Arbor, USA, and Chair of the  
forthcoming HPLC 2016 conference  
in San Francisco.





How are you managing all of your current responsibilities?

It's pretty crazy right now. Being chair of the department is a full-time job – and chairing HPLC 2016 is also taking a good bit of my time. And, of course, I have my research group to run. Thankfully, I have a lot of support – and I'm trying to delegate things as much as I can. Once I get HPLC 2016 under control, I can cut back a little bit – 10-hour days, evening work and no rest at the weekend loses its appeal pretty quickly!

How did you become HPLC 2016 chair?

Simple – I was asked. And though I wasn't looking for more work, I've enjoyed so many conferences over the years – and truly recognize that they help the wider analytical community – so I thought it was about time to give a little something back.

One thing that will make next year's event great is the location: San Francisco. It's a wonderful city and there is a lot going on in biotech and biopharmaceutical spaces. We'll have an emphasis on those fields at the event, which will make it quite special. Another theme of the conference is personalized medicine; expect to see some excellent speakers from this growing field. I'm really excited and looking forward to it. Everyone reading this needs to put June 19 to 24 2016 in their diaries and plan to attend this special event!

How did you get into science?

I was always interested in science and I can remember being particularly interested in biology as a child. I'd watch natural history shows and was very interested in images of embryos developing. But, as I got older, I chose chemistry for practical reasons; I was doing well at it in school and I wanted to get into veterinary school (and

chemistry was one of the best routes). I was also fascinated by the mathematical side – the patterns that emerge from the Periodic Table and the stoichiometry of reactions; I thought it was cool that you could calculate chemical reactions in that way.

But you never made it into veterinary school...

No. As an undergraduate (in Gainesville, Florida), I decided to pursue a PhD in chemistry. I found research to be my chief interest – making new molecules, or discovering new things about molecules, making measurements were all very appealing. And I really enjoyed what I was doing in the organic lab, using all the different instruments (NMR and GC). I should also thank John Dorsey (now at Florida State University) for analytical chemistry courses that further triggered my interest.

When it was time to go to graduate school, I chose the University of North Carolina at Chapel Hill. I remember talking to Jim Jorgensen who told me he had an idea for a new project to analyze single cells. I thought that was the coolest thing ever. Then as a post-doc, I worked with Mark Wightman who was doing bioanalytical work.

Making measurements in biological systems has continued to be a big focus for me – and very fortunately it's become a prominent trend overall. Indeed, the US National Institutes of Health and National Science Foundation are very supportive of developing new analytical tools to study biology – so they are recognizing these trends for proteomics, metabolomics and so on. And, of course, that's related to the advancement of analytical instrumentation.

How do you make your group stand out from the crowd?

We've tended to focus on problems that demand the development of new

*“We've tended to focus on problems that demand the development of new analytical methods.”*

analytical methods. For example, making measurements in the brain and neurotransmitters, where sampling probes provide minute samples – but lots of them. It drove us to think about how we perform sensitive and high-throughput measurements, which led us to microfluidics and high-sensitivity mass spectrometry (HSMS) and a variety of fluorescence-based detection methods.

Another example is how cell biochemistry drives secretion, which brought us to metabolomics using HPLC-MS, CE-MS, capillary LC-MS, and MALDI-MS. We wanted to push further and began collaborating with Jim Jorgensen on developing ultra-high pressure liquid chromatography (UHPLC) for metabolomics. And, while all that was going on, we began developing microfluidic tools for studying beta cells and measuring insulin and glucagon secretion from them.

When you get an idea for a question, ideally it's one where the instrumentation is not yet available or fully developed so you can start to think about developing a solution. I suppose I'm a separation scientist – but we've had projects in electrochemistry, fluorescence and MS. In reality, I try to find the best technique for the job or develop a new one.

*For more about HPLC 2016, visit: [www.hplc2016.org](http://www.hplc2016.org)*

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