AUGUST 2017 # 55

the Analytical Scientist

A Life of Fine Art and Finding Fakes

Sotheby's James Martin on the beauty of art analysis.

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Image of the Month

Eel-Time Monitoring

Meet Envirobot, a robotic eel that swims through contaminated water to find the source of the pollution. In tests carried out by its Swiss creators in a small section of Lake Geneva, Envirobot was able to generate maps of water conductivity and temperature. The robot can be remote controlled or move independently, using chemical, physical and biological sensors to measure water parameters, and send the data to a computer in real time.

Credit: École Polytechnique Fédérale De Lausanne (EPFL).

Would you like your photo featured in Image of the Month? Send it to charlotte.barker@texerepublishing.com

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On The Cover

James Martin in the lab at Sotheby's. See page 20 for details.

Upfront

the **Analytical Scientist**

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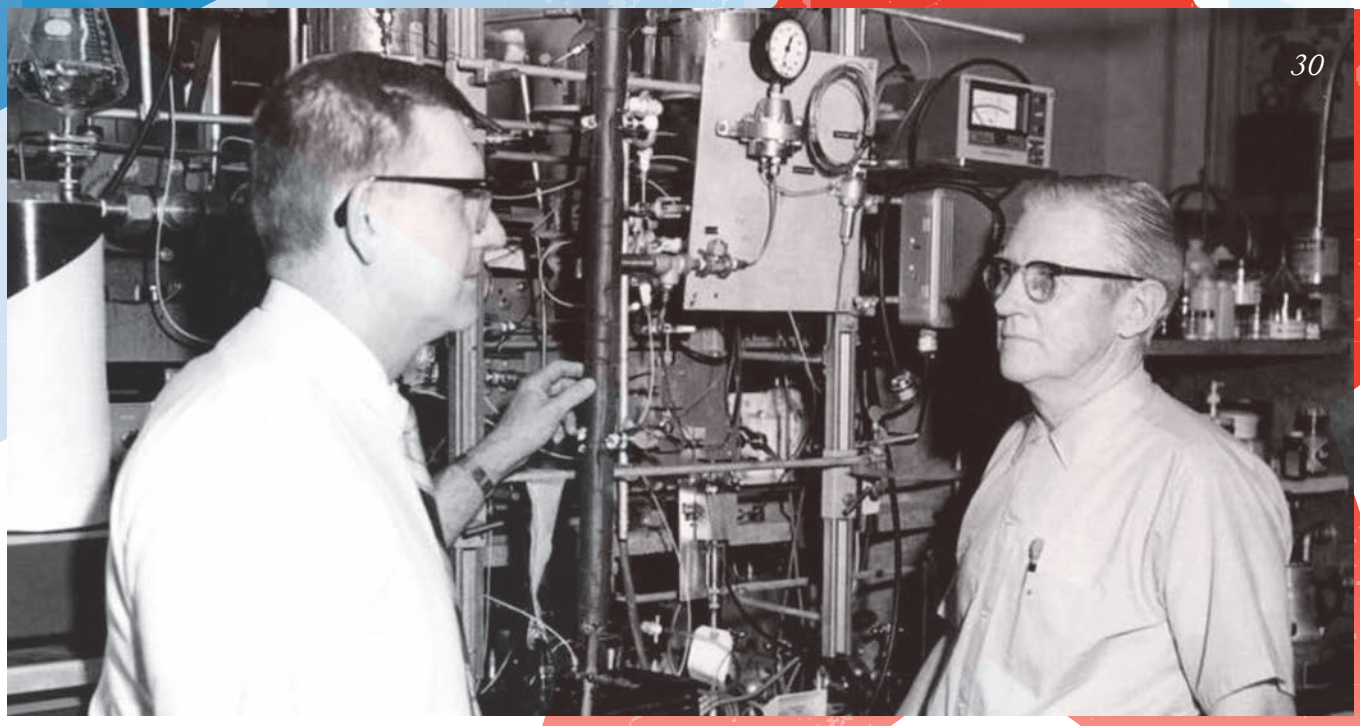

In My View

Features

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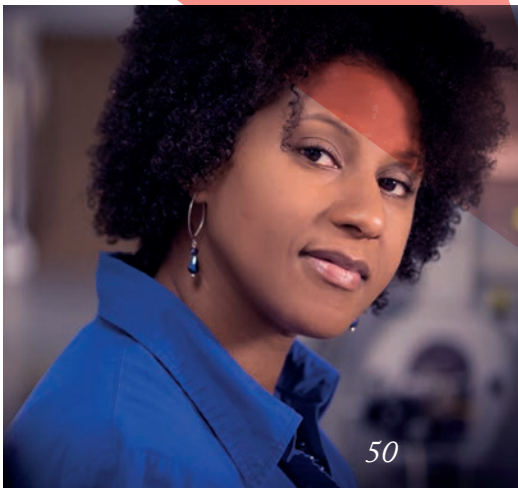

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Those Who Cannot Remember the Past…

…are condemned to repeat it, according to George Santayana. And so, to get the full story of analytical science, we must sometimes delve into the history books.

The Analytical Scientist has a (we think good) habit of sharing the fascinating stories of yesteryear, and this issue is no different. Our feature (on page 30), which investigates life and separation science behind the Iron Curtain, is a testament to the resilience and adaptability of a dedicated group of Eastern European researchers, many of whom are still working today. With few resources at their disposal, they pushed forward the theory of chromatography immeasurably, and concentrated their energy on more accessible techniques, such as thin layer chromatography. However, with limited access to Western journals and conferences, their findings often went largely unrecognized; several contributors point out instances of work being duplicated years – or even decades – later by groups who were unaware that they were following in the footsteps of others.

We hear much about the reproducibility crisis that plagues most areas of science – and it's certainly a grand challenge for the future. But there are those who argue that there is rather too much repetition at play in certain other camps (1). Unintentional duplication of efforts slows progress, especially in a "supporting science" like analytical chemistry. Younger researchers may be forgiven for missing seminal work published behind the Iron Curtain. But, as Ian Wilson pointed out last month, in a fast-paced, technology-focused field like analytical science, there can be a tendency to regard anything more than five years old as archaic. Trusty solutions should not be cast aside in favor of the "latest and greatest" (but sometimes unproven) techniques.

We feel it is our duty to report on the innovations that are likely to shape the future, but it's just as important for us to explore the past of our fascinating and diverse field from time to time. This month's Profession article shares a scheme with a similar vision; by allowing top scientists to tell their stories in their own words, and explain why they made the decisions they did, CASSS (formerly the California Separation Science Society) hope to inform and inspire up-and-coming researchers – and perhaps help them to avoid oft-made mistakes.

Telling personal stories is at the core of what we do at The Analytical Scientist, and we hope that's reflected in the nearly 1,500 articles we've published over the past five years.

Charlotte Barker
Editor

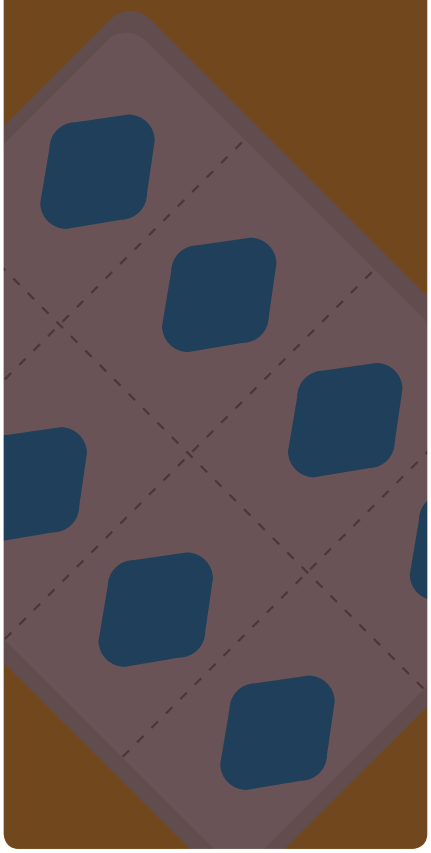
Reference

1. *http://bit.ly/2vIs4zu*

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: charlotte.barker @texerepublishing.com



The Game Is Up

Thin layer chromatography and SERS track down Viagra in adulterated healthcare products

What?
Drug counterfeiters, beware. A new method has allowed scientists from China to analyze for adulteration in widely available health supplements – detecting small amounts of Viagra, as well as other phosphodiesterase type 5 enzyme (PDE-5) inhibitors.

Why?
Adulterated medication and supplements can be extremely dangerous to human health. "Natural" aphrodisiacs are frequently adulterated with pharmaceutical drugs such as PDE-5 inhibitors. Drugs like Viagra can already cause side effects such as dizziness and a runny nose – not exactly conducive to an amorous encounter – but, more seriously, unmeasured or unapproved doses (which are impossible to judge in cases of adulteration) can cause cardiovascular problems and are dangerous for those with heart disease.

Current techniques?
Common methods used for this type of analysis include HPLC-DAD (diode array detection), nuclear magnetic resonance spectroscopy, LC-MS and GC-MS – each of which, while effective, require the skills of highly-trained technical staff and can be time- and resource-intensive. The team from Tianjin University of Science and Technology, and Beijing Technology & Business University, both China, felt a more rapid solution was needed.

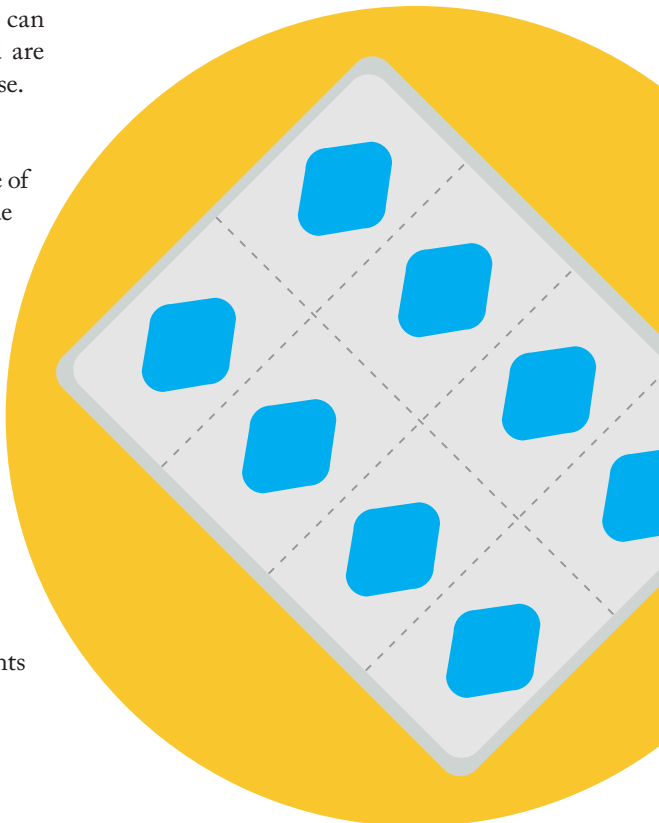
How?
The researchers spiked supplements with six PDE-5 inhibitors: sildenafil, hydroxyhomosildenafil, thioaildenafil, acetildenafil, vardenafil dihydrochloride salt and pseudo vardenafil before attempting detection using a combination of thin-layer chromatography (TLC), surface-enhanced Raman spectroscopy (SERS) and a BP neural network.

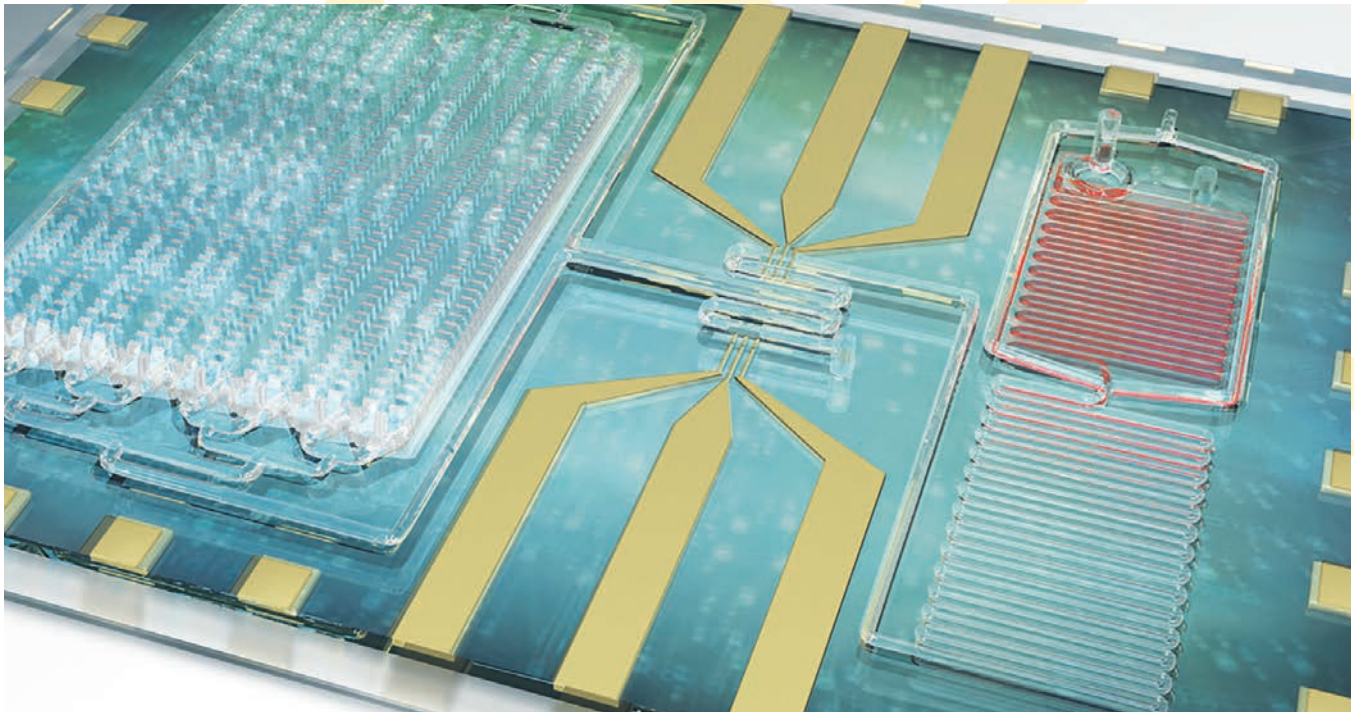
Findings?
Using this technique, a limit of detection of less than 5mg/kg was obtained.

So what?
Its ability to cheaply and quickly achieve this level of sensitivity means TLC-SERS has scope in other areas vulnerable to adulteration, such as cosmetics, agriculture and food.

Reference

1. *N Sukenik et al., "Rapid detection of six phosphodiesterase type 5 enzyme inhibitorsin health care products using thin-layer chromatography and surface enhanced Raman spectroscopy combined with BP neural network", PLOS 12 (2017).*





The lab-on-a-chip system that uses a patient's immune response to diagnose sepsis. *Credit: Janet Sinn-Hanlon*

When Minutes Matter

New tests can speed up the diagnosis of severe sepsis, ensuring patients get the right treatment before it's too late

Sepsis is one of the most time-critical diagnoses a hospital can make. In the most severe cases, it's estimated that patients' likelihood of survival decreases by 7.6 percent each hour that passes without effective treatment (1). But with common symptoms like fever and pain, it can be difficult to conclusively identify sepsis in a timely manner.

Fortunately, science is on the case. Two groups of researchers have recently published tests that promise rapid, reliable diagnosis of sepsis: one, a new PCR-based method, and two, a portable lab-on-a-chip device.

The first, a TaqMan-based multiplex real-time PCR detection system, probes conserved regions of the 16S rDNA gene in 10 common bacterial pathogens (2). It not only detects the organisms causing sepsis, but also positively identifies them in a matter of hours, ensuring that patients can receive appropriate antibiotic treatment as soon as possible – and freeing doctors from the need to wait a day or more for blood cultures to provide the same information.

The second test takes a unique approach – instead of looking for the cause of infection, it detects the patient's immune response (3). How? The device takes a complete white blood cell count, a neutrophil count, and measures levels of the CD64 neutrophil cell surface marker. As the immune response increases, so do these numbers, giving doctors a rapid heads-up that the patient's condition is deteriorating. In some cases, the immune response can spot sepsis even before the causative pathogen is detectable in the blood.

"We think we need both approaches," said Rashid Bashir, senior author on the latter study. "Detect the pathogen, but also monitor the immune response. (4)" *MS*

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4. *L Ahlberg, "Quick test finds signs of sepsis in a single drop of blood", (2017). Available at: http://bit.ly/2vwc8Ai. Accessed August 4, 2017.*

Blubber Luck

A combination of nanoLC and electrospray ionization could help "save the whales"

Gray whales may be big…but when it comes to blubber analysis, they provide small sample sizes. And why do we need to analyze whale blubber? With gray whale species hovering dangerously close to the endangered zone, "analysis of steroids from precious blubber biopsies…can provide valuable information on their endocrine status" say the authors of a new paper (1). This could include data on reproductive capabilities and stress levels of the marine mammals – crucial for conservation efforts.

Serum and feces – analyzed in previous research – are less reliably accessible than blubber, but biopsies of blubber are necessarily small (as well as harder to obtain due to dwindling populations). In addition, current methodology such as ELISA (enzyme-linked immunosorbent assay), requires the majority of the tissue, making multiple analyses yet more of a challenge.

But thanks to a new combination of analytical techniques, blubber analysis may be about to get easier. A collaborative team from Alaska and Texas used nanoLC to separate the progesterone, testosterone and hydrocortisone from blubber samples, before carrying out nano electrospray ionization (ESI) mass spectrometric analysis. Both detection and quantitation limits were lower than previously obtained using conventional methodology.

NanoLC-MS/MS offers other advantages: "NanoLC uses much lower flow rates [than LC-MS/MS]…and therefore, uses less solvent, making it more cost-effective and consistent with green chemistry principles," according to the paper. The ability to conduct multiple analyses on small samples can also help provide "a more complete health assessment" – which can only be good news for our gargantuan friends. The researchers intend to include other steroid hormones such as estradiol and glucocorticosteroids in future analyses. *JC*

Reference

1. *M Hayden et al., "Nanospray liquid chromatography/tandem mass spectrometryanalysis of steroids from gray whale blubber", Rapid Commun. Mass Spectrom.31, 1088–1094 (2017).*

Awards, Assays and AMCs

What's new in business?

In our regular column, we partner with www.mass-spec-capital.com to let you know what's going on in the business world of analytical science. This month, Eurofins' acquisitions continue apace, while both early career and thought leaders are recognized with awards from Agilent.

Products

- SCIEX launches Topaz LC-MS system for clinical diagnostics
- Ionicon launches new AMC-Monitor T-1000 for semiconductor industry
- Numares identifies candidate metabolomic network for bladder cancer diagnostics
- 908 Devices launches 3-in-1 GC-HPMS cannabis analyzer

Investment & acquisitions

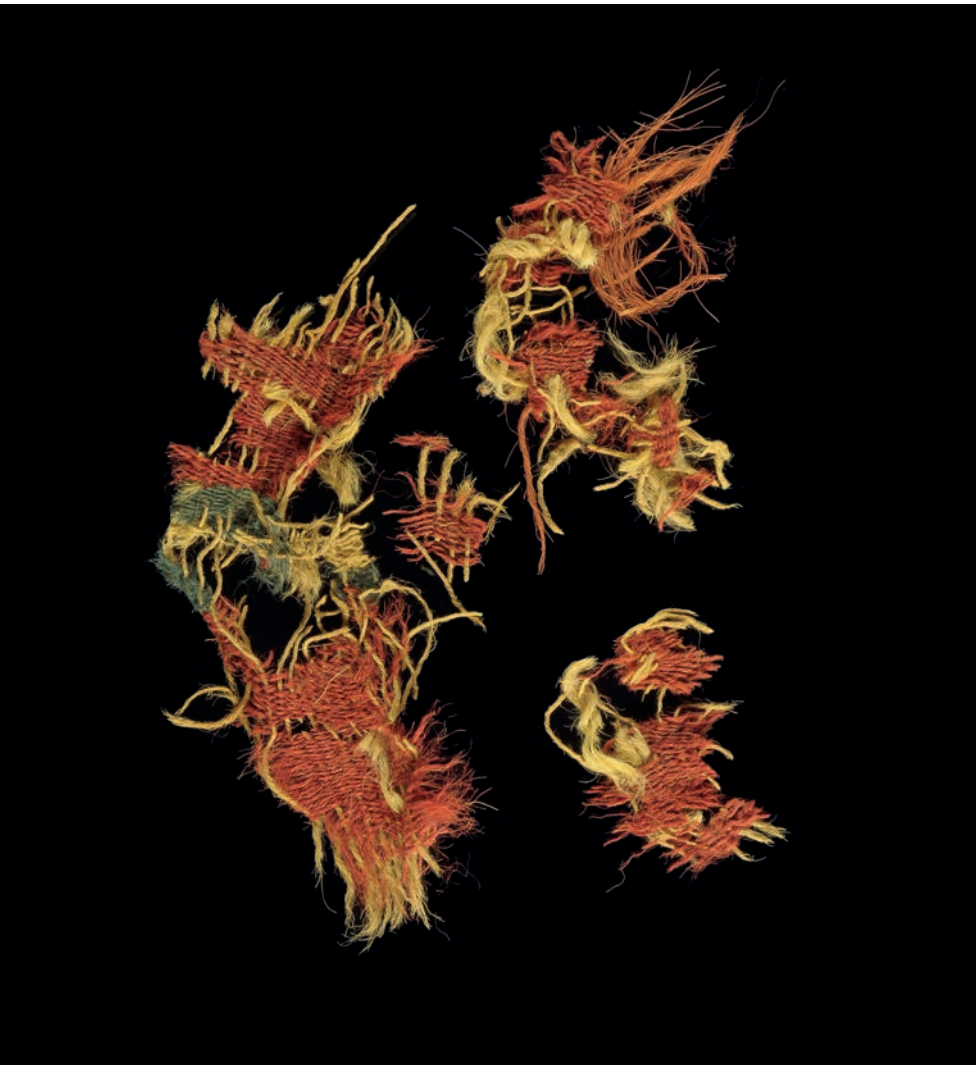
- Agilent acquires Cobalt Light Systems for £40m
- Eurofins strengthens NIPT portfolio with LifeCodexx, and acquires India-based CRO Advinus Therapeutics from Tata Group and Ana Laboratories, Inc. in the USA. They will soon acquire Amatsigroup for €130m plus residual debt

Collaborations

- Fluidigm and Ascendas Genomics to develop MDx in China
- SCIEX equipment now available through flexible financing packages via Evosciences
- Agilent Thought Leader Award for Ram Sasisekharan at MIT and Early Career Professor Award for Gary Patti at WUSTL
- Siscapa licenses LC/MS assay technology to Waters
- Genedata Selector expands partnership with AB Enzymes
- EPL Bio Analytical Services selects SCIEX QTRAP 6500+ LC-MS/MS

People

- Hans E. Bishop to join Agilent's Board of Directors
- Waters elects Flemming Ornskov to Board of Directors



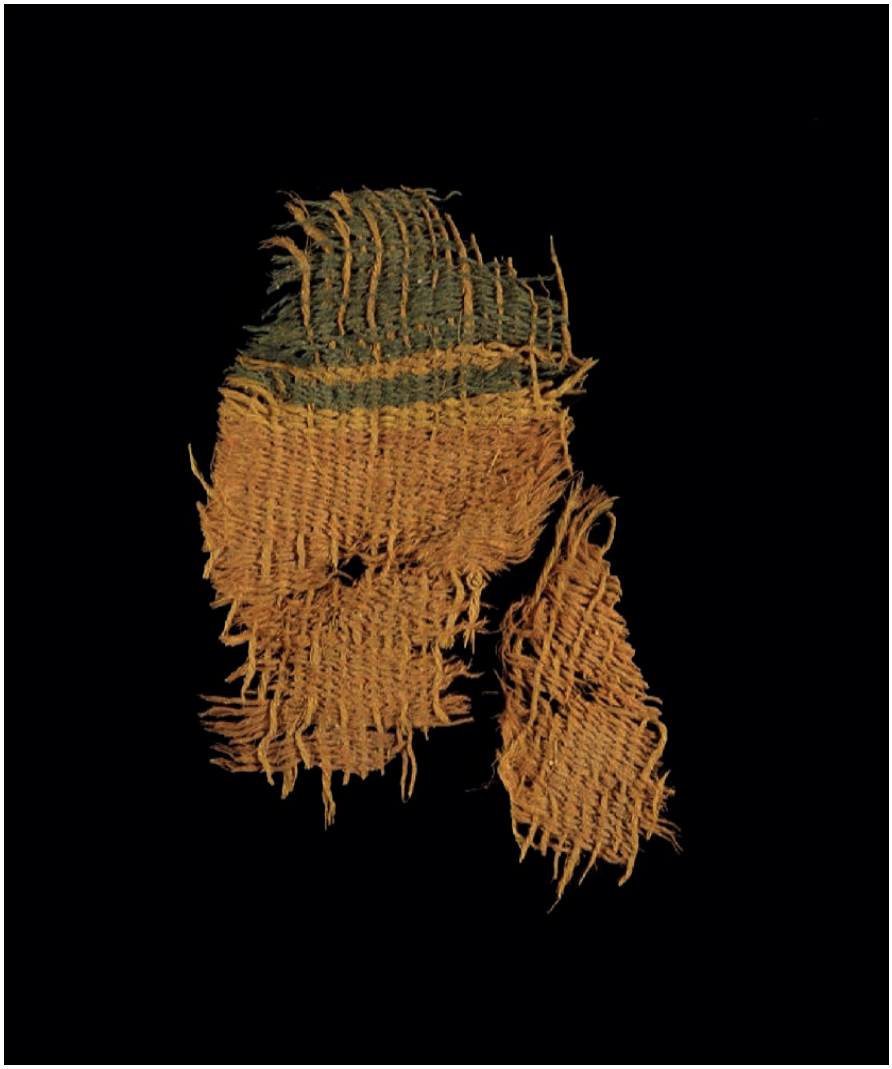
The Fabric of Society

HPLC helps uncover earliest evidence of plant-based dyeing – and the existence of an Iron Age elite

Archaeological textiles, as well as having kept our ancient ancestors warm, can tell us much about the society in which they were created; shedding light on the skills, access to plants and even trade developments of a particular period. However, finding specimens is a rarity, as, like our forebears themselves, fabric is subject to the ravages of time, with only exceptional physical conditions preventing decomposition. But according to a new study by Israeli archaeologists (1), the Arava desert boasts exactly such conditions.

Nineteen textile pieces, estimated to be from the 13th–10th centuries BCE, were discovered at a copper smelting site in southern Israel, and samples of five of these were analyzed by researchers at Tel Aviv University. Their aim? "To identify the natural dyes and associated dyeing technologies used in the colored Timna textiles, as a basis for shedding new light on the ancient dyeing industry and the society operating the copper mines at the turn of the 1st millennium BCE" (1).

Microscopic analysis first ascertained that the wool textiles were dyed before being spun into fabric, which, say the authors of the paper, suggests a more sophisticated approach to manufacture. The researchers then radiocarbon-dated



the fragments, before using HPLC-DAD to identify the chemical compounds within the red and blue stripes of dye. The two dyestuffs they found – Rubia tinctorum L. (the madder plant) and indigotin (the woad plant) – were not thought to have been used until 1,000 years later – making these fragments the earliest evidence of plant-based dyeing in this region.

The authors believe the remnants paint a picture of a stratified society; the dyeing of the blue fabric in particular was a "complex and comprehensive process of reduction and oxidation that took several days", making them in all likelihood a luxury item ascribing status to the wearer. And according to the authors, the plants used for dyeing were more likely to have come from Mediterranean regions than in Timna, where they were found, suggesting the existence of long-distance trade within this period. *JC*

Reference

1. *N Sukenik et al., "Early evidence (late 2nd millennium BCE) of plant-based dyeing of textiles from Timna, Israel", PLOS 12 (2017).*

In My View

In this opinion section, experts from across the world share a single strongly-held view or key idea.

Submissions are welcome. Articles should be short, focused, personal and passionate, and may deal with any aspect of analytical science. They can be up to 600 words in length and written in the first person.

Contact the editors at edit@texerepublishing.com

Rush at Your Peril

Poor study methods and false discoveries have plagued biomarker research for years – so don't trust everything you read

By Eleftherios P. Diamandis, Hold'em for Life Chair in Prostate Cancer Biomarkers, Head of Clinical Biochemistry, Mount Sinai Hospital and University Health Network; Professor & Head, Division of Clinical Biochemistry, Department of Laboratory Medicine & Pathobiology, University of Toronto.

I have now been working in the field of cancer biomarker discovery for over 30 years. The investment over the last decade or so has been high – as has the excitement – but, in my opinion, the actual yield of new cancer biomarkers has been very poor.

There are many reasons for this, but I believe there is a major problem that needs to be tackled: false discovery. All too often, a group will believe that they have discovered a new biomarker, and they will hurry to publish in a prestigious journal. And all too often, it becomes apparent that the biomarker is not performing as expected, and that the results are unreliable and can't be reproduced. In short, the discovery is a false one.

I have previously published papers highlighting the fact that a great number of studies describing novel biomarkers actually suffer from false discovery (1). Another issue is that a research group may indeed discover a biomarker showing a statistical difference between, for example, a non-cancer group and a cancer group, but the differences are not sufficient for the biomarker to be used in the clinic – the performance is too poor. Again, we end up with published papers that contain information on a biomarker that is not useful; it can never make it to the clinic. If you were to delve into the literature and examine 100 or even 1,000 published biomarkers, you would likely find that half of them are actually false discoveries, and that the other half are so poor that they don't provide clinically useful information...

Some questions to ask yourself when setting up this type of study: were your samples properly collected, processed and stored? Have you selected your control groups appropriately? Are you looking at men, women, or both?

"If you rush a study, even though you might get published in a big journal, your poor methods mean that whatever you publish will not enter patient care."

"I believe there is a major problem that needs to be tackled: false discovery."

What age are the controls versus the diseased group? What methods are you using to interpret your data? These are common areas for error to creep in – and the responsibility for making sure that every parameter is controlled and accounted for in any project lies with the investigator. It's also important for all of us to remain vigilant against rushed and inadequate research. I personally publish a lot of papers essentially saying "this paper is false, and this one, and this one."

Unfortunately, even though the information on how to avoid false discovery is out there, many researchers do not appear to be heeding it. But if you rush a study, even though you might get published in a big journal, your poor methods mean that whatever you publish will not enter patient care – it will fall into the cracks and make no real impact.

My recommendation? When you read that first report on the glorious discovery of a new biomarker, you should also wait and see if subsequent validation reports, especially by other groups, corroborate the results. With so many biomarkers proving too good to be true, I would advise a healthy level of skepticism!

Reference

1. *EP Diamandis, "Cancer biomarkers: can we turn recent failures into success?", J Natl Cancer Inst, 102, 1462–1467 (2010). PMID: 20705936.*

Making the Leap

Finding that all-important postdoc position can be a grueling process. How do you weather the storm – and hang on to your sanity?

By Anthony Stender, Assistant Professor of Forensic Analytical Chemistry at Ohio University, Athens, Ohio, USA.

Have you ever gone to a party and felt like you were invisible to everyone there? Or worse, waited in vain for an invitation to a party you were longing to attend? Life as a job-seeking grad student can leave you facing the same sinking feeling.

There's a cynical STEM joke out there that has an air of truth: "Undergraduates who can't find a job go to graduate school. Graduate students who can't find a job get a postdoc, and then another postdoc, and then another..."

The problem that many graduate students face upon finishing school is actually getting that first job or postdoc position. In my case, I was seven months out of graduate school before a postdoc offer came, and I was definitely feeling like I would never get an invitation to the party. It was fortunate the call came when it did because, an hour later, I received another phone call – an offer to work at a home improvement store...

Finding a permanent job after graduate school is not an easy process these days, at least for the majority of students. Gone are the days when you could apply for 20 jobs, get 10 requests for interviews, and entertain at least three offers. (If you are currently a grad student or postdoc and you have employers fighting over you, there's no need to read any further!)

In the past five years, I have attended several career advice seminars and job fairs, in the hopes of gaining insight on how to stand out and get interviews. Unfortunately, these events seem to be exclusively targeted at undergraduates.

"The problem that many graduate students face upon finishing school is getting that first job or postdoc position."

Instead of finding valuable advice, I was nauseated by speakers pontificating about their surefire method of online networking and how to use bullet points properly on a resume. Another annoying practice of job seminars is to share optimistic statistics that suggest there are many jobs available and that unemployment rates are low in STEM. However, these statistics often describe scientists who answered a survey – not people like me – unemployed and therefore not part of the professional

"Many of us would benefit hugely from mentors who could offer practical advice on how to make a smooth transition from graduate school to the real-world workforce."

society that ran the survey.

When I was in full job-search mode, I figured out how to write my CV and a LinkedIn profile by looking at what other people were doing, but it was not a straightforward process. There is a perception that people with a graduate degree can learn to do anything, and require no help. In fact, many of us would benefit hugely from mentors who could offer practical advice on how to make a smooth transition from graduate school to the real-world workforce.

In looking back on my own journey from grad school to faculty position, my impression is that there isn't a "one-size-fits-all" approach. In theory, it should be easy (hasn't every analytical chemist heard that one before?). Careers fairs sell the idea of a template solution, and many graduates enter their job search with unrealistic expectations. In reality, early-career job seekers need to work hard, be persistent, and keep an open mind when searching for a position.

At this year's SciX conference, for the second year in a row, I will be moderating an honest and practical panel discussion on how to establish your career trajectory after graduate school. I will be joined by six scientists who will share their unique stories and provide perspectives on the common questions that job seekers and early career scientists face. The panel session, "Making the leap: pathways from graduate school to a permanent position" will be held on Wednesday, October 11, at 9:15am. I encourage everyone attending SciX who's thinking about the job search process to stop by for some or all of this discussion. And come armed with plenty of questions!

Good on Paper

As we develop new point-of-care diagnostics for resource-limited settings, the humble sheet of paper has a lot to offer...

By Andres Martinez, Associate Professor of Chemistry, California Polytechnic State University, San Luis Obispo, USA.

Diagnostic assays can play a critical role in remote, resource-limited settings where doctors or other trained medical personnel are not available (1). In these environments, most existing technologies are either too expensive or not compatible with the extreme conditions encountered (2). The answer? Low cost, point-of-care tests (POCTs) – if developed appropriately – have the potential to overcome both of these challenges.

A POCT is the combination of assay chemistry and a platform (i.e. a device) to support that chemistry. To be useful in resource-limited environments, the device must be cheap, small and portable; the reagents must be stable at room temperature; the results of the assay chemistry need to be accurate and easy to interpret; the assay should have minimal power requirements (ideally the assay should not require electrical power, but battery-powered assays are an option); and the assay should be relatively simple to perform – ideally, the user need only apply the sample to the device and then read the results. The WHO released the "ASSURED" criteria to describe the ideal assay: affordable, sensitive, specific, user-friendly, rapid, equipment-free and deliverable to end-users. Paper-based platforms were developed specifically to meet the demands of resource-limited settings.

"Paper-based platforms were developed specifically to meet the demands of resource-limited settings."

Paper has many inherent characteristics that make it well suited as a platform for POCTs – it is cheap and widely available,

it wicks fluids by capillary action, it has a large surface-to-volume ratio, and it provides a white background that makes color changes easy to see. The first examples of paper-based devices were simple dipstick assays (like litmus paper) that monitored the concentrations of certain analytes using color changes. Then came lateral-flow immunoassays, such as the rapid diagnostic test for malaria and the home pregnancy test, which vastly expanded the range of analytes that could be detected on paper by relying on antibodies for detection. A global community of researchers is now working on the next generation of paper-based devices known as microfluidic paper-based analytical devices, or microPADs.

MicroPADs are devices made from paper, or other porous membranes, patterned with hydrophobic inks to create hydrophilic channels. Like conventional microfluidic devices made from glass or plastic, microPADs comprise a network of channels that can be used to process small volumes of sample and perform multiplexed assays. Unlike conventional microfluidic devices, microPADs wick fluids by capillary action, so they don't rely on pumps or other supporting equipment. The combination of microPADs with new assay chemistries is leading to more sensitive and quantitative assays that should expand the applications and utility of paper-based tests (2).

Though POCTs for use in resource-limited settings must be cheap, rapid and simple, the process of developing these devices is challenging, expensive and time consuming. However, the potential benefits of new diagnostic technologies easily justify the investment in time and resources required to develop them. And who knows – the device originally developed to use in rural villages could one day end up serving the populations of major cities too.

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1. *D Mabey et al., "Diagnostics for the developing world", Nat Rev Microbiol, 2, 231–240 (2004). PMID: 15083158.*
2. *AK Yetisen et al., "Paper-based microfluidic point-of-care diagnostic devices", Lab Chip, 13, 2210–2251 (2013). PMID: 23652632.*

BRINGING LIGHT TO THE DARKNESS

"A painter should begin every canvas with a wash of black, because all things in nature are dark except where exposed by the light." – Leonardo da Vinci

Light is not only a crucial element in any painting – it has the power to reveal new insights about an artwork or artifact. Here, we meet analytical scientists who are bringing some of the mysteries of art out of the shadows.

A Life of Fine Art and Finding Fakes

Now Director of Scientific Research at Sotheby's auction house, James Martin has spent 25 years ascertaining the authenticity of art, cultural property, and collectibles. In an interview with Joanna Cummings, Martin shares the beauty of art analysis, and the love of art that drives him.

As an art conservation scientist, I work in the field of art research and use my art and scientific skills to make discoveries. I now practice my profession at Sotheby's auction house – with skills I have honed over many fascinating years.

Art meets science

When I was a teenager, my father bought me a simple compound microscope (which still sits on my desk) and, at about the same time, sent me to art school. It was a realist school modeled on 19th century French ateliers, where my instructors showed me how prepare and use art materials to emulate techniques of Old Masters. I loved to draw and paint, and was fascinated by science, specifically chemistry.

These two passions coalesced during college, when an art conservator took me behind the scenes at the Baltimore Museum of Art, showing me spotless laboratories where microscopes and priceless works of art stood side-by-side – laboratories where people used technology and science to understand and preserve works of art.

I was sold. My career goal changed that day, from medical illustration to art conservation. I went on to obtain a Master's degree at the University of Delaware, and then was a Fellow at the Hamilton Kerr Institute, University of Cambridge, UK.

On my return to the US in 1990, I established the first fee-for-service conservation science laboratory at the Clark Art Institute in Massachusetts. The laboratory was awarded grants from the National Endowment for the Arts and the US Department of the Interior, which designated it a national laboratory for the conservation and historic preservation fields. The lab provided routine materials analysis to conservators and museums – and others. The FBI called on me there to investigate art forgery cases, including the case of Ken Perenyi, who claimed to be the world's greatest forger, but was, in fact, an easy forger to detect because he used historically inaccurate materials.

I also conducted research there for the American Society for Testing Materials (ASTM), to develop a test method to identify organic pigments in art materials. Preceding ASTM test methods used solvent extraction and solution spectrophotometry to separate and identify pigments based on absorption of visible light. My team also used solvents to separate – and recrystallize – pigments, but replaced solution spectrophotometry with a combination of microspectroscopy techniques, Fourier transform infrared spectroscopy (FTIR) and scanning electron microscopy with x-ray energy-dispersive spectrometry (SEM-XEDS). The test method predated common use of Raman microspectroscopy, which we now use to identify organic pigments.

Stripping back the layers

In 2000, I left the Clark and established the first private fee-per-service conservation science laboratory in the US. The firm, Orion Analytical, continued to serve conservators, museums, and the FBI – and soon expanded its clientele to include manufacturers, collectors, law firms, and insurance companies.

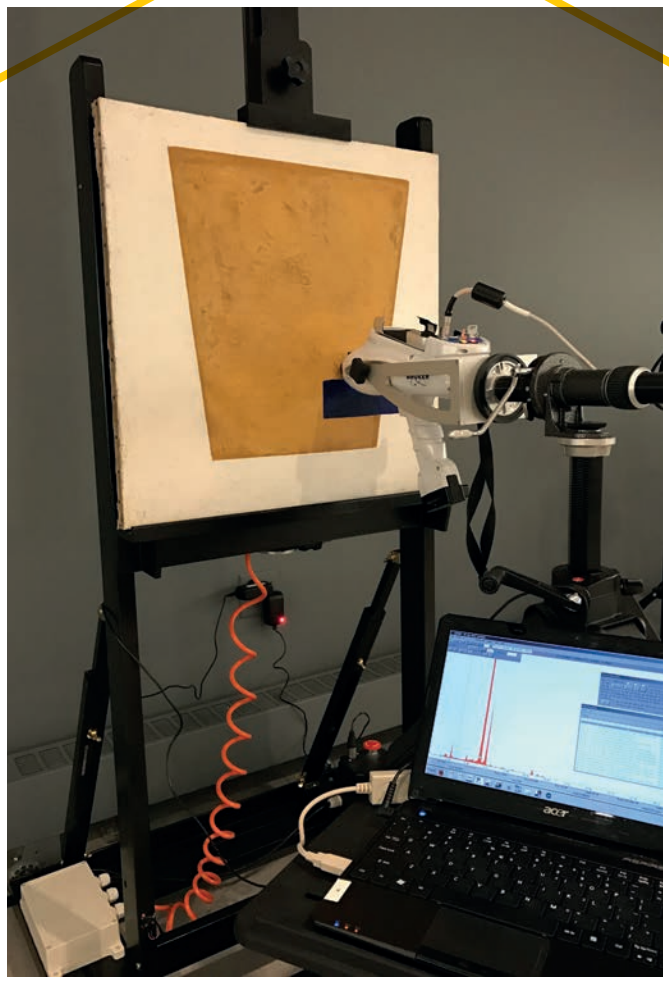
The materials Orion studied were very diverse – works of art and cultural property (from ancient Egyptian artefacts to contemporary art), architectural finishes, consumer product packaging and sealants… and contaminates on gyroscopes used for guided missile systems!

The technical and analytical tools Orion used were diverse, too. Analysis of art can be as "multi-layered" as the objects we investigate. Conservation scientists generally begin analyses using different wavelengths of energy, from x-rays to infrared, to visualize the composite structure of works and the distribution of materials based on their average atomic mass, visible fluorescence, color, or infrared absorbance.

We then use stereomicroscopes to study the surface of objects. Stereomicroscopes are common, but ours are not mounted on the traditional stands you would see in a biological lab – they are mounted on gantries that allow them to be suspended over works of art, and articulated on stands to examine vertical surfaces and three-dimensional objects. These microscopes allow us to look at the general construction and condition of objects, and to look for evidence that works have been intentionally altered to impart a false appearance of age (for example, whether cracks are real, or have been drawn on with a needle or a pencil). Further, stereomicroscopes also allow us to select microscopic areas for in-situ analyses and to remove samples for other analyses.

Conservation scientists use non-invasive techniques whenever possible, but samples are usually required to examine layer structure and to identify pigments, polymers, and other organic materials. The good news is that most samples are microscopic in size; for example, the optimal sample size for FTIR microscopy is about 35 µm across, meaning that one could fit several hundred samples on the head of a pin. Further, a single sample often can be used for multiple analyses – SEM-XEDS to map its elemental

Clockwise from left: Analysis of "Suprematist Composition with Plane in Projection" by Kazimir Malevich. Martin appearing on "60 Minutes". Visible and transmitted infrared images of the Malevich painting.



distribution, a combination of FTIR and Raman to identify its molecular composition – and more.

In the same way that a cross-section view of the Grand Canyon tells more about geographic chronology and weathering than does a bird's eye view, cross-section samples from objects allow us to see and analyze the individual layers used to make works of art, and evidence of the passage of time. For example, fluorescence microscopy of cross-sections helps to elucidate oxidation, weathering between layers and the buildup of grime and contaminants.

This systematic use of particle, elemental, and molecular analyses provides information on different physical, optical, and chemical features of materials. Used in combination, these analyses allow us to identify hundreds of thousands of materials, from an ancient pigment or alloy, to natural fibers, to modern synthetic polymers.

Making a mark

In 2016, Sotheby's acquired Orion and hired me as its first Director of Scientific Research. Orion had built an unblemished reputation for art analysis, and consulted on the highest-profile art forgery cases between 2000 and 2016.

My laboratory at Sotheby's is the first of its kind in the art industry – in any auction house. To put this into historical perspective, my profession traces its roots to the 1920s, Sotheby's to 1744!

My aim at Sotheby's is to integrate art conservation science into the day-to-day work of the auction house. In the same way that museum laboratories support the work of curators and conservators, my team supports the work of Sotheby's researchers and specialists. On any given day, we help our colleagues see hidden parts of works, identify materials and techniques used to create works, and to provide investigative

leads that inform the attribution process.

The College Art Association codified standards and guidelines for authentication and attribution in 2009, when they identified three essential components – what I liken to a "three-legged stool." The first essential component is analysis of style by a connoisseur, the only expert who can offer an affirmative attribution or authentication of a work of art – a scientist cannot do that. The second element is the documented history of the work, otherwise known as provenance. The third element is technical and scientific examination to determine whether the physical substance of the work is consistent with its attribution and provenance – what I and my team at Sotheby's do – like umpires, we call balls and strikes.

The laboratory at Sotheby's includes the techniques I used at Orion, and more. Some of the instruments we use at Sotheby's also work in the field – anywhere we have electricity or a battery pack. For example, we are the first conservation science laboratory in the world to use a new generation of FTIR microscope that can be hand-carried anywhere – and used without liquid nitrogen. Such instruments make it possible for us to characterize materials on-site, without delay.

We have also invested in other cutting-edge instrumentation, including scanning x-ray fluorescence spectrometry (MA-XRF), a technique that scans works of art and produces maps of elemental distribution, often revealing restoration and hidden changes in paintings and other cultural property. Our next purchase likely will be a portable Raman microscope that is sensitive enough to detect materials we see using our laboratory-based microscope, like modern synthetic pigments.

My current laboratory is my third, and my favorite! I am chief science officer at Sotheby's, the largest revolving collection of art in the world – and it is an absolute joy!

Light at the Museum

Synchrotron-based large-area x-ray fluorescence (SR-XRF) and diffraction (SR-XRD) mapping has uncovered unexpected trace elements in ancient manuscript fragments. Louisa Smieska (Metropolitan Museum of Art) and Ruth Mullett (Cornell University) talk us through the process of analysis and the significance of their discovery. And give us a taste of how they navigate this complex interdisciplinary field.

How did you come to study this particular manuscript?

Louisa Smieska: When I was a postdoc at the Cornell High Energy Synchrotron Source (CHESS) last year, my supervisor Arthur Woll and I organized a workshop on applications of scanning x-ray fluorescence for the study of cultural heritage materials. Laurent Ferri, curator of pre-1800 materials in the Cornell Library Rare and Manuscript Collection, attended the workshop and suggested that we look into the group of fragments that Ruth was cataloguing. Happily, Ruth and I already knew each other from a course we'd taken at the Johnson Museum on campus...

Ruth Mullett: Our initial goal was to learn more about these fragments by looking at trends in pigment and color use. Initially, we were hoping to uncover how many of our pages used lapis lazuli – a blue pigment.

What did you uncover with your initial portable XRF analysis?

LS: We found that most of the blue pigments were copper-rich, suggesting that these blues were azurite, a copper carbonate mineral, rather than lapis lazuli. A few of the manuscripts we looked at showed the presence of barium in the blue areas, which we really weren't expecting.

RM: We then selected fragments that represented a geographical and temporal range that yielded unusual or surprising results in the p-XRF, for synchrotron analysis. We were interested, for example, to find out more about the fragments that demonstrated the presence of noticeable concentrations of barite in blue pigments.

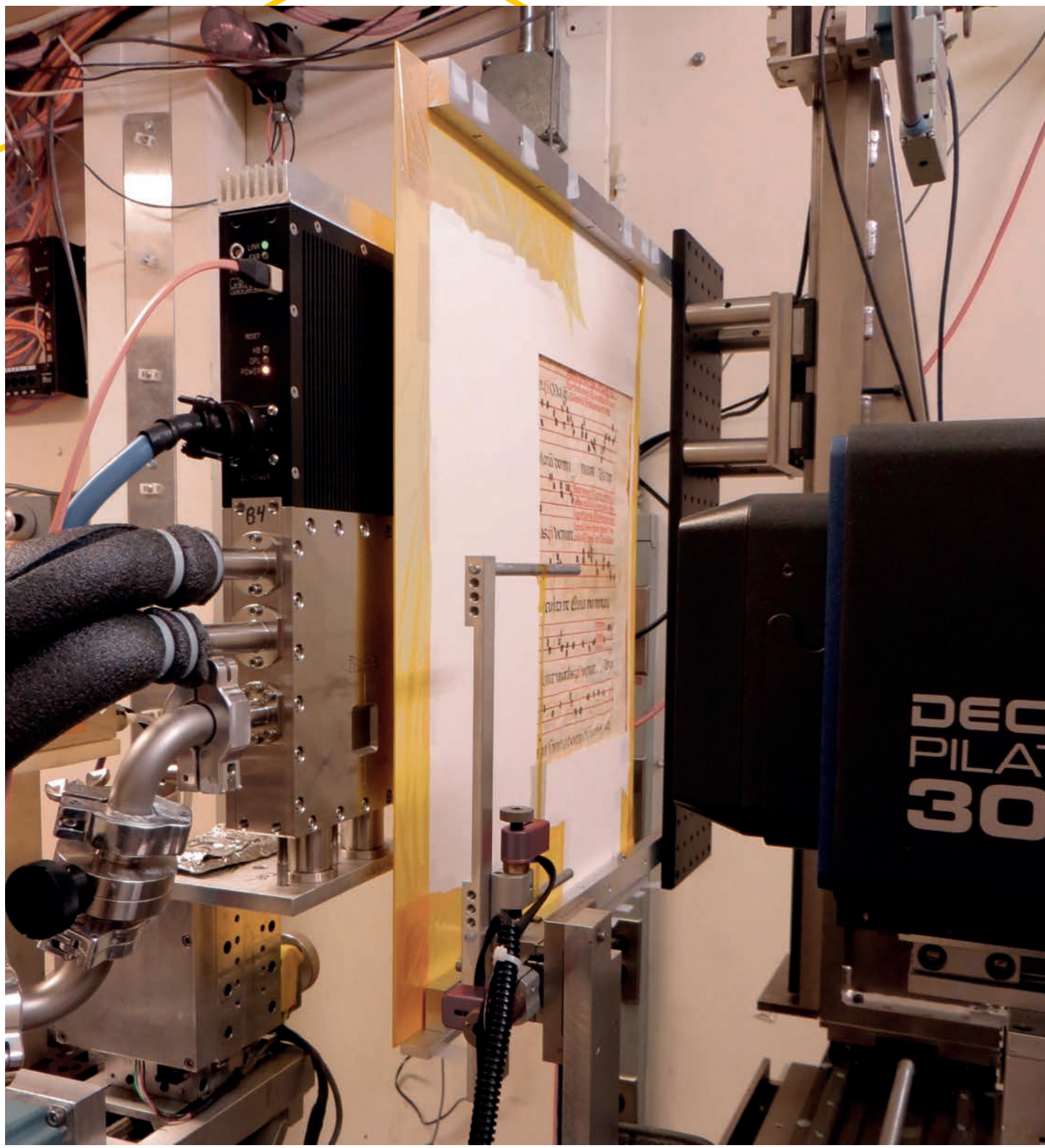
LS: We didn't know from the portable point XRF survey that all the azurite pigments contained barium – we selected a few fragments where we had detected it, but expected that the others would not. Our scanning XRF measurements at CHESS allowed us to clearly identify which elements – not just barium – were associated with azurite, by looking at which elements correlated with copper-rich blue regions. Our scanning XRD measurements confirmed that these blue regions were in fact azurite.

What methods did you use for a more in-depth analysis?

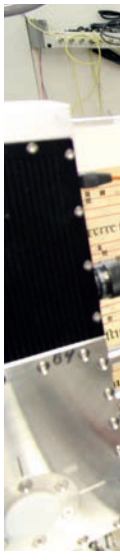
LS: The facilities at CHESS provided several advantages over the laboratory-based point XRF survey we began with. First, we were able to use a Maia XRF detector at CHESS, which allowed us to move from point XRF measurements to fast-scanning XRF experiments of square centimeter areas. There are only a few Maia detectors in use around the world. We were able to quickly scan large areas and discover spatial trends in the elemental maps, such as confirming that barium can be associated with azurite. Second, we added simultaneous scanning x-ray diffraction (XRD) to our scanning x-ray fluorescence measurements. The diffraction information allowed us to definitively identify major compounds, not just infer their presence from the elemental maps. Finally, CHESS was able to provide much higher energy x-rays than a laboratory-based x-ray source can offer. The higher energy x-rays conferred greater XRF sensitivity to heavier elements, including barium, than a laboratory source.

Why was the barium significant?

LS: Our synchrotron measurements showed that barium was present in trace amounts in all six of the 13–16th-century manuscript fragments we examined. At first, we were surprised to find barium in the azurite blues because we hadn't seen this finding reported in illuminated manuscripts before. We often think of the element barium as associated with modern paints or, in smaller amounts, in natural clays or chalks, but not with azurite.



A portable X-ray flouroscence (p-XRF) scanner being used on an illuminated manuscript fragment.



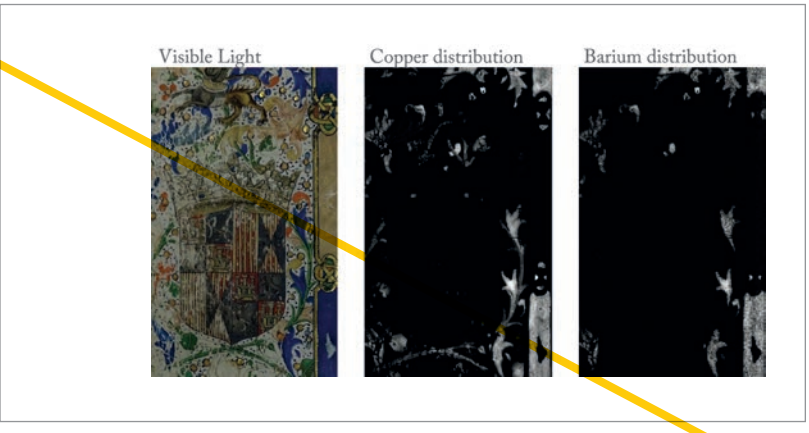
For azurite, the amounts of barium involved are often so low that they are undetectable with the portable point XRF survey.

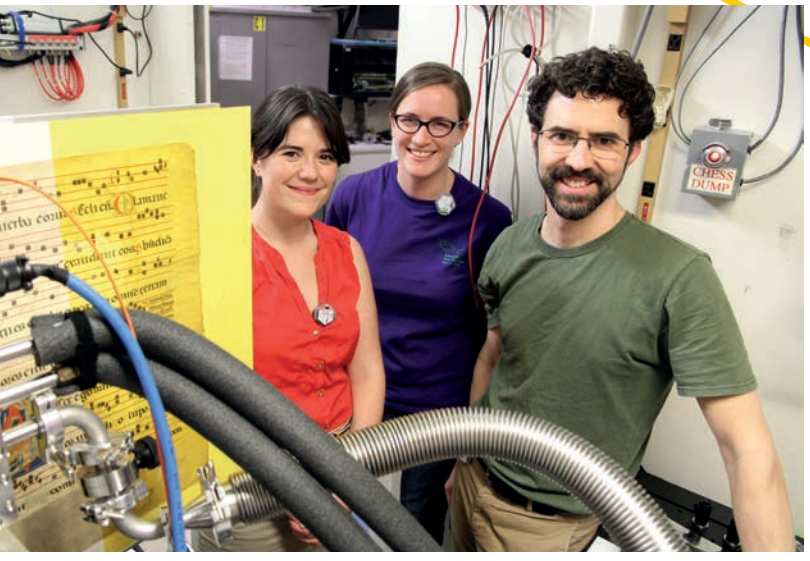
Combining scanning XRF and XRD, we found that many azurite blues contain small amounts of the mineral barite, or barium sulfate. Although barite is a fairly common mineral, we are excited because the relative amount of barium in each azurite blue is not the same, and combining this information with the amounts of other trace elements, such as iron, zinc, and antimony, might help with efforts to learn whether different fragments were originally related to one another.

RM: Research like ours may make it possible, for example, to narrow the geographic region of production by identifying unusual pigments in a palette.

How would you like to develop your research further?

LS: Expanding our study to additional manuscript fragments would be extremely valuable for uncovering broader trends in azurite trace mineral compositions. We would also like to study the composition of azurite mineral samples of known provenance, complementing the survey of fragments by evaluating similarities and differences between historic sources of the pigment. It is not clear how the purification techniques affect the trace element composition in the final pigment, so it would be exciting to recreate historic methods for grinding and washing the azurite mineral followed by a study of the trace element composition. It is frequently impossible for illuminated manuscripts to travel to facilities like CHESS for analysis; it would be helpful to compare the results of our measurements with laboratory-based scanning XRF systems to learn which trace elements in azurite are most diagnostic across measurement techniques.





Top: Distribution of elements in a fragment. Bottom: From left to right: Ruth Mullett, Louisa Smieska and Arthur Woll at CHESS with one of the manuscript fragments mounted to be scanned.

Louisa Smieska took on the project as a postdoctoral researcher at CHESS (Cornell High Energy Synchrotron Source) after completing her doctorate in chemistry. She studied fine art as an undergraduate at Hamilton College; she is now an Andrew W. Mellon Postdoctoral Fellow in the Department of Scientific Research at the Metropolitan Museum of Art in New York City.

Ruth Mullett is a medieval studies doctoral student at Cornell. She is also a fellow in the Fragmentarium project based at the University of Fribourg in Switzerland, which is building a database of fragments from different institutions.

Reference

1. *L Smieska et al., "Trace elements in natural azurite pigments found in illuminated manuscript leaves investigated by synchrotron x-ray fluorescence and diffraction mapping", Appl Phys A, 123 (2017).*

Met Detective

Matching manuscript fragments was just the start of Louisa Smieska's adventures in art analysis. Here, she tells us how she's applying XRF analysis in her role at the Metropolitan Museum of Art.

Last fall, I was awarded a one-year Andrew W. Mellon Foundation Conservation Fellowship to work with the Department of Scientific Research at The Met, where I am working with the laboratory-based XRF scanning system housed in the paintings conservation department.

Having the ability to make scanning XRF measurements in the museum rather than at a synchrotron is relatively new, so a significant part of my role here is improving data analysis protocols. The instrument is primarily used to study paintings in The Met's collections, but I have also been able to contribute to ongoing collaborative research efforts with other departments.

In my independent research, I am exploring applications of scanning XRF for the study of other 2D objects, particularly 19th/early 20th century photographs. There are enormous variations in the chemistry of photographic processes that are difficult to assess by eye, but strongly influence how the objects should be treated. Examining photographs with point XRF is also challenging because there is not very much inorganic material present to measure, so I am evaluating what role scanning XRF might play in examination of photographs.

Of course, I miss working with the team at CHESS, as well as the synchrotron's unique combination of experimental flexibility and sensitivity. On the other hand, the opportunity to work with the extraordinary collections at The Met is unbelievable. Many of these objects will probably never visit a synchrotron, so it's important to improve the methods museums can use onsite. I'm hopeful that I will find a way to continue research in the cultural heritage field that takes advantage of both lab-based and synchrotron-based experiments.

THE SEPARATION OF SCIENCE

Ahead of ISSS 2017 in Vienna, the city where East meets West, five researchers share stories from behind the Iron Curtain – and consider how life changed when it fell.

Today, we often take for granted the free exchange of scientific ideas. With instant online communication through a multitude of channels, scientists are more connected than ever before. What would become of science, if those freedoms were curtailed?

During the Cold War, the Soviet Union-imposed 'Iron Curtain' restricted the ability of Eastern Bloc citizens to travel, trade or communicate with the wider world. Many of the participants of the upcoming International Symposium on Separation Sciences (ISSS 2017) in Vienna have ties to Eastern Europe. We asked some of them to share their experiences of analytical research before and after the fall of the Iron Curtain.

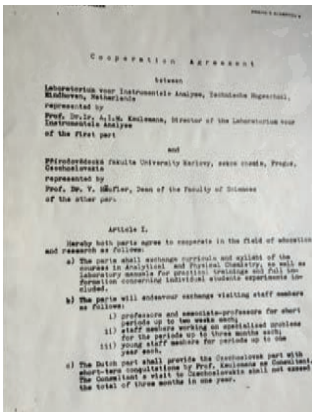
The results make for interesting reading. All describe challenges in obtaining supplies, sharing their findings and collaborating with Western institutions. Nevertheless, separation science in Eastern Europe survived, and even thrived, during this period – testament to the resourcefulness of researchers but also confirmation that science will always "find a way."

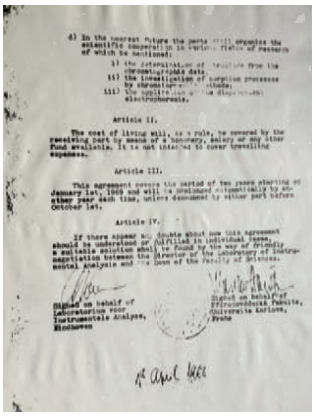
SCIENCE **FINDS A WAY**

Simple instruments and great enthusiasm allowed chromatography to flourish in Czechoslovakia – despite all the challenges.

By Eva Smolkova-Keulemansova

The Scientific Exchange Agreement between the Technical University Eindhoven and the Faculty of Science at Charles University, Prague.





My memories of the Cold War period are intertwined with the rise of gas chromatography (GC) in Czechoslovakia, which I witnessed from its infancy in the early 1950s. At the time, I was a PhD student at the Department of Analytical Chemistry at the Faculty of Science of Charles University, Prague. The head of the department asked me to "fulfill his dream" of adding gas analysis to our research and educational program in analytical chemistry. Of course, he had classical gas analysis in mind, with Bunte or Hempel burettes and pipettes, and so on. However, as at other times in my life, I was in the right place at the right time – in this case, at an analytical conference held in Prague in 1952, where Jaroslav Janák presented an early gas chromatograph, a fully glass device with volumetric detection, with CO_2 as the carrier gas and classical absorbents as column packing.

The rise of GC

It was a simple device, easy to build, and soon became very popular – and not only in our country. In our laboratory, we changed the volumetric detection, which required manual evaluation of the retention data, for a glass thermal conductivity detector placed in a thermostat, and used hydrogen as carrier gas. This device was more universal and, thanks to the hydrogen, more sensitive. For a time, homemade/tailor-made instruments were used successfully for both basic research and specialist applications. Then, in 1956, the first commercial gas chromatographs were built by Laboratory Instrument Company in Prague and became known under the name Chrom I–V, with innovations in each iteration.

Very early on, Jaroslav Janák organized a meeting where only five people (Janák – Brno, Cabicar – Prague, Franc – Pardubice, Šingliar – Nováky and I) came together to share their experiences, but after a few years (1957) there were 22 representatives, not only from academic and university laboratories, but also researchers from the main industrial institutions – reflecting the great interest and rapid expansion of GC.

Crossing the divide

Behind the Iron Curtain, the lack of foreign currency restricted opportunities not only to buy instruments, but also books and journals from the so-called Western countries. Having said that, we were not as isolated as it may seem. Czech scientists were represented on the editorial boards for the main international separation science and chromatography journals of the time, and there was no lack of Czech chromatographers authoring and contributing to important books both in Czech and in English.

For the leaders of the field, there were many options for contact with leading scientists in Western countries. As the level of scientific research in our country became known, Czech scientists were invited to international conferences and often asked to present keynote lectures. It is true, however, that this happened for a limited number of people – and was always dependent on whether the authorities would give their permission to travel abroad. At any rate, there were channels for personal contacts. From 1954 there were important conferences in Leipzig or East Berlin, which made it possible for chromatographers from Middle and Eastern Europe to meet the world's top scientists.

Extraordinarily important for facilitating contact between leading laboratories in the West and in our country was the Scientific Exchange Agreement (SEA). This idea from A. I. M. Keulemans was realized in 1968 thanks to the generous financial support of Clark Hamilton. The basis of the activities were short visits and long-term research stays between labs in East and West. It started with an agreement between the Technical University Eindhoven and the Faculty of Science at Charles University, Prague and part of the official culture agreement between the Czechoslovak Ministry of Education and Culture and the Netherland authorities. The cooperation soon extended to leading labs in Western Europe (including the Guiochon lab in Paris, Huber in Vienna, and a number of labs in West Germany) and laboratories across Czechoslovakia. Later, labs in Hungary, East Germany, Poland and Yugoslavia came on board. According to an article published in Chromatographia in 1982 by Georges Guiochon, around 120 research stays exceeding six months and a large number of 3-6 month stays were supported, as well as

"Extraordinarily important for facilitating contact between leading laboratories in the West and in our country was the Scientific Exchange Agreement (SEA)".

close to 300 discussion visits, lecture tours and participation in symposia, including the "Danube symposia" which were held in Bratislava, Karlovy Vary, Hungary and Poland. All of these initiatives had the same goal – to make connections between scientists from East and West.

All change (or is it?)

What changed in 1989? The exchange of ideas and cooperation between laboratories across the whole world opened up. Young people suddenly had new opportunities in research, foreign languages and, most importantly, making contacts. The labs in our country are now equipped with modern instrumentation and can compete on an international level.

Modern analytical separation methods have a proud tradition in our country, and a lot was done behind (and despite of) the Iron Curtain – thanks to simple devices and great enthusiasm.

The first national symposium in our country was held in 1956 in Brno followed by many conferences with international participation and, later, even important international symposia took place in our region. It was great to see the traditions and experiences of the past renewed in 2017, when the important HPLC Symposium was held in Prague.

Eva Smolková-Keulemansová, is a Retired Professor of Analytical Chemistry, Faculty of Science, Charles University in Prague, Czech Republic. Born on April 27 1927 in Prague, in March 1943 she was taken to the ghetto Theresienstadt and from there to Auschwitz, Hamburg and Bergen-Belsen concentration camps. She returned to Prague in November 1945 and continued her studies in chemistry, including diploma work in the field of polarography, a PhD focused on gas chromatography and a DrSc dealing with inclusion compounds in chromatography. From the early 1950s she started to build a team devoted to modern analytical separation methods (GC, HPLC and electromigration). She has authored or coauthored 140 original papers, and a number of reviews, book chapters and books i.e. Analysis of Substances in Gaseous Phase (Elsevier).

Read more about the "First Lady of Chromatography" at tas.txp.to/Smolkova [https://theanalyticalscientist.com/issues/1114/the-first-lady-of-chromatography/]

NECESSITY IS THE MOTHER OF INVENTION

In Cold War–era Russia, one could be successful... if one was innovative.

By Vadim Davankov

I am approaching my 80th jubilee in a few months, and I believe it puts me in a position to fairly and critically evaluate the years spent in the presence and absence of the "Iron Curtain" – years that have gone by sooner than I expected.

In 1957, I was fortunate to be selected for the very first group of Soviet students delegated to the German Democratic Republic to complete our chemical education. I graduated in 1962 from the Technische Hochschule in Dresden, which gave me broad chemical knowledge and some command of the German language (as well as a few key English phrases).

On returning to Russia in the 1960s, I joined the Nesmeyanov-Institute of Organoelement Compounds (INEOS) in Moscow for my PhD studies. I quickly understood that in Russia, with very little modern equipment, I had to be inventive if I wanted to be successful.

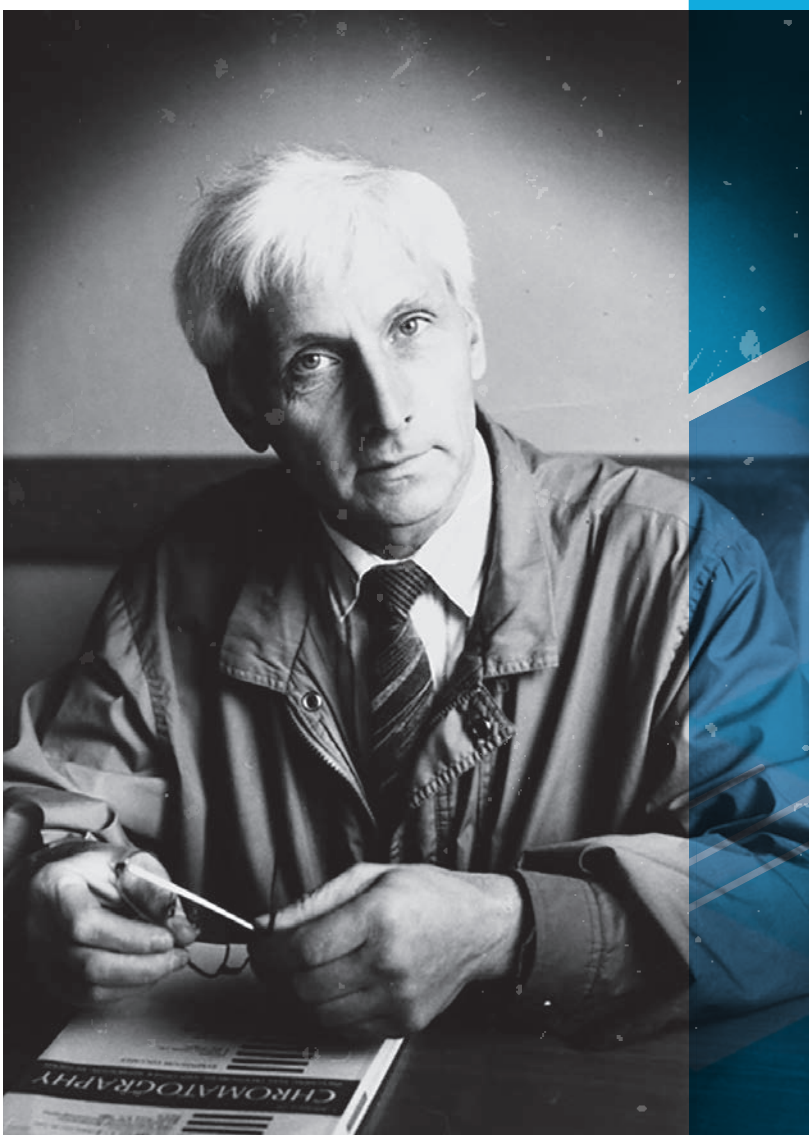
Two big ideas

In an attempt to separate two enantiomers of amino acids by liquid chromatography on a chiral ion exchange resin (that I prepared by binding chiral proline on polystyrene beads), I introduced copper (II) ions into the chromatographic system in 1968. And that was the beginning of what proved to be a very successful technique – chiral ligand exchange chromatography (CLEC). Later, the principle of CLEC served as the technique of choice for developing two-dimensional LC, chiral capillary electrophoresis, chiral preparative simulated moving bed (SMB) techniques and others.

The keen interest in CLEC amongst specialists in the fields of chromatography, general stereochemistry, asymmetric organic synthesis, pharmacology and polymer chemistry gave me the unique opportunity of lecturing at numerous international meetings. I was able to visit many interesting countries and develop friendships with outstanding scientists – readily supported by both the organizing committees of meetings and the Academy of Sciences of the USSR.

Though the principle of CLEC was 'protected' in 1969 by several international patents assigned to my state, we did not benefit from any of the chiral stationary phases that a series of Western companies brought to market – the USSR was simply not equipped for international court debates. Though totally unprepared for any kind of business activity myself, I was pleased to see Regis Technologies offering "Davankov's columns" for enantiomeric resolutions of complex-forming compounds, such as amino acids...

My lab and I also worked on another important idea: preparing nanoporous polymeric adsorbing materials by intensive crosslinking of linear polystyrene chains in solution. The key was to introduce many rigid struts between the



"We used to have a stable budget; nowadays, our state has reduced basic financial support dramatically."

chains, thus converting the initial solution (or soft gel) into a rigid open-work material with a huge effective surface area – in the order of 1000–2000 m2/g. Twenty years later, hypercrosslinked polystyrene adsorbing materials appeared on Western markets, manufactured in the hundreds of metric tons for the purification of water, isolation of valuable components, removal of odors from gas streams, and so on. While monitoring natural and industrial waters, analysts often use small solid phase extraction (SPE) cartridges with polymeric adsorbing materials, but most don't know the details of the sorbent. Even fewer know that the polymer can be made in true nanoporous form, thus functioning as a restricted access material (RAM) for direct extraction of small molecules, while rejecting bigger ones. Even specialists do not yet appreciate that neutral nanoporous beads can be successfully used for direct separation of mineral ions with an unprecedented self-concentration of isolated components. Still, we are pleased that we succeeded in developing hypercrosslinked polymeric hemosorbents, which have already saved the lives of many patients with sepsis and septic shock.

No regrets

Reflecting on the years behind the Iron Curtain, I can state that I would not radically change anything in my scientific or personal life. As a scientist, I would not have been able to influence, much less change, the political situation from behind the walls of INEOS, where I have now worked for 55 years. During the first half of that period, the Institute belonged to the Academy of Sciences of the USSR; thereafter, it belonged to the Russian Academy of Sciences. It is impossible not to notice the difference between the attention paid to basic science in former times, and the "permission to earn money by ourselves" that we have gained since we've become "open to the world."

There is and never was sufficient research money. But we used to have a stable budget; nowadays, our state has reduced basic financial support dramatically. A large portion of the funding available is now being distributed via various foundations, but the evaluation of proposals is far from fair. As a result, the funding success of research groups often has little to do with their scientific productivity. More regrettable still, we are overloaded with writing endless plans, evaluations and reports, so that I no longer find it enjoyable to be Department Head. And there are no younger scientists to replace me; of the many PhD students whose work I had the pleasure of initiating and supervising, not one can afford to continue a scientific career at INEOS.

I joined the Communist party of the USSR rather late, when Brezhnev announced "collective leadership" in the party. My party membership has not damaged my reputation at INEOS, demonstrated by the fact that, when permitted to elect a new director, our staff nominated me three times for the position (though it was never approved by 'democratic' academy chiefs).

Before the fall of the Iron Curtain, I was twice elected to the position of first bureau secretary of INEOS, something that allowed me to participate in all the important decisions in the life of the institute, in close cooperation with the director of the institute (Nesmeyanov) and the chairman of the local trade union. After 1989, this 'totalitarian' tradition was abolished, and our staff appear to be helpless to oppose the dictates of appointed bureaucrats.

Looking back over my life, I realize it has been full of activity and interesting events – irrespective of the Iron Curtain. Though traveling much less in later years (mostly because of the lack of financial support from the Russian Academy of Sciences, but also difficulties in obtaining a Schengen visa), I have enjoyed an active and often successful career at INEOS – as well as the respect of my colleagues and the love of my nearest and dearest who, thank God, stayed in the homeland with me.

Vadim Davankov is Professor and Head of the Laboratory for Stereochemistry of Sorption Processes, Nesmeyanov-Institute of Organoelement Compounds, Russian Academy of Sciences, Moscow. He was born on November 20, 1937 in Moscow, and followed in the footsteps of his parents by studying at the Mendeleev Higher School for Chemical Technology. He later graduated from the Technische Hochschule Dresden, and there, despite the recommendations of USSR Embassy officials, married a Greek woman, Evtichia. He joined the Nesmeyanov-Institute in Moscow as a technician in 1962, gained a PhD and DrSc, and became a full professor in 1980. He is the proud recipient of numerous awards, including the State Award of Russia (1996), Distinguished Scientist of Russia (2005), Kargin Award in Polymer Chemistry (2017), Chirality Gold Medal (1999), Martin Gold Medal (2005), Molecular Chirality International Award (2010), M. Tswett & W. Nernst Separation Science EU Award (2010). He has two sons, six grandchildren and one great-grandchild.

A BARRIER **TO LEARNING**

For a young researcher, restrictions were stifling, but we made best use of the resources we had.

By András Guttman

In the early 1980s, I worked at the Semmelweis University Medical School in Budapest, Hungary as a Research Scientist and Assistant Professor in the Department of Pharmacodynamics. My projects included the development and application of combined and multidimensional bioanalytical techniques to drug metabolism research, for the study of urinary and serum metabolic pathways of new potential antidepressants in rats, dogs and humans. I also taught bioanalytical and chemistry classes and supervised student laboratories.

Separation science certainly thrived in Hungary, but it was not easy to work in that period. Instruments were mostly manufactured within the Eastern Bloc countries, and much less efficient than Western counterparts. As a result, we mostly used cheap techniques, such as polyacrylamide gel electrophoresis and thin-layer chromatography.

Our professors and supervisors were from the pre-communist era; truly inspirational people who tried to get by within the system and concentrate on theoretical work, which did not require state-of-the-art instrumentation or consumable support. Interestingly, funding was not a problem, as all labs had defined budgets irrelevant of the results they produced, as with everything else in the socialist system. In my department, political issues were never mentioned, and it was never suggested that we become a member of the party for advancement or any other reason.

We knew about scientific advances from the West, but literature was never up-to-date, as journals arrived two to three months after publication. We published mainly in journals within the Warsaw Pact countries. I was a very young researcher at that time, so did not even dream about publishing in a Western scientific journal. On occasion, we were able to pick the brains of researchers who returned from fellowships in the West – though many chose to remain overseas illegally.

"Separation science certainly thrived in Hungary, but it was not easy to work in that period."

I left Hungary in 1987, having secured a two-year postdoctoral position at Northeastern University in Boston. By the time I was supposed to return in 1989, revolution had swept aside the Iron Curtain. Not only did that mean I could stay in the West, but also that I need not fear criminal charges for leaving the country without a permit nor face being banned from Hungary for decades – common practice during the communist era.

András Guttman, Lendulet professor of Translational Glycomics, is the head of the Horváth Csaba Memorial Institute of Bioanalytical Research in Debrecen, Hungary, and also leads application efforts at SCIEX (Brea, CA, USA). His work is focused on capillary electrophoresis and CESI-MS based glycomics and glycoproteomics analysis of biomedical and biopharmaceutical interests. He is an author or coauthor on close to 300 scientific publications and holds 23 patents. He is a member of the Hungarian Academy of Sciences, on the board of several international organizations, serves as editorial board member for a dozen scientific journals and has been recognized by numerous awards including the Analytical Chemistry Award of the Hungarian Chemical Society (2000), named as Fulbright Scholar (2012), received the CASSS CE Pharm Award (2013), the Arany Janos medal of the Hungarian Academy of Sciences, the Pro Scientia award of the University of Pannonia and the Dennis Gabor Award of the Novofer Foundation in 2014.

Timeline

1945
End of World War II

1947
Marshall Plan

1949
East and West Germany Separate

1949
Soviet Union develops atomic bomb

1953
Death of Stalin

1955
The Warsaw Pact

1956
Hungarian revolt

1961
Berlin wall erected

1962
Cuban missile crisis

1968
Czechslovakian revolt (Prague Spring)

1979
USSR invades Afghanistan

1980
Ronald Reagan elected President of the USA

1985
Gorbachev becomes leader of Soviet Union

1989
Berlin wall falls, new regimes throughout Eastern Europe

1991
Formal dissolution of the USSR

SCIENCE WITHOUT BORDERS

Working (and living) behind the Iron Curtain wasn't easy; fortunately, good chemistry is applicable all over the world.

By Frantisek Svec

I started my academic career as an assistant professor at the University of Chemical Technology and then as a scientist at the Institute of Macromolecular Chemistry of the Czechoslovak Academy of Sciences, both in Prague. Established by renowned chemist Otto Wichterle – and largely supported by royalties from the licensing of his work on soft contact lenses – the institute integrated the best Czech minds in the field of polymer preparations and separation applications, including Jiři Čoupek, Mirek Kubín, Josef Janča, Jiří Štamberg and, guru of macroporous polymers Karel Dušek (1). I learned a great deal from working alongside these talented people.

In the early 1970s, I started my own research into the development of reactive porous particles designed for applications such as polymer-supported reactions, heterogenized catalysts (including immobilized enzymes as well as fishing-out and chelating resins), and for both liquid and gas chromatography.

We came up with the idea of using glycidyl methacrylate, a reactive monomer that had never before been used for this application. Typically, we copolymerized this monomer with an ethylene dimethacrylate crosslinker in the presence of porogens cyclohexanol and dodecanol to obtain macroporous beads. These last components remain very popular porogens in the preparation of both porous particles and monoliths, even today. We learned methods enabling control of particle size and porous properties, permitting a variety of functionalization processes involving the epoxide functionality of the monomer, and tested various applications.

Separated (sometimes)

We were "separated" from the West, but we had rich collaborations with the Eastern Bloc countries, as this type of travel was prioritized. For example, thanks to the unique reactive porous polymer beads we were developing, I did some very rewarding work with scientists in Moscow and what is now St. Petersburg, as evidenced by numerous joint publications.

As our polymers were new, publishing our results was relatively easy – but, unfortunately, we were not aware of variations in journal quality and instead published our results in whichever journal was easiest. We also failed to appreciate the importance of writing review articles summarizing our work and putting it into context. Thus, many of our studies that could have been considered "world class" fell into oblivion and did not receive the attention they deserved.

High-caliber scientists from all over the world came to visit us, and conferences organized in the Institute of Macromolecular Chemistry attracted an international audience, even during the Cold War. The Academy of Sciences also supported travel (to a limited extent) to conferences outside the Iron Curtain; however, people who did not have a good "pedigree" were not so fortunate. This inequity was particularly apparent after the Prague Spring in 1968, during which many people were engaged in activities later considered to be against official policy. Many excellent scientists could not travel for this reason. Some young scientists were allowed to do postdocs in the West, but their families were not allowed to go with them, and were instead "held hostage" in their home country...

A barter economy

Funding was straightforward, but problems arose from the lack of "hard currency". For example, the importing of chemicals had to be planned up to a year in advance. Of course, knowing which chemicals or instruments I might need in a year's time was "mission impossible"! So we ordered chemicals we believed we might need, kept them in our labs and engaged in 'horse trading' with other labs. When we needed something, we asked our friends in the institute or in other locations, and they did the same with us. Amazingly, this worked! The only problem was that our storage was full of chemicals for bartering. Sometimes, if we couldn't get hold of a certain compounds, we had to synthesize it in the lab; I vividly recall carrying out the large-scale preparation of liters of glycidyl methacrylate.

A bright future

Despite the difficult political climate, I chose not to leave the country, and I feel it was a good decision. My wife and I had good jobs, although the overall economic situation of my family was of course worse than that of our peers in western countries. My kids went to school, got an education, and grew up among their friends. Plus, illegal emigration would have meant significant problems for family members who remained. I decided to relocate to the United States only after the children were grown and the move was legal.

The situation is completely different these days. The Czech Republic is now a member of the EU with free movement and employment within member states, and Czech scientists work in labs around the world. Many of the world-class separation

"Some were allowed to do postdocs in the West, but their families were not allowed to go with them, and were instead 'held hostage' in their home country."

scientists born in the Czech Republic have chosen to continue their work there and those who decided to leave are very proud of their origin. Thanks to their excellent education in analytical sciences, they are welcomed even in the most famous labs – and when they return to their homeland they enhance the quality of research and education there. I believe the future of separation science in the Czech Republic is a bright one.

Frantisek Svec lives in California and is Professor at the Beijing Advanced Innovation Center for Soft Matter Science and Engineering, Beijing University of Chemical Technology, Beijing, China and at the Department of Analytical Chemistry, Faculty of Pharmacy, Charles University, Hradec Králové, Czech Republic. He received a BSc in chemistry and PhD in polymer chemistry from the Institute of Chemical Technology, Prague (Czech Republic). In 1976 he joined the Institute of Macromolecular Chemistry of the Czechoslovak Academy of Sciences, before joining the faculty at Cornell University in 1992. In 1997, he was appointed at the University of California, Berkeley and also affiliated with the Molecular Foundry of the Lawrence Berkeley National Laboratory. Svec has authored 450 scientific publications, edited two books, and authored 75 patents. He is editor-in-chief of the Journal of Separation Science, member of editorial boards of a number of renowned journals and was President of CASSS in 2003–2015. He is best known for his research in the area of monoliths and their use in liquid chromatography, electrochromatography, supports for solid phase chemistry, enzyme immobilization, and microfluidics.

Reference

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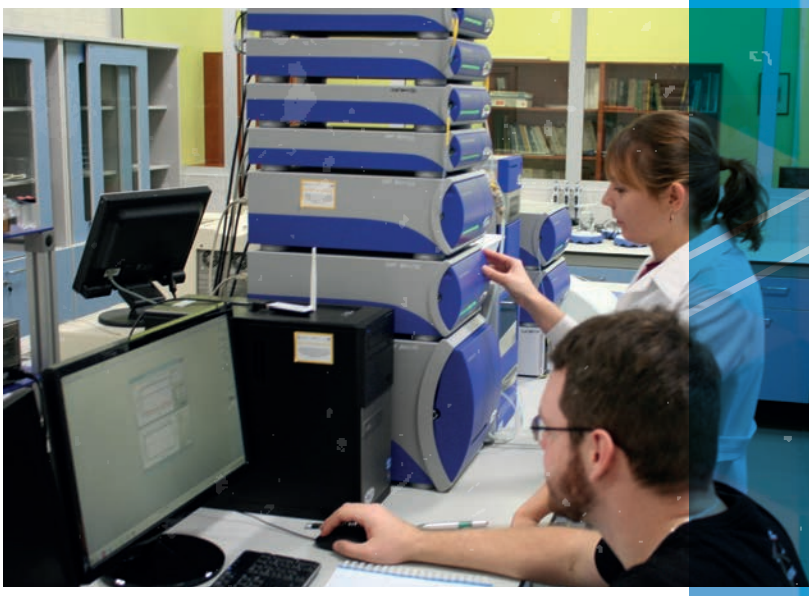
OPEN TO THE WORLD

Chromatography in Poland has always been a strength – but the fall of the curtain has brought new opportunities for collaboration.

By Bogusław Buszewski



I undertook my education in the time of communism in Central and Eastern Europe; however, I was fortunate to have great professors from Warsaw, such as Wiktor Kemula, Jerzy Minczewski, Zygmunt Marczenko and Adam Hulanicki, and mentors from Lublin, such as Andrzej Waksmundzki, Edward Soczewiński and Zdzisław Suprynowicz. They set the tone of Polish analytical chemistry, not only in terms of scientific standards, but also aesthetic and practical.

I finished my studies at the Faculty of Chemistry at the Maria Curie Skłodowska University in Lublin, where I first came into contact with chromatography and where I became a pioneer in Poland in the construction the first liquid chromatograph and the first HPLC columns. Here I also built the elutriator - a device to fractionate sorbents. The influence of Waksmundzki made Lublin a leader in separation methods.

Poland has always excelled in separation science, but a lack of instrumentation during the Cold War-era meant there was a particular focus on the development of thin-layer chromatography. In this area, the center in Lublin dominated, with people such as Waksmundzki, Suprynowicz and Soczewiński making the biggest contributions. Column liquid chromatography also took its first tentative steps in Lublin, specifically in terms of the new generation of stationary phases and synthetic packing with controlled density coverage on the basis of silica (silica gel and porous glass).

In terms of gas chromatography, the scope of basic research was related to the interpretation of the retention-structure of an analyte and provided the basis for the use of topological species for group analysis. At the same time, methods of sample preparation were developed based on the distillation and extraction processes. The range of its application was related to environmental analysis (PCBs, PAHs, pesticides) and pharmaceutical analysis with retention-structure (QSRR) elements. A new generation of DS chamber for TLC and HPLC detectors was introduced, as well as the first ITP apparatus.

I actively participated in the research described above – mainly the theory of reversed-phase systems, new stationary phases, solvation effects and adsorption of solvent components on the surface of column packings. The introduction of SPE in 1976 for the use of stationary phases with a chemically bounded phase to isolate pesticides, was a major "theme" in these studies. At the same time, new packings for SPE were applied in pharmacognosy analysis, specifically the isolation and purification of biologically active substances extracted from plants.

"Despite the advances we made behind the Iron Curtain, after 1989, we found it much easier to cooperate with countries in Western Europe and the rest of the world."

Despite the advances we made behind the Iron Curtain, after 1989, we found it much easier to cooperate with countries in Western Europe and the rest of the world. We started to organize laboratories, apply for financial support and equip our laboratories according to the Western model. In 1994 I moved from Lublin to Nicolaus Copernicus University, Torun and began to organize research in modern analytical chemistry, and especially the use of separation techniques in environmental chemistry, pharmacy, medicine and food chemistry. We started teaching MSc and PhD students according to European and

world standards; now, our laboratories have hosted postdocs or PhD students from more than 20 countries and we share in numerous international programs and projects.

I initiated a new Interdisciplinary Center for Modern Technologies, which is considered one of the best centers in Poland for research in the field of omics. The center is very well equipped and frequently collaborates with local small and medium-sized companies.

I have been fortunate to have many opportunities to travel beyond our borders, and have been visiting professor at several universities in the USA, Japan, China, South Africa, Australia, Taiwan, Austria, the UK, the Netherlands, and many other European countries. I have also tried to pass on my knowledge to my students, which I believe is crucial for the development of the field. Cooperation in analytical science is key; working with colleagues within Poland and overseas allows us to pursue ambitious goals that fit in with our research.

Bogusław Buszewski is full Professor of Analytical Chemistry and Head of the Chair of Environmental Chemistry and Bioanalytics, Faculty of Chemistry, Nicolaus Copernicus University, Torun, Poland. He graduated at the Faculty of Mathematics–Physics–Chemistry of the Maria Curie Sklodowska University in Lublin. In 1986, he received his PhD at the Faculty of Chemical Technology, Slovak Technical University in Bratislava, Czechoslovakia, followed in 1992 by a DrSc degree. In 1994 he became a professor at Nicolaus Copernicus University in Toruń and in 1999 received the title of Professor of Chemistry. He has been Humboldt Fellow at Tübingen University (Germany) and visiting professor at several universities around the world. He chaired the Committee of Analytical Chemistry of the Polish Academy of Sciences from 2015 to 2019 and serves on the editorial boards of 26 national and international journals. He has authored or co-authored 15 books, numerous patents (most of which have been implemented), and more than 460 scientific papers. He is one of the most cited chemists in Poland and received awards from numerous national and international organizations (including Doctor Honoris Causa).

Business

Ergonomic drivers
Emerging trends
Business strategies

Joining Forces: Rise of the Omics

Our series profiling academia–industry collaborations continues by looking at how Thermo Fisher Scientific is supporting the University of Birmingham's metabolomics research program.

With Mark Viant, Professor of Metabolomics, University of Birmingham, UK and Iain Mylchreest, vice president, R&D, analytical instruments, Thermo Fisher Scientific

Tell us about your project…

Mark Viant: We have two metabolomics research centers here at the University of Birmingham – the Phenome Centre Birmingham, which is a £8 million research center opened by UK Government Chief Scientific Adviser Professor Sir Mark Walport in May 2016, and the Birmingham Metabolomics Training Centre. Thermo Fisher Scientific is technology partner with both of those research centers and with the University's proteomics program. Helen Cooper, a professor of mass spectrometry here at Birmingham, leads the proteomics part of the relationship, while Rick (Warwick) Dunn and I lead the metabolomics side. Rick and I have a joint lab with about 25 PhDs, postdocs and technicians, and we direct both the training center and the Phenome Centre.

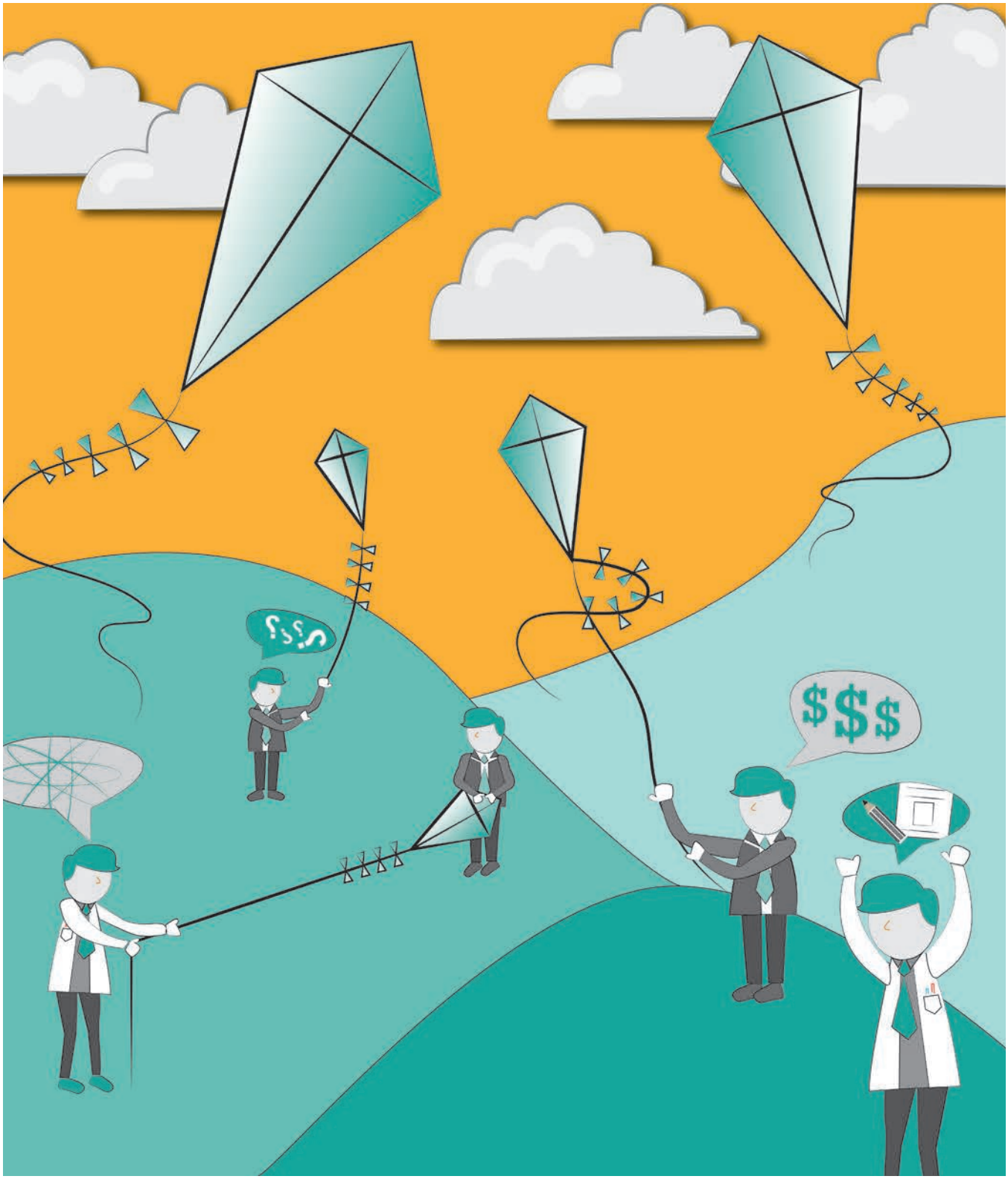
Phenome Centre-Birmingham (PCB) conducts metabolic phenotyping (metabolomics) studies across the breadth of human health research. We apply both non-targeted and targeted metabolomic approaches to study human diseases and aging in large-scale studies to translate into stratified medicine, ultimately benefiting both UK and global populations. Specifically we use these approaches to measure the "metabolome" of patients – the set of naturally occurring metabolites in cells, tissue or biofluids such as plasma or urine. The big data that is generated is then analyzed using bioinformatics and biostatistical tools to understand molecular mechanisms associated with disease onset and progression, and to identify clinically relevant metabolic markers (biomarkers) that could be used to stratify the human population in terms of disease risk and choice of drug treatment. Current projects include metabolomics studies of reproductive medicine, blood cancers, trauma and organ transplantation.

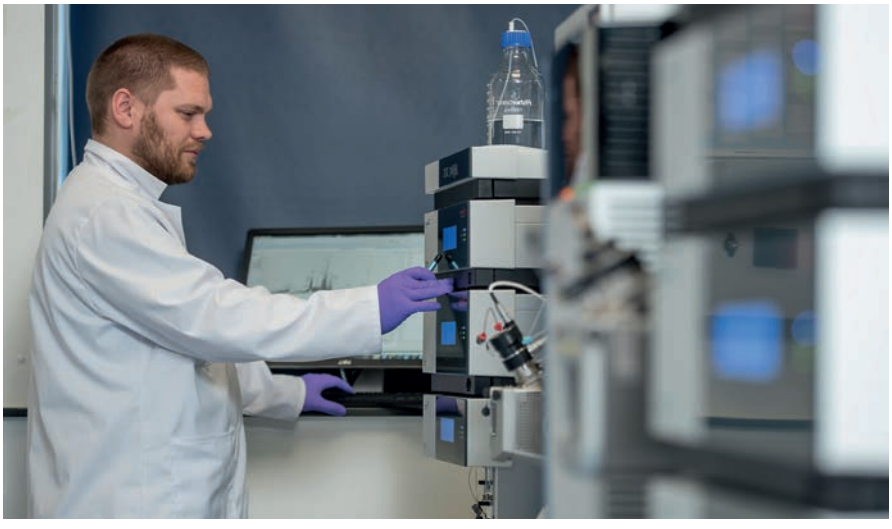
Thermo Fisher works with us on a number of levels. They currently fund multiple Cooperative Awards in Science & Technology (CASE) PhDs in metabolomics here in Birmingham that provide a bedrock for our collaboration. As well as input from Thermo Fisher on the scientific direction of these projects, the PhD students visit the Thermo Fisher analytical laboratories, spending time working with their scientists – that's a pretty deep interaction and a great experience for the students, who are more used to an academic research environment. We also beta-test some of their instrumentation and software – and that means we get early access!

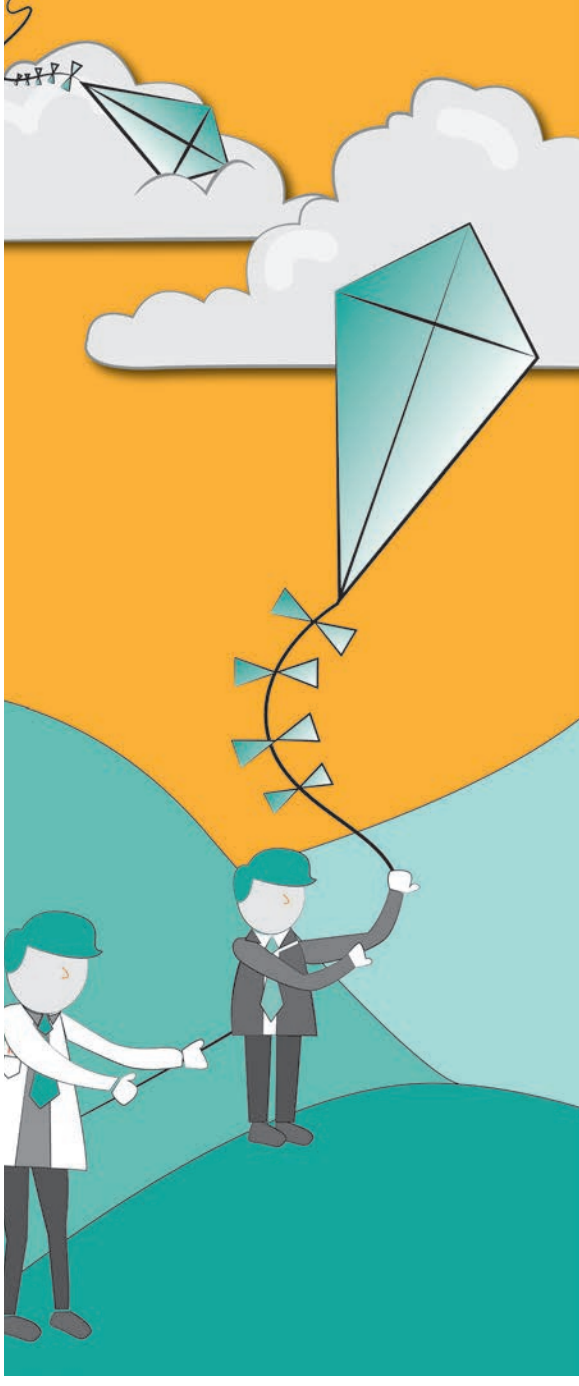
How did you build the partnership?

MV: I was invited to give a keynote presentation at a conference in Washington DC in 2012. I talked about the science, our approach, and instrumentation. After the talk I was approached by Thermo Fisher. We had an extremely productive chat over a coffee, and it turned out that the company was looking to strengthen its relationships with different academic laboratories around the world, and metabolomics was a big growth area for them.

Iain Mylchreest: The partnership evolved over a series of conversations and visits to Birmingham, where we got to know Mark and his team and were exposed to the science and the collaborative network he was building. Partnerships like these always evolve as we explore mutual interests and visions. As an analytical tools provider, we appreciate collaborations like these where we can enable science, not just for today's challenges, but to develop new capabilities to answer future questions. It was clear to us right away that the team at Birmingham is pushing the field







of metabolomics into new areas and is thinking on a bigger, broader scale that requires new channels of information and needs more experimental capability. One of the goals of this collaboration is to take emerging and new capabilities and make them more accessible to the broader community.

What are the benefits of academia–industry collaborations?

MV: There are many benefits, and it's become an activity I am passionate about it. We have a lot of industry collaborations, and it is a key part of how we conduct our research. I'm not interested in being locked in an academic ivory tower with the sole focus on publishing papers – I want to translate our science and achieve impact, and I can make that happen by working with companies. They provide a very challenging 'problem space' in which we can deeply engage with them and further the science of metabolomics.

Diversification of our funding portfolio is also very important to us – you can't depend on the research councils, and here in the UK there are uncertainties around Brexit and the European funding situation. Having industry funding has become a vital fuel for our research program. However, it's not a case of begging for money – it's a two-way relationship. We genuinely believe we can help the company design a better product and ultimately increase sales. We openly acknowledge this partnership in talks and on posters,

and we thank Thermo Fisher as our technology alliance partners. It's something that we're very proud of.

A common negative that people bring up is restrictions on publication, but we have never found this to be a problem. It's never slowed down a publication.

IM: Collaborations allow us to stay close to the basic and applied research in emerging fields, and get feedback where we should be directing our technology developments. Additionally, we can see how our current products perform against specific challenges. We then are able to gather input on how we could further enhance products. Essentially, by giving scientists access to technology we can develop new concepts and test them against real-world problems. This is critical for us and helps us to enable better science, open up new experimental capabilities and informational output. Long-term relationships like these can span many generations of a project and helps us see the complete picture – creating opportunities for potential evolutions of products.

"I want to translate our science and achieve impact, and I can make that happen by working with companies."

What challenges have you encountered?

MV: Here at Birmingham, we have many industry partners. The Phenome Centre alone has four, two of whom (Waters and Thermo Fisher Scientific) sell mass spectrometry instrumentation. Therefore, one challenge is to think carefully about what research we conduct with one partner and what we do with the other, to avoid damage to either relationship.

IM: We really haven't experienced many challenges with this collaboration. We do our best to avoid potential pitfalls through careful scoping of projects and by focusing our efforts on specific projects. Regular, open dialogue is critical to success.

What makes for an effective partnership?

MV: Two words: deep trust. Without trust, you're not going to build a relationship. You have to be able to look your collaborators in the eye and know that both you and they are offering informative, relevant information.

If you're considering going to go into a relationship like this then my advice is to take it seriously. Think about it and nurture it – if you do that, it's a win–win. You have to respect the relationship and see it from both sides: give them what they need, while ensuring you get what you need. It's the same fundamental basics as any relationship.

IM: Partnerships are successful when expectations are clear and when we are careful about setting realistic deliverables for both parties. Collaborations usually involved multiple projects and can span many areas, so it's important to have a primary point of contact for each aspect of the collaboration. Also, establishing a team to navigate the different projects is critical, so that everyone is clear who to turn to for answers and so that support is provided in a timely manner.

Phenome Centre Birmingham: www.birmingham.ac.uk/phenome-centre

Birmingham Metabolomics Training Centre www.birmingham.ac.uk/bmtc

Profession

Leadership
Talent Development
Career Planning

Science Gets Personal

To better understand the evolution of the field, we are collecting the human stories of key figures in separation science

By Lloyd Snyder, Frank Svec, and Robert Stevenson

Science is a uniquely human endeavor. But what makes humans become scientists?

About 50 years ago, high performance liquid chromatography (HPLC) and related techniques in separation science burst over the horizon, attracting interest from many gifted scientists. Over the next decade or so, a small cohort of scientists devoted their careers to understanding and advancing separation science – predominately liquid chromatography. The literature since then provides a history of the technical evolution of separation science, but one that is impersonal and largely ignores the many personal trials and tribulations that shaped the work.

Each of these innovative individuals invested decades of their lives into advancing separation science. But what motivated them to make this choice? What hurdles did they face and overcome? These are the human challenges that we all face in our lives. And it was this largely unpublished story that the three of us began to ponder in early 2015, eventually leading us to solicit personal biographies from some of the talented scientists who were influential in advancing our understanding of HPLC.

Separation stories

As members of CASSS (formerly the California Separation Science Society, Emeryville, CA), we naturally first approached living recipients of the CASSS Award for Outstanding Achievements in Separation Science. The complete list of awardees reads like a "Who's Who" of separation science (1). Of course, many died before the project started, including academics Calvin Giddings, Josef Huber, Csaba Horvath, Georges Guiochon, Phyllis Brown and Goren Shill, as well as industrial chemists such as Jim Little, Yoshio Kato, Walter Jennings, and Uwe Neue. But the personal stories we were able to collect provide fascinating insights.

Under the authors' impetus, CASSS has now curated and posted a collection of stories from several leading specialists in separation science at http://www.casss.org/?BIOINTRO and we expect more to come. We hope that reading these stories will prove useful to chemists looking for guidance in developing and managing their own careers. The biographies we've received so far certainly illustrate some key lessons for all scientists.

Find your passion

Pier Righetti's anthology begins with a recollection of his childhood in post-war Italy, including a stint as a stable hand for military mules. Later, he writes "As soon as I graduated, I got married and we left right away for the USA, the mythical land of opportunity." His magical career moment occurred at MIT when an unnamed Japanese scientist presented a lecture on isoelectric focusing, which had been commercialized by LKB Produkter, AB. Rigetti comments:

"I knew that I would embrace this methodology and grow up with it in my scientific career..." And he did, as spelled out in the rest of his biography.

"I knew that I would embrace this methodology and grow up with it in my scientific career"

Two heads are better than one

Joseph J. (Jack) Kirkland titled his contribution "Biography of an Analytical Chemist." After a stint in the Navy, he attended Emory University and then earned his PhD at the University of Virginia. Then he joined DuPont de Nemours. In 1954, Stephen Dal Nogare

Jack Kirkland and collegues.

Jack Kirkland with colleagues in the lab.

introduced Jack to gas chromatography. Jack then designed and built an all-glass GC that helped him get to the bottom of several previously unsolved problems. He also extended the range of GC analytes via derivatization.

Fortuitously, Jack's lab was next to that of fellow chemist Ralph Iler, who was developing new methods to layer particles on glass plates. Jack adopted this technology to layer particles on glass beads for both GC and HPLC column packings. The resulting Zipax technology, introduced in the mid-1960s, eventually evolved into the exceptional core-shell technology that is widely used today for HPLC packings.

The importance of chance

Our reading of Klaus K. Unger's contribution is that he was not satisfied with the career prospects open to him in the German Democratic Republic, so he joined the refugee movement to the West. He navigated a complex set of circumstances to earn the equivalent of a BS degree. He entered graduate school

"Networking and dedication are essential, but so much is still governed by serendipity."

and was assigned a project to develop novel synthetic routes to make porous silica with controlled pore structure for use in steric exclusion chromatography of proteins and synthetic polymers. It appears that the project was chosen by his advisor, with little input from Unger – a lucky gain for separation science.

Unger then collaborated with Istvan Halasz to pool his knowledge of porous silica based bonded stationary phases and Halasz's experience in instrumentation. Unger's participation at the first HPLC symposium in Interlaken, Switzerland, was key to his acceptance as a researcher in HPLC. In return, he provided column technology that helped fuel decades of exponential growth in HPLC, starting in the mid-1970s. Today, Unger is recognized as one of the leading developers of HPLC column technology of the past several decades.

Separation science continues to advance, with new problems to solve, and yet future scientists will face many similar personal and professional challenges as described in the collected biographies. Research and development can be tough – networking and dedication are essential, but so much is still governed by serendipity.

Since the three of us have been fortunate enough to have interesting lives in science, we are eager to help younger scientists develop similarly successful and satisfying careers. Hopefully, the biographies we received can serve as models, highlighting both the possibilities and challenges in a career in chromatography. In the sciences, each day can present a new challenge. Rising and facing those challenges is key to making a difference in the few short years allotted to us, and eventually being able to look back with satisfaction on a life's work.

Lloyd Snyder is a Principal at LC Resources in Walnut Creek, California; Frantisek Svec lives in California and is Professor in Beijing Advanced Innovation Center for Soft Matter Science and Engineering, Beijing University of Chemical Technology, China and in Department of Analytical Chemistry, Faculty of Pharmacy, Charles University, Hradec Králové, Czech Republic; and Robert Stevenson is Editor Emeritus, American Laboratory/ Labcompare, USA.

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Carving Out an Analytical Niche

Sitting Down With... Renã Robinson, Assistant Professor, Department of Chemistry and Principal Investigator at RASR Lab, University of Pittsburgh, Pennsylvania, USA.

How did you get into analytical chemistry?

As part of my undergraduate chemistry research, I used GC-MS and LC-MS to detect fatty acids in glaucoma. It was my first exposure to using mass spectrometry for biological applications – and I was immediately excited by the possibilities. At Indiana University, I chose a dissertation project using analytical mass spectrometry methods to study proteins and aging in fruit flies. I used ion mobility-MS, which added another dimensionality to the data, increasing the separation space and allowing me to see more low-concentration proteins. It was a very interdisciplinary, collaborative research project, and everything was new to me – from the genetics of fruit flies to sifting through massive amounts of proteomics data to get something meaningful. It was exciting to be working in the field in the mid-2000s, when proteomics had just started to become a big deal.

How has proteomics changed since then?

The field has moved from establishing initial methods to measure proteins, to advancing instrumentation in such a way that allows us to profile entire proteomes with incredible sensitivity, and detect differences in diseased and healthy individuals. We have gotten really good at quickly analyzing the resulting data and focusing on the functional implications for proteins. The question now is: how can we analyze dynamic networks, and use spatial and temporal information in the best way to advance research?

Where did your research take you after your PhD?

Collaborating with a colleague who was working on Parkinson's disease sparked my interest in the possibilities of applying MS in age-related diseases. I have personal connections to Alzheimer's disease (AD), and wanted to dig deeper into the mechanisms behind neurodegeneration. I started looking for postdoctoral opportunities where I could focus more on age-related pathology. One universal aspect of aging is a decline in the immune system, which led me to focus my work on the role of immunosenescence in age-related disease.

What are your current projects?

We're using Orbitrap technology – very high-resolution and sensitive mass spectrometers – to carry out multiplexing experiments (MS, then MS/MS, and then MS/MS/MS) investigating how proteins change during aging and immunosenescence, and looking for potential drug targets in neurodegenerative disease. It's exciting work – we're seeing things that have never been seen before. For example, we have been able to determine that the liver plays a significant role in Alzheimer's disease by identifying many proteins with different expression in AD mouse models compared to wild-types. Additionally, we have begun to better understand the effects of oxidative stress in AD by measuring nitrated and S-nitrosylated proteins. While we are aware that AD is a brain disease, we have significant proteomics data to show that peripheral organs also have an important role. Our current projects are geared towards understanding the system-wide nature of AD and determining if there are systems which make certain populations more at risk for developing AD.

What motivates you?

It's a gift and a privilege to be doing this type of research; I feel like this is my purpose. The thought of all the people who are being left devastated by AD keeps me focused. It reminds me that we need to aim for more than just incremental improvements in our technology and analytical approach – there's a bigger picture that we have to keep in mind.

What's next for your lab?

Our lab is moving to Vanderbilt University this summer. There are lots of opportunities at Vanderbilt to do really top-notch mass spectrometry – and to engage with the Memory & Alzheimer's Center to help further research in this area. We'll be able to add to our repertoire of approaches and techniques, and beef up our mass spec platforms and technologies. As well as proteins, we're interested in measuring lipids and other metabolites. The team already has a lot of analytical expertise, but we're planning to expand our capabilities in informatics and functional biology, to allow us to follow up on our proteomics findings. We're particularly excited to have more access to human samples in the clinic. In ten years' time, I hope we will have been able to help advance AD research – and be one step closer to an effective treatment.

Congratulations on winning a 2017 Pittsburgh Conference Achievement Award…

It was a real highlight, especially to be presented the award by Sarah Trimpin (now at Wayne State University). Sarah has been a mentor to me since she was a postdoc and I was a PhD student at Indiana. She showed me how to push away at a problem and give it everything I've got! She works extremely hard and extremely smart; not only has she done so much with ionization techniques and mass spectrometry, but she also considers every angle that you could to approach a particular problem. She has carved out a niche for herself, and inspired me to ask myself, "What's going to be my thing?"

And what is your "thing"?

I hope I'll be able to look back at my career and say my niche was developing and applying quantitative proteomics in a way that has furthered our understanding of AD and aging – specifically, how things outside of the brain are related to what's happening in the brain. From the start, I knew I wanted to take on a problem in human health, and use my analytical skillset to help answer that problem.

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