Autumn 2025
#123

the Analytical Scientist

the Analytical Scientist POWER *List*

Leading Voices EDITION

Thought-provoking answers to the field's biggest questions – and a celebration of those shaping its future

07 – 19

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No Time for Complacency

Feelings of excitement and urgency underpin this year's Leading Voices Edition of the Power List

There is a strong feeling in the analytical science community that the field does not get the recognition it deserves; that analytical scientists are seen as mere service providers rather than innovators and leaders; that the field struggles to attract talent – even funding. Yet, as Georgios Theodoridis points out on page 8, "analytical laboratories are among the best-funded and most comprehensively staffed." Moreover, human genome, microbiome, and brain initiatives, had "large components related to tool development and analytical chemistry interwoven throughout," as Jonathan Sweedler said in 2024.

Perhaps we can unravel this paradox by saying that analytical science could accomplish even more if people were fully aware of what it does, and, perception problems aside, the field is simply too fundamentally important to completely overlook. But given the current economic and political climate, especially uncertainty surrounding research funding – is it?

Our feeling is that we cannot afford complacency – nor is the emphasis on "power" what the field needs in our current moment. That's why this year's Leading Voices Edition of the Power List showcases the most compelling and original responses – judged blind by our expert panel – to three existential questions for the field. We hope these perspectives will help forge a path forward for analytical science. Our hypothesis: understanding "the point of analytical science" will help the field "rise to prominence as the keystone of all good science" which will assist today's analytical scientists to become "tomorrow's science leaders" – who can in turn advocate for the field from positions of influence.

James Strachan,
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Proteomics Pinpoints Drug Target in Rare Pediatric Tumor

Study demonstrates the ability of proteomics to inform real-time, personalized treatment decisions

Researchers have used proteomics to identify and validate a druggable metabolic vulnerability in a child's rare, treatment-resistant cancer (1).

Led by teams at the University of British Columbia (UBC) and BC Children's Hospital Research Institute, Canada, the study combined deep proteomic profiling of preserved biopsy tissue with a fast, in vivo testing model. Using LC-MS/MS, the researchers analyzed formalin-fixed samples and identified elevated levels of SHMT2 – a key enzyme in one-carbon metabolism. They then grafted the patient's tumor onto the membrane of a chicken egg (CAM model) to assess drug response in a living system.

The antidepressant sertraline, known to inhibit SHMT2, slowed tumor growth in this model and was recommended for off-label use. This treatment reduced the patient's tumor growth rate, although the disease continued to progress.

We spoke with co-senior author Philipp Lange – Canada Research Chair in Translational Proteomics of Childhood Malignancies, and Associate Professor of Pathology and Laboratory Medicine at UBC – about the rationale behind this approach and the implications for real-time precision oncology.

What was your main inspiration for this work and the approach you took?

Precision oncology has provided new treatment opportunities for children with cancer after standard-of-care therapies have been exhausted. Largely driven by genome sequencing and transcriptome analysis, this strategy now identifies actionable genome alterations and mRNA changes in the majority of patients. Unfortunately, however, only a subset of patients experiences clinical benefit, which is often short-lived.

As most drugs act on proteins and substantial regulation occurs between the genome, transcriptome and targeted proteome, the logical next step was to directly measure proteome changes to complement genomic information. Inspired by the opportunity to provide potentially life-changing information to patients and their families, we sought to adapt our proteomics workflows to integrate seamlessly with clinical practice. Importantly, since this was a research study, we could rapidly integrate non-validated functional precision oncology approaches following identification of a drug target; for example, using stable isotope tracing to confirm the drug mechanism of action and patient-derived xenograft models to confirm sensitivity to the identified drug through the BRAvE initiative.

What implications do your findings have for the future of proteomics-based precision medicine?

Demonstrating the ability of proteomics to inform real-time treatment decisions, even for a single case, has fundamentally changed the conversation with clinicians and patient advocates. Generally seen as a complex research exercise only a few years ago, most now see the value of proteomics as a complementary layer.

I believe if we keep advancing analytical technologies at the current pace, we will soon reach truly personalized healthcare. Longitudinal point-of-care or at-home sampling will allow us to establish individual baselines, eliminating population-based reference ranges with their inherent biases and limitations. Innovations in AI will enable high-dimensional multi-parametric assessments that have the potential to not only identify single treatment opportunities but also detect disease heterogeneity and predict personalized strategies to limit the development of drug resistance.

What's next for this work?

The next milestone is to establish proteome-based treatment recommendations for 50 or 100 patients across the country and then re-evaluate the value proposition. Together with lessons learned in similar studies in, for example, the US, Europe and Australia, this will give us a good idea if, and where, this is best applied and where further improvement is required. Ultimately, the key goal will be to move from the research environment into clinical routine, importantly at an affordable price to reach for all patients in public and private healthcare settings.

Reference

1. *GD Barnabas et al. EMBO Mol Med, 17, 4, 625–644 (2025). DOI: 10.1038/s44321-025-00212-8.*

Sculptor Revealed in Unprecedented Detail

Astronomers have created the most detailed map yet of the Sculptor Galaxy (NGC 253), capturing thousands of spectral fingerprints across its sprawling disk and uncovering a trove of new planetary nebulae. Using over 50 hours of observations with the MUSE instrument on ESO's Very Large Telescope, the team stitched together a full-spectrum mosaic, revealing the age, motion, and composition of stars and gas in unprecedented detail.

Reference: K Migkas et al., A&A, 698, A270 (2025). DOI: 10.1051/0004-6361/202554944.
Credit: ESO/E. Congiu et al.

QUOTE *of the month*

"We must support the next generation of analytical scientists not only in becoming brilliant researchers, but also bold communicators, innovators, strategists, CEOs, and change-makers who can amplify our impact across society."

Isabelle Kohler (See page 12)

Night Vision Lenses

Contact lenses embedded with upconversion nanoparticles have enabled both humans and mice to perceive near-infrared light

Credit: Yuqian Ma, Yunuo Chen, Hang Zhao

The lenses convert near-infrared wavelengths (800–1600 nm) into visible light, allowing wearers to detect pulsed signals and spatial cues, even with their eyes closed. In human tests, participants were able to perceive Morse-code-like infrared flashes; mice displayed both behavioral and physiological responses to infrared stimuli (1).

The team characterized the optical properties of the lenses using UV–Vis–NIR spectroscopy and fluorescence measurements, confirming wavelength conversion and emission intensity. A trichromatic version of the lenses further distinguished between different infrared wavelengths by converting them into red, green, and blue visible light.

"Our research opens up the potential for non-invasive wearable devices to give people super-vision," said senior author Tian Xue in the press release (2). The technology could support future applications in surveillance, signaling, and spectral encoding.

References

1. *Yuqian Ma et al., Cell, 188, 13, p3375-3388.e18 (2025). DOI: 10.1016/j.cell.2025.04.019.*
2. *Cell Press (2025). Available at: http://bit.ly/4lKT0V4.*

the Analytical Scientist

POWER List

Leading Voices EDITION

Each year, we ask the individuals on our Power List about the biggest challenges facing analytical science – visibility, talent, and data overload often come up. In 2025, add to the list economic and political turmoil – especially around research funding – which present their own serious difficulties while also amplifying those existing challenges.

Therefore, we believe the time is right for sober reflection, fresh thinking, and new solutions to forge a path forward. And that's why, for 2025, we've turned the Power List on its head. Instead of the usual nominations process, we invited entrants to respond to one of three crucial questions for the field.

This year's Power List presents the 30 most original thoughts and compelling arguments – selected blind by our expert panel – and, as always, celebrates the thinkers behind them. What follows are curated excerpts to whet your appetite; to read each essay in full, simply scan the QR code below.

Read the full-length essays online

What should be done to help analytical science rise to prominence as the keystone of all good science?

1 / Georgios Theodoridis

Professor of Analytical Chemistry, Department of Chemistry, Biomic Laboratory, Aristotle University; ThetaBiomarkers, Thessaloniki, Greece

Analytical science forms the backbone of many life science disciplines. Our work supports not only routine laboratory operations but also fuels groundbreaking research and drives innovation. When analytical results are flawed – whether through incorrect analyte identification or inaccurate quantification – the consequences can be serious and far-reaching. The ripple effect of poor data can undermine scientific publications, policy decisions, regulatory assessments, clinical outcomes, safety assessment, and many others. Regulatory agencies, accredited laboratories, and public authorities may act on incorrect results, potentially leading to the distribution of unsafe food or misguided medical decisions. Simply put: garbage in, garbage out.

Fortunately, clinicians and other scientists are increasingly aware of the fundamental role that analytical quality plays in their work. Their decisions, credibility, and long-term impact are more dependent than ever on accurate and reliable laboratory results. Our responsibility now is to communicate this more effectively, ensuring that analytical science receives the recognition and trust it rightly deserves.

Analytical scientists already hold leadership positions across many scientific fields. While our contributions may not yet be widely recognized by high-profile awards such as the Nobel Prize or ERC grants, the reality is that analytical laboratories are among the best-funded and most comprehensively staffed. This reflects the essential role we play across diverse sectors. Yet, we are too often viewed as enablers or support personnel rather than as key innovators and drivers of scientific progress.

Changing this perception is no small task. But by raising awareness of our impact and clearly articulating the indispensable role of analytical science, we can reposition our field – not just as facilitators, but as creators and leaders in scientific discovery.

In addition, we must deliver fully developed solutions – validated and ready for implementation by non-experts. By advancing to high technology readiness levels and delivering robust, market-ready products, we demonstrate the tangible value of our discipline.

Looking ahead, analytical science will play an increasingly vital role. The field is poised to lead in areas such as the analysis of novel specimen types – like patient-centric and non-invasive samples (e.g., saliva, dried blood spots, urine) – and in refining analyte reference ranges, identifying new biomarkers for disease and wellness, and promoting method standardization and harmonization. These efforts will ensure deeper integration of analytical technologies – particularly in automated formats – into clinical chemistry and beyond.

2 / Luigi Mondello

Professor of Analytical Chemistry, Messina Institute of Technology, University of Messina, Italy

"We must elevate analytical science's identity and purpose by rebranding as the foundation of evidence-based research across disciplines and emphasize its role in ensuring reliability, reproducibility, and data integrity.

"We must promote analytical scientists as leaders by encouraging institutions and journals to highlight the contribution of analytical scientists in collaborative research, and nominating analytical scientists for high-profile awards and speaking roles."

Watch Luigi's video entry

3 / Sinéad Currivan-Macdonald

Lecturer and Principal Investigator, Technological University Dublin, Tallaght, Dublin, Ireland

"Analytical science topics are covered by many fields, in lectures and in the lab. Oftentimes, the infrastructure (equipment/instrumentation) to support learning is outdated, obsolete, and with technical failures during laboratory sessions (their primary hands-on experience) it often leads to frustration and a disheartening experience.

"An interactive-hub sponsored by industrial-partners would offer a glimpse at professional/accredited labs. This hub may be fixed or mobile, with AR facilities, with a furnished suite of high-tech analytical instruments, commonly used in industry labs. Students could interact with instrumentation, run analyses, and with expert guidance, analyze example data – emphasizing the importance of their role within the community, and the field."

4 / Michael Witting

Co-Head Metabolomics and Proteomics Core, Helmholtz Zentrum München, Germany

"Analytical scientists need to step out of their shadow position as service providers and claim their spot. Analytical science, and the people living and breathing it, enable other scientists to generate new hypotheses and refine or reject them. This is the keystone of all good science: not guessing but measuring! Perhaps it is time to be less humble. Renaming analytical science to 'enabling science' would be a significant step because this is what analytical science does: it enables others to see and measure things that have not been measured so far."

5 / Coral Barbas

Director of the Centre of Metabolomics and Bioanalysis (CEMBIO), Universidad CEU San Pablo, Madrid, Spain

"A crucial strategy is advocating for rigorous peer review processes. Scientific journals must implement stringent review criteria focused specifically on the analytical methods used in submissions.

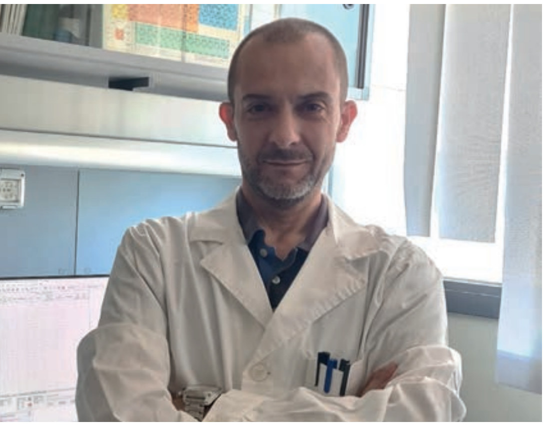
"I propose creating a section titled 'Analytical Watcher' – initially launched in The Analytical Scientist, and expanded into a methodological review section in various journals. This section would evaluate and critique the analytical methodologies used in high-profile studies. The goal is to ensure every study meets a high standard of analytical precision and to provide feedback for improving analytical practices. Content could include re-analyses of data, commentary on the suitability of analytical techniques, and recommendations for best practices."

6 / Alexander Böser

Senior Innovation Lead Chemistry, 5-HT Chemistry & Health, Germany

"We must place analytical scientists in cross-functional project teams and leadership roles to guarantee that potential issues are caught – and creative solutions offered – from the very beginning. If analytical considerations shape experiments and development plans from the outset, teams avoid costly surprises later on.

"Analytical data must be treated like a precious resource: curate it, normalize it, and use it to guide. Strong data sharing and governance practices can make routine results into a machine learning, process improvement, and improved decision-making center of knowledge for the organization."



7 / Marcello Locatelli

Associate Professor of Analytical Chemistry, Department of Science, University "G. d'Annunzio" Chieti-Pescara, Italy

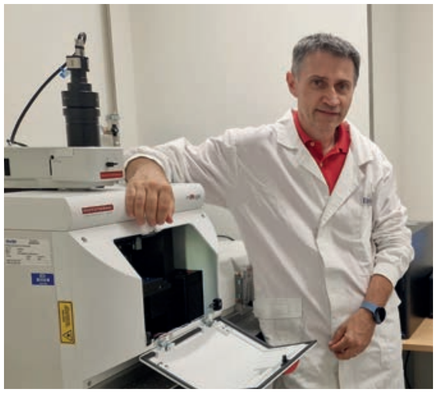
"The key point to start from is certainly a greater emphasis on education and training through an early integration of the fundamental principles of analytical science in scientific curricula to develop an analytical mindset right from the start. This could be done through interdisciplinary training, specialized advanced courses and continuous updating that starts from the mentor and moves down. This implies that the 'System' should approach and update itself above all on new technologies and approaches such as artificial intelligence and machine learning, sensors and portable technologies, big data and data science."

8 / Philip Marriott

Professor, Monash University, Melbourne, Australia

"It is now important, in the eyes of all scientists, to elevate the analytical scientist to a central position as the enabler of research into quality instrumentation, methodology and associated procedures underpinning all measurement science, without which chemical research is compromised.

"What is required to achieve this goal is the engagement of both analytical science and those who benefit from this very science in recognition of the importance that new analytical science innovations have delivered to their fields."



9 / Michele Suman

Food Safety & Authenticity Senior Scientist Research Manager at Barilla SpA; Adjunct Professor at Catholic University of Sacred Heart Milan, Italy

"In the main area of my competence, namely that concerning food analysis, there are some specific aspects to be considered to help analytical science become fundamental: (i) invest in the development and adoption of advanced analytical technologies such as mass spectrometry, chromatography, spectroscopic techniques, also with a propensity for field portability; (ii) develop and adopt standardized and harmonized protocols for the analysis of food in order to allow comparability in different contexts and situations; (iii) strengthen the training of food analysis professionals, fostering two-way cooperation between academia and industry for transferring knowledge of analytical methods."

10 / Liam Heaney

Senior Lecturer in Bioanalytical Science, Loughborough University, UK

"Topics that rely heavily on analytical science, such as exercise physiology (my area), should encourage their students to improve their knowledge around analytical science to help critically analyze its use within both their work and that of their peers. I believe we can achieve this in three ways: (i) integrating teaching of theoretical elements of analytical processes which are prominent within the field of study (e.g. the theory behind immunocapture assays); (ii) embedding the reasoning and relevance of quantitative validation for students and staff working in all fields that require quantitative assessments (i.e. accuracy, precision, etc.); (iii) improving the quality of analytical reporting within research that is published in journals/fields that would usually fall outside the scope of the analytical scientist."

How do we help today's analytical scientists become tomorrow's science leaders?

1 / Isabelle Kohler

Assistant Professor, Division of BioAnalytical Chemistry, Department of Chemistry and Pharmaceutical Sciences, Vrije Universiteit Amsterdam, The Netherlands; and CEO and Founder, NextMinds

Analytical science is everywhere – but why aren't its leaders?

I advocate that we need to broaden how we define leadership in analytical science, and how we prepare young analytical scientists for it.

Today, professional development in our field remains largely centered on academia. Early-career scientists are still mostly trained to follow the academic path, often without exposure to the full spectrum of career options. This is a missed opportunity. We all agree that talents thrive when aligned with the right environment. However, without guidance or training, many never discover where they can lead best. As the saying goes, if you judge a fish by its ability to climb a tree, it will live its whole life believing it is stupid.

Science leadership is not limited to universities. Leaders in industry, government agencies, non-governmental organizations, non-profits, publishing, and science communication play a critical role in translating analytical science into societal value. They bring research to the public, turn ideas into products, influence policy, and tackle global challenges – in a broad range of applications.

To develop future leaders, we must equip young analytical scientists with the tools to navigate these broader landscapes. That means integrating career exploration and professional development into scientific training. It means mentoring *beyond* experiments and publications. And it means giving visibility to role models outside of academia.

In 2025, The Analytical Scientist turns the Power List on its head. Over the last 10 years, the Power List editions have reflected our field's narrow focus, as most names came from academic institutions – sometimes with a spin-off attached, but still rooted in academia. It's time to turn this idea that success equals publications, grants, and professorships on its head, too. We must show more.

By celebrating leaders from diverse sectors, we expand the definition of impact in analytical science. We inspire young talents to think beyond the academic box and to align their skills with real-world needs. Last but not least, we strengthen the role of analytical chemistry and science in society at large, especially at a time when scientific misinformation is on the rise.

Analytical science is everywhere. Its future leaders should be, too.

My call to action: we must support the next generations of analytical scientists not only in becoming brilliant researchers, but also bold communicators, innovators, strategists, CEOs, and change-makers who can amplify our impact across society. Let's integrate comprehensive career development into doctoral programs, highlight diverse role models beyond academia, and redefine success beyond publications and professorships.

2 / Francesco Cacciola

Full Professor of Food Chemistry, University of Messina, Italy

"Mentorship plays a pivotal role in shaping the next generation of science leaders. Structured mentorship programs that connect early-career scientists with established experts can foster growth, strategic thinking, and leadership development. At the same time, it is important for senior scientists to provide space for emerging professionals to propose and lead research initiatives. Encouraging young scientists to participate in international projects, publish their findings, and present at scientific conferences helps cultivate their visibility and credibility within the scientific community.

"Another vital aspect is fostering regular collaboration with professionals from related disciplines such as chemistry, biology, and engineering to build strong, interdisciplinary teams. These collaborations can drive innovation and broaden scientific perspectives."

3 / Maite Ibarretxe

Professor of Sustainable Business UIBS, International University of Monaco, Monaco; and ITESO I Partner at IBARRETXE Associates

"I would like to offer a fresh perspective on this topic through the application of my Leverage Wheel framework. As the name suggests, it focuses on creating and applying leverage to unlock the full potential of an ecosystem. In this context, the goal is to harness the capabilities of today's analytical scientists and transform them into tomorrow's science leaders by simultaneously activating the three dimensions of the wheel. The first is Excellence – analytical science must shift from being seen as a technical service to being recognized as an intellectual anchor. Second is Trust, which becomes a currency of leadership when scientists are seen as guardians of transparency and co-creators of societal value. And finally, Innovation – it's vital to engage and develop analytical scientists to see innovation not just as a product or process, but as a mindset and as such a way of designing resilient solutions that anticipate disruption and guide future progress."

4 / Charlotta Turner

Professor and Vice Dean of Education, Lund University, Faculty of Science, Sweden

"We can help today´s young analytical scientists by fostering engagement in societal challenges, and by embracing all aspects of analytical chemistry – from fundamental curiosity-driven research in analytical chemistry, to applied chemical analysis within collaborative projects, as well as routine analytical service. The success factors for our future analytical scientist leaders are: (i) deep knowledge in analytical chemistry; (ii) an ability to communicate and collaborate across disciplines; and (iii) being a skilled user of generative AI."

Credit: Anna Thorbjörnsson

5 / Lourdes Ramos

Senior Research Scientist, Department of Instrumental Analysis and Environmental Chemistry, Institute of Organic Chemistry (CSIC), Madrid, Spain

"I would highlight the following features as desirable for our tomorrow´s leaders: (i) deep knowledge and understanding of your specialization field that you continuously update; (ii) belief in yourself; (iii) dare to try what you devise based on your strong knowledge – the only risk is learning for the future; (iv) be a mentor, but also the coach for your students; (v) always listen and be kind – all ideas can be valuable; (vi) your team is your strength – support professional development and celebrate their successes; (vii) collaborate with colleagues from the same area, but also from other research fields; (viii) balance your professional and personal life."

6 / Laura Sanchez

Professor of Chemistry and Biochemistry, University of California Santa Cruz, USA

"Funding is becoming harder and harder to acquire to support training, especially in light of a number of training grant opportunities that were just terminated by NIH and NSF. It is imperative that we train the next generation of analytical scientists in both their fundamental knowledge of instrumentation and application to biological problems. I have observed that without training in application and consideration of the statistics and caveats associated with working with complex biological systems, strong fundamental scientists struggle to make a translational jump, which can inherently limit job opportunities."

7 / Martina Catani

Associate Professor of Analytical Chemistry, University of Ferrara, Italy

"I observe that scientific challenges are becoming progressively more interdisciplinary. Given the central role and versatility of analytical chemistry, it is crucial for young scientists to cultivate interests across different fields. I believe we must actively involve young scientists from the beginning of their career in research meetings with both academic and industrial partners. This exposure will allow them to grasp the complexity of modern science.

"Since teams are composed of individuals with different mindsets, cultures and aptitudes, the development of good communication skills is fundamental to create a stimulating and productive work environment. Moreover, given the growing role of universities in the context of knowledge society and technological transfer, future leaders must also develop their communication skills to effectively engage a non-academic audience."

8 / Paweł Świt

Assistant Professor and Research Associate, Faculty of Science and Technology, Institute of Chemistry, University of Silesia in Katowice, Poland

"The FUTURE (funding, understanding, training, unity, research, engagement) is key to helping today's analytical scientists become tomorrow's science leaders:

- Funding – create mini research teams within the research groups of science leaders with their budget, access to equipment, and the ability to choose research topics.
- Understanding – recruitment for internships should not only be for scientific and research purposes, but also for organizational and management purposes.
- Training – organize workshops on writing scientific articles, research projects, and presenting results.
- Unity – ensure professional stability, which will allow you to focus on scientific aspects.
- Research – build an international cooperation network, which will allow for involvement in international research initiatives.
- Engagement – organize congresses of current science leaders, at which young researchers will be able to participate in numerous discussions with science leaders to a greater extent than is possible at traditional conferences."

9 / Kevin Schug

Shimadzu Distinguished Professor of Analytical Chemistry, The University of Texas at Arlington, USA

"Analytical measurement science is essential to provide insight into nearly any scientific or engineering process. As analytical scientists, we have become masters of some techniques, but we can hardly possess all the expertise needed to speak in depth about all the potential application spaces where they can be used. This trend is only going to continue and increase. If you are an up-and-coming analytical scientist, you need to be grounded in the fundamentals of your science, and you must be able to cooperate and work with others. Your new credentials or position may be a recognition of your accomplishments, but it should not be an impetus to start building your pedestal so you can look down on others. If you do this, you will quickly find your sphere of opportunities and interactions shrinking."

10 / Brooke W. Kammrath

Professor, University of New Haven; Executive Director, Henry C. Lee Institute of Forensic Science, West Haven, USA

"First, scientific illiteracy is a plague facing the world. It is therefore critical for today's analytical scientists to develop effective scientific communication skills so they can successfully apply their expertise to global issues such as climate change, clean energy, unidentified aerial phenomena, infectious diseases, and crime. Second, analytical chemistry education should emphasize the scientific approach to problem-solving rather than the rote memorization of protocols. This focus will cultivate logical reasoning skills, which are essential for navigating complex scientific challenges."

What *is* the point of analytical science?

1 / Scott A. McLuckey

John A. Leighty Distinguished Professor of Chemistry, Purdue University, West Lafayette, USA

The progress of science is fundamentally linked to progress in measurement science. While most attention is understandably directed to the new discoveries and new knowledge revealed by measurements, the science that underlies measurements is foundational. The question "What is the point of analytical science?" therefore, cannot be distinguished at a high level from the question "What is the point of physical science?" The approach to understanding the physical world that we now refer to as "the scientific method" has obviously been spectacularly successful and is fundamentally based on observation and measurement. The Nobel Prizes awarded for spectroscopy, electrochemistry, chromatography, mass spectrometry, NMR, etc. and the discoveries enabled by these techniques (e.g., isotopes, fullerenes, etc.) clearly reflect the recognition that "new tools beget new science." Indeed, all good physical scientists are quantitative and understand the basic principles of measurement science specific to their fields.

Of course, measurements in physical science are not restricted to atoms and molecules. However, for the myriad of cases in which the information sought is manifest at the atomic/molecular level, highly trained and creative scientists are often needed, particularly when novel measurement approaches are required. At this level, the question "What is the point of analytical science?" can be addressed with more specificity. The point is to provide useful information, along with the levels of uncertainty, to enable informed decisions regarding issues that originate at the atomic/molecular level. The information sought may be qualitative (e.g., What is it?), quantitative (e.g., How much?), or both. Questions like "Where is it?", "When is it?", "How fast is it changing?", etc. may also be of fundamental interest. As we cannot see atoms and molecules with the naked eye, we must resort to tools.

In order to address the "point of analytical science," we must understand our tools, adapt them to novel scenarios, invent new tools as needed, and clearly communicate the information forthcoming from the measurements. As the measurement challenges are varied and evolving, we are challenged to find new and better ways to address them. While there is a common set of figures-of-merit associated with most measurements (e.g., sensitivity, specificity, dynamic range, etc.) and common statistical approaches to interpreting our data, the principles underlying our tools vary greatly (e.g., those of NMR versus those of mass spectrometry) as do the measurement challenges. Hence, as none of us can know or do it all, we need a community. As the community improves current approaches and invents new ones, old questions can be better addressed and new questions will be enabled. As this is a continuing process without a final destination, we are assured that analytical science will never be pointless.

2 / Katelynn Perrault Uptmor

Assistant Professor, Nontargeted Separations Laboratory, Chemistry Department, College of William & Mary, USA

"Back in 1972, the National Bureau of Standards released proceedings on 'Analytical Chemistry: Key to Progress on National Problems' that addressed the integral importance of analytical chemistry towards progress on electronics, clinical medicine, agricultural science, air pollution, water pollution, and more. And now, over 50 years later, we find ourselves still having to justify the point of analytical science? It is important, now more than ever, that we advocate for the importance of analytical chemistry as a discipline. It is the only way by which we can synthesize high quality information to advance many important facets of society."

3 / Peter T. Kissinger

Emeritus Professor, Purdue University, USA; Cofounder, Inotiv, Prosolia, and Phlebotics

"The point of analytical science is to uncover data that enables a better understanding of nature and better informed decisions for industry, medicine, and government. The former objective often uncovers new measurement principles that later enable the more goal oriented tasks yet to come. With respect to the latter, we often apply the 'technology' label. Goals must be set with respect to the use of the data, how good it must be, who will collect it and where. Analytical chemists understand the requirements for precision, accuracy, speed, and cost. The art requires tradeoffs among these objectives. The perfect will undermine the good enough. The term 'analytical chemist' covers a wide range of responsibilities. Often we are in the middle, between defining a problem and handing off a result to others. Regardless of our position, we respect the process. Those in the middle should understand the objectives. Those at the end should understand the methodology. All should be transparent so that trust can be achieved. Lives and money can depend on data. Trust but validate."

4 / Tao Chen

Senior Principal Scientist and Group Lead, Synthetic Molecule Analytical Chemistry, Synthetic Molecule Pharmaceutical Sciences, Genentech Inc., USA

"In the pharmaceutical industry, analytical science plays a foundational and integrative role across every stage of the drug development pipeline – from early molecule discovery to market-ready therapies. During active pharmaceutical ingredient development, it provides crucial data to elucidate reaction mechanisms, monitor impurity profiles, and optimize synthetic routes. In drug product development, it offers critical insights to guide the selection of excipients and delivery systems, evaluate formulation stability, and determine final dosage forms. These data and insights are essential for process and formulation development as well as manufacturing robustness.

"The importance of analytical science becomes even more pronounced in the development of emerging new modalities, such as biologics, peptides, oligonucleotides, cell and gene therapies. These complex entities present unique structural, functional, and stability challenges that far exceed those of traditional small molecules. Advanced and highly specialized analytical techniques are required to ensure molecular-level characterization, quality attribute identification, and the development of robust control strategies for these new modalities."

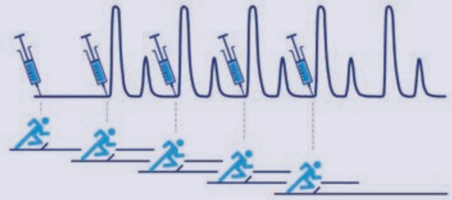
5 / Victoria Samanidou

Professor, Analytical Chemistry, Laboratory of Analytical Chemistry, School of Chemistry, Aristotle University of Thessaloniki, Greece

"The advancement of analytical chemistry relies on genuine analytical chemists who have knowledge and a deep understanding of the core science and its fundamentals. It is of utmost importance that analytical scientists redefine themselves by deeply understanding the fact that the two terms (analytical chemistry and chemical analysis) are different and cannot be interchangeably used.

"Ultimately, in my opinion, this is the point of analytical science as the cornerstone of a solid foundation, where all steps of chemical analysis have been properly executed based on deep knowledge of the core chemistry (properties, interactions, mechanisms, reactions etc.) behind sample collection, preservation, storage, sample preparation, measurement, and finally, the correct data handling. In this way, valid, precise and accurate results will be further used for interpretation and reporting in other scientific fields."

SPONSORED FEATURE



The Power of Automated Stacked Injection

KNAUER's flexible HPLC systems and PurityChrom® 6 software simplify stacked injection workflows – making high-throughput purification more accessible than ever

With Ulrike Krop, Team Leader Applications & Academy, KNAUER, wissenschaftliche Geräte GmbH, Germany

What current trends are shaping how labs approach preparative chromatography and purification workflows?

A major trend in laboratories is integrating sustainability into existing workflows and developing new, eco-conscious methods. In preparative chromatography and purification workflows, minimizing chemical and solvent use during sample prep and separation is key to reducing environmental impact.

Another challenge is increased sample throughput. Automation helps by reducing manual intervention and errors, but users need an intuitive, reliable software for this task. With time always a constraint, rapid method development and easy upscaling are essential. Stacked injections offer a solution to increase the sample throughput.

Finally, beyond system costs, chromatographic columns – especially specialized types like chiral columns – are expensive. Designing workflows that use them efficiently is critical to cost-effective purification.

What is stacked injection, and what are its advantages?

In traditional batch chromatography, each sample is injected separately, with the next injection delayed until the previous run is completed. However, as there's typically a gap between sample injection and peak elution, this idle time can be used to inject the next sample – an approach known as stacked or nested injection.

This technique significantly boosts efficiency by reducing total run time and solvent consumption. It also maximizes column usage, which is especially valuable in chiral separations where costly stationary phases are involved. With stacked injection, columns with smaller ID can be used without sacrificing throughput.

Stacked injection also helps overcome common limitations in yield and resolution. Traditional runs may require low injection volumes to preserve purity and resolution, resulting in minimal yields. In contrast, stacked injections allow for repeated, controlled dosing of the same sample over a single extended run.

How does PurityChrom® 6 simplify stacked injection, even for less experienced users?

PurityChrom® 6 is an intuitive software platform designed for biopurification and preparative HPLC workflows. Its animated flowpath visualization enhances usability, aids method development, and enables intelligent fraction collection. Stacked injection is fully supported via a dedicated module. Users first perform a single injection to define the cycle time. The method is then divided into clear, manageable steps, making it easy to integrate into a sequence. A user-friendly dropdown menu further streamlines the workflow design, allowing even less experienced users to implement stacked injections with confidence and precision.

What makes KNAUER's preparative HPLC systems especially well-suited for stacked injection workflows?

KNAUER's preparative chromatography systems are highly modular and flexible, allowing for seamless upscaling and easy method adaptation. Each system is tailored to meet specific purification and scale-up needs, making it particularly well-suited for stacked injection workflows.

A crucial element of stacked injection is the injection system itself. KNAUER offers two fully automated options. Injection via an autosampler is ideal for method development or when working with a variety of samples. Alternatively, injection using a sample pump is better suited for larger sample volumes or when processing a single sample. In this setup, the sample is either delivered directly onto the column via the pump or injected into a sample loop connected to the injection valve.

Fraction collection is another key factor in stacked injection workflows. KNAUER provides a range of solutions to accommodate different sample volumes and throughputs. For smaller sample numbers, a simple fractionation valve may be sufficient. For higher sample numbers, a fraction collector or even a preparative liquid handler is more appropriate. The newly launched AZURA FC 6.1 fraction collector is a versatile and efficient choice for a wide range of sample collection tasks.

What use cases can you share that demonstrate the time or efficiency gains achieved through stacked injection?

We have published a TechNote that describes the workflow for setting up a stacked injection method (1). It includes details of the system configuration and explains how to implement the method step by step.

With minimal effort, we set up an exemplary stacked injection workflow and successfully separated our model substances caffeine and paracetamol. When comparing the time required for single runs versus stacked injections, we observed a 40 percent increase in sample throughput, which also led to a 40 percent reduction in eluent usage.

Reference

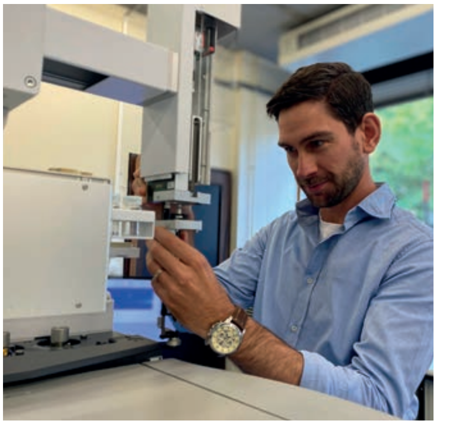
1. *Knauer, "Stacked Injection in Preparative Chromatography" (2025). Available at: http://bit.ly/4kbMmpv.*

KNAUER

6 / Pierre-Hugues Stefanuto

Lead scientist, Liège University, Belgium

"As analytical scientists, our guiding principle is trust. Regardless of the approach or technique, the cornerstone of our field is trust in the data we generate – trust in its accuracy, reliability, and significance. That, ultimately, is the point of analytical science: to ensure trust in the results. This pursuit of trust is a core value of our discipline. It's the driving force behind innovation. Analytical methods are becoming greener, faster, and more efficient – but never at the expense of robustness. We do not compromise on the integrity of our results. It is this unwavering commitment to quality and reliability that makes analytical science essential to scientific discovery. Entire research domains depend on analytical scientists to deliver accurate data on which reliable conclusions can be built. The vast universe of -omics fields, for example, rests on the innovations and rigor of analytical science."



7 / Chiara Cordero

Full Professor of Food Chemistry, University of Turin, Italy

"In my experience – particularly in food quality and authenticity – the most meaningful analytical advancements have stemmed from industry-driven demands: practical challenges, the need for rapid prediction, and a constant push for competitive advantage. Without these pressures and a clear willingness to innovate, even the most promising technologies risk remaining confined to academic labs or instrument brochures, disconnected from everyday application.

"We must bridge this gap. Researchers must engage more actively with practitioners, listen to their concerns, and reconsider their approaches. We need to build strategies around actual problems and cultivate a broader perspective. Stronger collaborations between academia, industry, and instrument manufacturers are key – and in some cases, especially where funding has historically not been an issue, new funding models that reward impact-driven innovation could help accelerate this alignment."

8 / Jessica Prenni

Professor, Colorado State University, Fort Collins, USA

"Analytical scientists often work behind the scenes – we are not typically the stars of the show - yet we are essential to the success of virtually every field of scientific inquiry. Our methods and insights connect disciplines, translating complex phenomena into measurable, meaningful information. This integrative role positions us to respond to shifting research priorities. Indeed, adaptability has long been a hallmark of analytical science. Whether addressing new regulatory demands, emerging contaminants, or technological frontiers, we continually evolve – developing new methodologies, advancing instrumentation, and improving data interpretation. But at our core, we remain united by a shared ethos: a commitment to precision, transparency, and the rigorous validation of results."

9 / Perdita Barran

Chair of Mass Spectrometry and Director of the Michael Barber Centre for Collaborative Mass Spectrometry, University of Manchester, UK

“In an age of alternative facts, fake news and a world of image and identity manipulation or hallucination coupled with ever increasing availability of data there is a clear need for a multidisciplinary understanding and definition of what is real. No matter which way you determine the truth, it has to be the same on each and every occasion; thus in chemical analysis, truth is represented by mass, abundance, and identity. It is fundamental to analytical science to retain truth in data as it is translated from initial measurement to applied knowledge. This relies on the integrity of analytical measurement scientists documenting how raw data is inevitably manipulated and altered as it is translated to useful knowledge.”

10 / James Hallam

Vice President, Liquid Chromatography-Mass Spectrometry, Waters Corporation, Wilmslow, UK

“Analytical science exists to make the invisible visible. It is the discipline that transforms uncertainty into clarity, complexity into comprehension, and trace into truth. In a world increasingly defined by its unseen threats – chemical, biological, and environmental – analytical science is not just a tool; it is a compass guiding us toward informed decisions, safer products, and a healthier planet.

“Nowhere is this more evident than in the global challenge of PFAS (per- and polyfluoroalkyl substances) contamination. These ‘forever chemicals,’ found in everything from firefighting foams to food packaging, resist degradation and accumulate in ecosystems and human bodies. Their ubiquity and persistence make them a formidable analytical challenge. Detecting PFAS at parts-per-quadrillion levels in complex matrices like drinking water, soil, and blood is not just a technical feat – it is a moral imperative.”

MASS SPEC

Is the Single-Cell Revolution Still Just Beginning?

Single-cell analysis has exploded in recent years, yet much of the chemical landscape remains uncharted, and we're only beginning to address – or, indeed, understand – many fundamental questions on cell chemical heterogeneity

With Jonathan V. Sweedler, James Eisner Family Endowed Chair of Chemistry, Professor of Bioengineering, Neuroscience, Physiology and Medicine, University of Illinois at Urbana Champaign, USA

"The single-cell analysis field has really blossomed over the past decade" is a phrase you'll often hear. And given the sheer number of talks and posters focused on single-cell analysis you'll see at conferences like ASMS these days, it's hard to argue. In fact, the field has come so far over the past few years that many seem to think that "single-cell analysis" didn't really exist until researchers began using mass spectrometry to study omics at the level of single cells. But measuring single cells – with microscopy, originally – dates back to Robert Hooke, nearly 400 years ago. Indeed, "single-cell analysis" is how we learned about cells having nuclei and other fundamental features. Microscopists first named brain cell types hundreds of years ago based on their shapes – stellate (star-shaped) cells, pyramidal cells, and so on – because that's what they could measure.

Of course, what we can measure has changed dramatically, which has opened the door to single-cell *chemical* analysis – which we can differentiate from temporal or spatial analysis. Single-cell mass spectrometry began in the 1970s, with Hillenkamp and others using lasers to ionize compounds in cells. Around the same time, there were a few reports of single-cell analysis using gas chromatography-mass spectrometry (GC-MS). But the real acceleration came in the 1990s, due to instrumental improvements. Back then, if you isolated a cell with few losses and carefully optimized every step, you might detect a few compounds in a single cell. Owing to significant advancements in sensitivity, today we can routinely detect dozens, even 100 compounds, without the need for complete procedural optimization.

These sensitivity improvements have made single-cell chemical analysis more robust and accessible. This is why the field has grown so much – it's easier to achieve meaningful results with the tools we now have without the need for heroic efforts.

Nevertheless, what interests me most is what we can't yet measure – the opportunities for discovery and the hurdles to overcome – which is what I'd like to explore here.

"The incredible heterogeneity of cells"

Right now, scientists are pretty good at transcriptomics, and single cell proteomics is also advancing rapidly. However, there are still invisible parts of the cellular landscape, and this is what fascinates me.

Take metabolomics: if you look at a metabolomic profile of a brain region, you might detect 1,000 or more metabolites. But at the single-cell level, you're often limited to detecting 50 lipids or 50 metabolites. It's not very deep coverage, but even with this limited depth, you can observe striking differences between cells. It's ironic that metabolites were the first molecules measured in cells, but now metabolomics has become the most challenging and slowest field to develop!

In the brain, for example, some cells use serotonin, whereas others might use dopamine, glutamate, or GABA instead. For many compounds, the cell-to-cell differences are much larger than people realize. Biochemistry textbooks might suggest uniform concentrations of molecules such as citrulline or arginine succinate, but in reality these molecules are only present in a small fraction of cells. In some cases, we measure near-millimolar levels in a few cells and almost nothing in others, thus yielding the expected millimolar average levels. This example highlights the incredible heterogeneity of cells.

Another factor that's often overlooked is the sample itself. Many researchers working on single-cell measurements use cell cultures, and although these can teach us a lot they tend to be homogeneous, as the cells are grown under very similar conditions. If you examine freshly isolated cells from a brain, you begin to see much more striking differences.

As another example, in our work with islets, cell to cell differences define cell types; beta cells contain insulin, alpha cells have glucagon, and gamma cells hold pancreatic polypeptide. Occasionally, we find cells with unexpected peptides, like oxyntomodulin instead of glucagon in alpha cells. These differences are massive – 100-to-1 or more in the level changes between cells. People sometimes ask about statistics, but in these types of cases there's no need for subtle statistical tests; the differences are so stark that they're unmissable.

This is also true for neuropeptides in the brain and other endocrine systems. The need to observe these differences helps drive the development of new single cell measurement technologies. Additionally, observing these huge variations in cellular signaling molecules highlights the importance of pushing the boundaries of single-cell analysis.

An omic dichotomy

One of the more interesting dynamics, particularly for an analytical chemist, is the contrast between transcriptomics and proteomics. With proteomics, if you're measuring a protein with mass spectrometry, analytical journals may not accept your results unless you fully characterize the protein, including post-translational modifications (PTMs). If you identify a protein but don't report its phosphorylation states, amidation, or acetylation, you'll be told that you didn't do a thorough enough job.

On the other hand, transcriptomics gives you sequences, and although methylation studies have been developed, transcriptomics alone does not fully characterize most RNA PTMs. It only tells part of the story, but the field is considered highly successful nevertheless. That dichotomy is intriguing – proteomics demands near-perfection, while transcriptomics has achieved widespread success without the requirement of complete molecular characterization.

> *"Will mass spectrometry continue to improve? Absolutely – it'll get faster, better, cheaper, and more accessible. But in many cases, the way we approach proteomics might look very different."*

Looking ahead 20 years, I wouldn't be surprised if a majority of people are using nanopores to sequence proteins. While this is exciting, nanopores may not capture all PTMs. For example, glycosylated proteins might not fit through the nanopore holes, and yet, nanopore sequencing could still be incredibly useful – just like transcriptomics has been. In this scenario, mass spectrometry would complement nanopore sequencing by filling in the gaps and providing the rest of the molecular details.

Will mass spectrometry continue to improve? Absolutely – it'll get faster, better, cheaper, and more accessible. But in many cases, the way we approach proteomics might look very different. Meanwhile transcriptomics is starting to tackle PTMs, and I expect both areas to see incremental advancements as well as revolutionary changes.

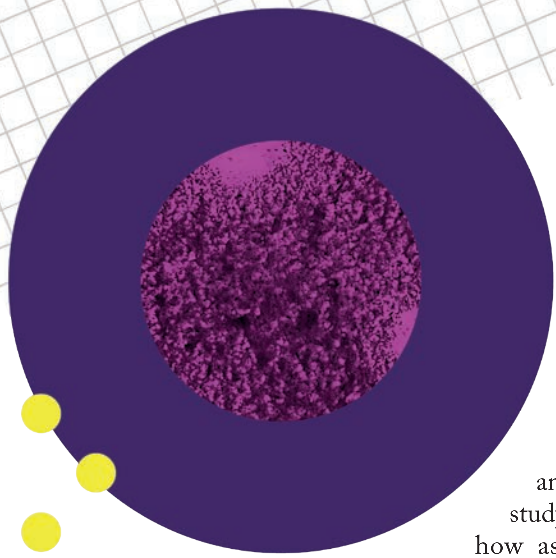
Sample preparation (and the unavoidable issue)

When handling an organism – whether it's a mouse or something else – you're dealing with a living system.

It doesn't matter whether you're using matrix-assisted laser desorption ionization (MALDI) imaging, electrospray, or even ambient techniques like desorption electrospray ionization (DESI), you still have to somehow get the molecules out of the brain and into the mass spectrometer. This process is inherently destructive – you might drill a hole in a skull and insert a probe. Alternatively, you can dissect the brain or work with living ex vivo brain slices, which we sometimes use, but even then, it's a highly disruptive process.

The core issue is: how do you sample without perturbing the system? Unfortunately, the answer is probably that you can't, at least not completely. This isn't just a challenge for mass spectrometry; it's also an issue for fluorescence imaging and similar techniques. When dealing with small molecules, especially short-lived ones like endogenous nitric oxide, it's nearly impossible to capture them in their natural state without altering the system.

Moving to a different topic; as a journal editor, I've noticed the difficulty in establishing standards for reporting data. People are comfortable with universal standards, but the single cell field is advancing so quickly that it's hard to create one-size-fits-all guidelines. Take mass spectrometry: MALDI imaging is very different from LC-MS, and the standards for one don't necessarily apply to



the other. Some journals have created reporting standards for LC-MS, but if those were strictly applied to mass spec imaging, much of that data wouldn't meet the criteria for publication. Similarly, new technologies like nanopore sequencing generate different types of information entirely and likely will require distinct reporting standards.

As the field evolves, whether it's in sampling methods, measurement approaches, or data analysis, it's difficult to establish fixed community standards. While standards are important for existing techniques, we also need to recognize that this rapid pace of innovation requires flexibility. Unlike X-ray crystallography, where methods and standards have remained relatively stable, technologies in single-cell analysis and mass spectrometry are constantly changing.

Unnecessary granularity?

If the goal is broad-scale chemical measurements, omics will remain important for the single-cell analysis field, particularly for comprehensive data instead of targeted approaches. Just as transcriptomics evolved from analyzing regions to single cells, I predict similar progress to happen with other omics fields.

That said, there's a certain "cachet" associated with single-cell analysis right now which I sometimes see people wanting to apply unnecessarily. If you don't need that level of detail, you simply don't need to do it – it's harder, generates significantly more data, and requires more effort to interpret.

For example, single-cell analysis can be crucial if you're studying the brain to understand how astrocytes, oligodendrocytes, microglia, and neurons interact, or how neurons change during learning, memory or disease. Similarly, single-cell approaches in cancer research are often essential to understand cellular heterogeneity. But in cases where you don't need that granularity, it's better to stick with the bulk measurement approaches.

The important question is: does single-cell analysis provide the data required to answer your scientific question? If the answer is yes, then it's worth pursuing, despite the added complexity.

Whether you're analyzing single cells or a microliter sample containing 100,000 cells, the goal is still to obtain the most complete information possible – typically on an omics scale. Transcriptomics, for example, is often easier to perform and may remain so. One reason for this is that transcripts and proteins are somewhat correlated, while the relationship between small molecules (metabolomics) and the transcriptome is far looser. A cell's metabolome is highly dynamic, influenced not just by its internal state but also by the environment.

In some cases, you'll find a good correlation between the metabolome, proteome, and transcriptome. In many others, the correlation is weak, and the only way to know is to measure it. While transcriptomics often reflects the cell's state, the metabolome represents its dynamic response to the outside world. This interplay makes metabolomics both crucial and challenging to interpret.

Even though metabolomics might offer more insights in certain cases, many labs prioritize transcriptomics because it is easier to perform and provides a starting point for understanding the system. From there, one can gradually integrate metabolic data to paint a fuller picture.

Coming together

Moving forward, there's no question that the chemical analysis of individual cells will grow in importance.

One exciting avenue for the field is the potential integration of chemical and spatial data at the single-cell level. Combining morphology and imaging to achieve nanoscale spatial resolution in optics while incorporating chemical omics information would be transformative for the field. I predict that this will be a major growth area.

Ultimately, although the field may have blossomed in recent years, we're only beginning to address fundamental questions – many of which we don't yet fully understand. To give one final example, in the brain: what's the difference between cell state and cell type? If you take an astrocyte from two different locations with distinct chemical environments, are they fundamentally the same cell type, even with distinct transcripts and metabolites? One astrocyte may be in a location where it manages extracellular dopamine, while the other deals with extracellular GABA. Do such environmental differences eventually change the cells into distinct cell types or are the differences reversible and reflect cell state?

Perhaps the full blossoming has yet to come.

CHROMATOGRAPHY

Industry's Chromatography Crusader

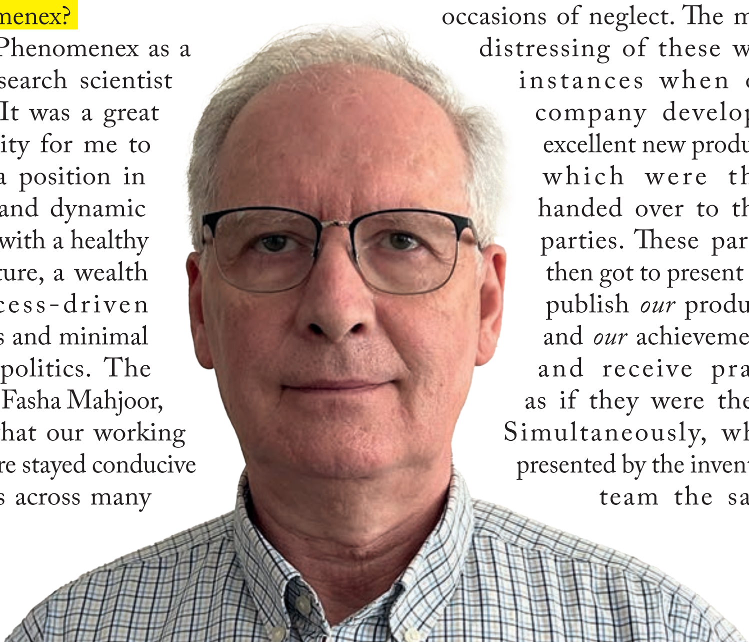
2025's Uwe D. Neue Award winner, Tivadar Farkas, shares his key lessons learned from a career in separation science spanning three decades

Could you give us an introduction to your background and career journey?

I began my career back in 1983 by engaging with professionals within the industry, research institutions and academia. Most of these years were spent gaining practical experience in analytical chemistry, specifically gas chromatography. In 1992, I moved to the US to pursue a PhD with the late Georges A. Guiochon at the University of Tennessee, Knoxville. During this time, I studied HPLC column heterogeneity using a variety of detection techniques.

How do you reflect on your time – close to three decades – at Phenomenex?

I joined Phenomenex as a senior research scientist in 1997. It was a great opportunity for me to take up a position in a young and dynamic company with a healthy work culture, a wealth of success-driven employees and minimal internal politics. The president, Fasha Mahjoor, ensured that our working atmosphere stayed conducive to success across many decades. Fasha was always open to new ideas and initiatives and ready to provide funding to many of them. Owing to its dedication to customer support, a culture of innovation, and the hard work of many of its employees, Phenomenex quickly succeeded in asserting itself as a leading product supplier for chromatography.



For several decades, the R&D department at Phenomenex has been extremely productive. Numerous new products have been launched each year for HPLC, GC, SPE and preparative LC applications. Our teamwork was excellent, perhaps as we collectively considered ourselves not as geniuses, but rather soldiers – all dedicated to the common cause. Emmet Welch – a home-grown chromatographer and our R&D director at the time – kept the team aligned and focused on delivering new products.

Given the limited access that a company of our size had to online journals, scientific meetings and new instrumentation, I think we performed well, all things considered.

Do you feel industry scientists are sometimes overshadowed by their academic counterparts?

Yes, industrial scientists are often overshadowed by academia – and for the wrong reasons too.

I personally have experienced occasions of neglect. The most distressing of these were instances when our company developed excellent new products, which were then handed over to third parties. These parties then got to present and publish *our* products, and *our* achievements, and receive praise as if they were theirs. Simultaneously, when presented by the inventing team the same information was often received mildly, or with reservations. I found this unfair and the reservations unjustified.

My view on the situation is this: some academic publications have disciples who may or may not confirm the published results. Compared to commercial products, only a limited number of academic publications are subject to scrutiny; most conclusions are rarely contested. No matter the claims from the inventing company, their new product will be evaluated by hundreds of analysts, who'll decide for themselves if the product is truly worthy of incorporating into their analytical workflows – now *that's* scrutiny! With this in mind, I wonder: why not allow the inventors to flaunt their achievements, knowing that the day of reckoning is soon to come?

During your career in industry, what are your big innovation lessons learned?

Just like academia, industrial development is limited by resources. With livelihoods at stake, companies cannot afford to waste too much on failed projects. For this reason, no matter how promising they seem, companies have to be cautious when pursuing new ideas. Any great idea needs champions within the company, otherwise leadership will not believe it's worth taking a risk on.

It's for this reason that scientists working in industry have to be the champions of their own ideas. They should look to sell them internally – whenever the front door is slammed shut, they should look to sneak in through the back. My advice to younger industrial researchers is to be evangelists in your ideas, right up to the very end when the project is completed.

Tivadar Farkas was presented with the Uwe D. Neue Award in Separation Science – created to recognize industrial scientists that have made and continue to make significant contributions to the field of separation science – at HPLC 2025.

SPECTROSCOPY

Meet Spectroscopy's "New School"

How compact, connected, and consumer-ready technologies are taking spectroscopy out of the lab and into the world

With Boris Mizaikoff, Chaired Professor and Director at the Institute of Analytical and Bioanalytical Chemistry at Ulm University, Germany

How is spectroscopy changing – and why now?

Spectroscopic techniques have long been regarded as core analytical methods, routinely used in laboratories worldwide. However, the perceived delicacy of optical setups hindered their broader translation into analytical systems suitable for real-world – and often harsh – application environments. Today, that picture is changing. Routine fabrication methods – especially microfabrication technologies originally developed for the "electronic world" – have driven significant advances in integrated optics and optical systems. These systems are now not only highly robust, but can also be batch-fabricated, resulting in dramatically reduced component and device costs. Against this backdrop, the broad electromagnetic spectrum – from the ultraviolet to the terahertz range – offers an extraordinary window into photon–matter interactions, many of which have been exploited for centuries. Together these contemporary developments are paving the way for modern analytical spectroscopy to meet the evolving demands of a modern society.

Which spectroscopic technologies are emerging – and how might they affect everyday life?

Perhaps the most transformative development in recent years is the degree of miniaturization and integration now achievable. The convergence of integrated photonics and integrated electronics is paving the way for truly compact, multifunctional devices – ushering in what we might call the age of "consumer photonics," analogous to the revolution of consumer electronics. Already, mini-spectrometers are integrated as hand-held devices, or even into cell phones for applications ranging from fruit or vegetable ripeness analysis in the supermarket to more sophisticated quality control in the food sector.

In parallel, health-related applications are accelerating. Spectroscopy is increasingly enabling personalized, non-invasive diagnostics in point-of-need (PON) or point-of-care (POC) settings. This includes breath, saliva, and urine testing for fitness monitoring or disease detection, as well as mobile diagnostic tools that can serve clinical settings, emergency scenarios, or under-resourced communities around the world.

Can you share any specific examples that demonstrate the real-world impact of optical spectroscopy?

In process analytical technologies (PAT), there's a growing need for continuously operating methods that interface directly with processes in-line, on-line, or at-line – ideally with little to no sample preparation. Optical spectroscopies are particularly well-suited for such scenarios: they offer label-free analysis with inherent selectivity, operate non-destructively, and can be used in real time through flow-through interfaces or probes in batch reactors. Within our ongoing Collaborative Research Center CATALIGHT, we are developing PAT tools specifically adapted to monitor chemical transformations in both batch and continuous-flow photoreactors.

In environmental analysis, optical spectroscopies are being deployed across a wide range of use cases – from laboratory techniques and micro-spectroscopies in imaging mode, to field-deployable photonic sensor systems. These are being used to detect and monitor a growing list of emerging pollutants, including per- and polyfluoroalkyl substances (PFAS) and disinfection byproducts, as well as micro- and nano-plastics. A variety of spectroscopies have been used for characterizing, classifying and monitoring such pollutants in water, and more lately in food and feed matrices too, as well as within organisms – including humans and animals.

Perhaps the most striking development – both scientifically and in terms of public attention – is the shift of spectroscopy into the medical domain. Techniques traditionally bound to the lab are now finding applications in clinical diagnostics, such as real-time intraoperative analysis or breath-based diagnostics. In our own work, we developed a miniaturized breath analyzer using photonic integrated circuits and mid-infrared spectroscopy. This device can detect *Helicobacter pylori* infections via non-invasive analysis of exhaled breath. What surprised us most was the level of media and public interest this work generated – it highlighted just how strongly society is beginning to recognize and respond to accessible, non-invasive diagnostic tools.

Boris Mizaikoff Chaired the Colloquium Spectroscopicum Internationale (CSI) XLIV Conference, which took place in Ulm, Germany, from July 27–31, 2025.

Speed up Your Oligonucleotide Analysis – In Under 2 Minutes!

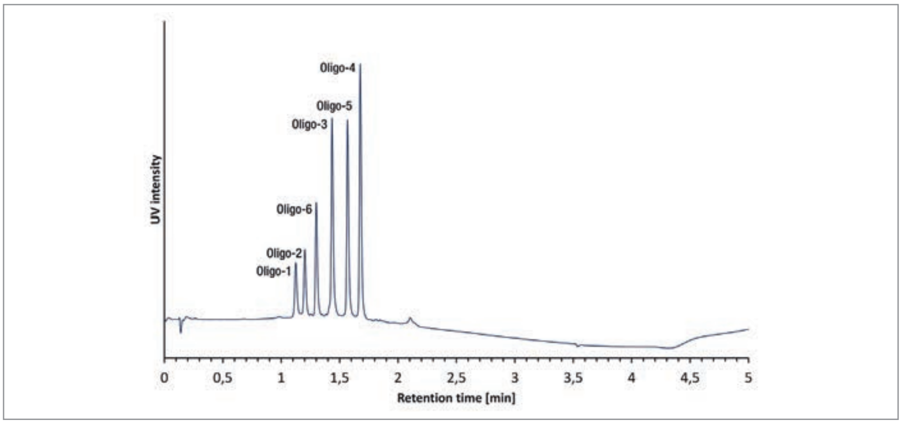


Figure 1: Ultra-fast separation of six oligonucleotides using a YMC Accura BioPro IEX QF column.

Precise and rapid oligonucleotide analysis supports efficient production and consistent quality. This Application Note demonstrates how a six-oligonucleotide mix (12–33mer, Supelco) is efficiently resolved using a 30 mm long YMC Accura BioPro IEX QF column at 70 °C – delivering high-resolution results in less than two minutes.

Thanks to its compact format and excellent thermal stability, this column is ideal for high-throughput bioanalysis and demanding quality control in oligonucleotide production. The bioinert YMC Accura column, packed with robust BioPro IEX QF resin, ensures precise separation of all six oligonucleotides with exceptional resolution.

Operating at 70 °C sharpens peak shapes and boosts efficiency. Together, these optimised conditions enable ultra-fast analysis and support dependable, time-saving routines in your daily lab work.

Full method details can be accessed here: https://ymc.eu/d/brDra


"I love immersing
myself in different
communities,
understanding their
unique challenges,
and figuring out how
technology can solve
real-world problems."

Bridge to Impact

Sitting Down With…
Ying Ge, Vilas Distinguished Achievement Professor, Department of Cell and Regenerative Biology, Department of Chemistry, and Director of the Human Proteomics Program, University of Wisconsin-Madison, USA

Did you always want to be a scientist?
Actually, no! No one in my family was a scientist, and I was more interested in business initially – maybe even starting a company one day. In China, however, the education system requires students to choose between science and humanities early in high school. I was performing well in STEM courses, and, at that time, there was a strong emphasis on promoting STEM education because of its perceived job security. So, I was placed into the science track.

When I was admitted to Beijing University, I initially wanted to study biology, but I was assigned to chemistry instead. (Ironically, that turned out to be beneficial because now I work at the intersection of chemistry and biology.) But it wasn't until I joined Fred McLafferty's lab that I truly became passionate about science. His infectious enthusiasm and dedication to research were inspiring – he embodied the ideal of a scientist committed to pushing boundaries. Working with him made me realize how powerful mass spectrometry could be in tackling health challenges, and that's when I truly embraced my identity as a scientist.

What lessons did you learn from Fred McLafferty?
Fred taught me so much about being a rigorous scientist – how to have high standards, how to pay attention to detail, and how to always strive for excellence while pushing the boundaries of what's possible in science. Beyond his brilliance, what stood out to me most was his generosity – to his students, to young scientists, to collaborators. He truly believed in supporting the next generation – and he had an incredible energy for science. Even toward the end of his life, he was still working on manuscripts – that level of dedication and passion is something I will always carry with me.

Another major lesson I learned from Fred was about collaboration. He once told me: "You can't be an expert in everything, but you should always find the right people to collaborate with to complement your expertise." That advice has shaped how I work today. My lab is highly interdisciplinary and collaborative – our trainees from different disciplines including chemistry, biology, and medicine, and we work closely with biologists, bioinformaticians, clinicians (cardiologists, cardiac surgeons, etc.) and more. But true collaboration isn't just about exchanging samples and data. It's about learning from each other's fields – really engaging in intellectual exchange to drive discoveries forward.

You mentioned that you were originally interested in business. Have you considered starting a company?
Yes – much of what we do has commercial potential – and we hold several patents. In fact, we're currently in discussions with investors (I even have a name in mind for the company…). But I'm a very cautious person – I don't rush into things until I'm fully prepared. Right now, I'm in the preparation stage.

What drives me isn't just technology – it's the opportunity to help patients. I understand technology deeply, but I also know the biology and the medical landscape. I've been fully integrated into the cardiovascular research community despite being trained as an analytical scientist, not a cardiologist – I've learned a tremendous amount from my colleagues, attended their conferences, and now serve on councils for major organizations, including the American Heart Association and the International Society for Heart Research (North America section).

I often see silos between chemistry, biology, and medicine. People in these fields often don't communicate with each other as they could, and that's where I see my role as a bridge. I love immersing myself in different communities, understanding their unique challenges, and figuring out how technology can solve real-world problems.

In planning a company, my vision is to leverage these technologies for early disease detection and monitoring disease progression, making them clinically accessible. Delayed disease detection remains a major issue – there is still a critical need for better biomarkers, improved diagnostic tools, and more effective ways to monitor treatment response. Many treatments come with severe side effects, and if we could monitor a patient's biological response in real time, we could adjust treatments more precisely and effectively.

What advice can you offer to the next generation of analytical scientists?
I think we're entering a new era for analytical science – where we're not just developing technology for the sake of developing technology. There has to be a bigger purpose.

My advice to the next generation of analytical scientists: don't just stay in your comfort zone. Don't get too narrowly focused on a specific technology. The world is full of real-world problems that need solutions. Reach out and understand them. Don't just wait for someone to come to you and say, "Hey, I have this problem – can you analyze it and give me the data?" Instead, be proactive. Look into these problems yourself.