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Analytical Chemistry, a great success despite the unfortunate divisions in academic departments

I thank the editors of Talanta for the invitation to share my views on the field of analytical chemistry, where it has been and what it promises for the future and I thank the readers for perusing the next few pages in what is, I hope, a candid appraisal of our bright prospects and serious challenges.

Looking at current activities in chemical measurement, one would have to say that the analytical chemistry field is as vibrant, innovative, significant, and productive an area of science as one could imagine. It is broad in methodology and areas of application. It is innovative in the extension of methods and the invention and quick introduction of new approaches. It is significant in that its innovations have enabled huge strides in biomedical research, environmental studies, and understanding of fundamental processes. New approaches are quickly deployed and analytical researchers are demonstrating immense versatility while making fundamental contributions to many areas of biological and material science.

Coming out of the University of Illinois in 1959, a veritable hotbed of analytical chemistry at that time, I was unprepared for the attitude that many in other areas of chemistry had toward analytical chemistry. The analytical chemistry graduate program at Princeton closed upon my departure in 1966 after having been the home of N. Howell Furman who mentored there no lesser lights than Clark Bricker, Gil Haight, George Morrison, Rudy Bottei, Charlie Reilley and Ralph Adams. This coincided with the elimination of analytical chemistry as a discipline at Harvard, Columbia, Yale, MIT, Pennsylvania, and many other northeastern departments upon the retirement or departure of their illustrious analytical faculty (J.J. Lingane, Dave Hume, Buck Rogers, and others). By 1970, only a few good programs such as U. Mass. Amherst and Northeastern U., remained in the entire region. I was fortunate to get a position at Michigan State U. where the subject flourished along with many other excellent programs in the Midwest. In the departments with strong analytical programs, the analytical faculty was among the most productive and innovative in the department, had the strongest student recruiting and the strongest graduate placement. It is a source of wonder to me that the field has been so remarkably successful in advancing science in general against this continual headwind of disrespect. To be fair, I think this problem is the by-product of the creation of the four divisions of chemistry and the wide-spread practice of rivalry among them. I also believe that the resulting hardening of the divisions has done serious if not fatal harm to the entire structure of chemistry graduate education in the USA.

So let me widen the topic to where the broader field of chemistry is today in this, its International Year. In the world, it is a huge factor. It is the basis of new materials from nanoparticles to semiconductors, to optical devices, to drugs, better batteries and solar cells, and so much more. At the same time, it is more than a little tarnished from the overuse of potentially harmful chemicals in the environment, foods, and building materials and those abuses have hurt its public perception in addition to having disrupted the lives of way too many people. In the non-synthetic areas, analytical and theoretical chemistry, once restricted to the simpler molecular entities are now routinely applied to very large systems and molecules of wondrous complexity. Mass spectrometry and chromatography have combined to provide characterizing power that has revolutionized drug discovery, disease diagnostics, microbiology, forensics, and many other areas. Spectroscopy has expanded across the electromagnetic spectrum and has achieved sensitivity to the level of single molecules. My own recent work indicates that it is reasonable to contemplate the nearly complete analysis (>99% of all components) of natural complex mixtures but that we will need further advances in dynamic range and throughput to realize that previously unimaginable goal.

Given all these exciting and ground-changing developments, why does the number of chemistry B.S. degrees continue to decline and the trickle of quality domestic chemistry graduate students fail to fill the groups of current chemistry research faculty? The lure of the MBA in today's world cannot be the only factor when one considers that biology departments have grown at a good clip and many have highly selective entrance criteria. Advanced study in chemistry is no longer limited to the chemistry department; it is taught and practiced in departments of material science, medicinal chemistry, molecular biology, geological chemistry, forensics, and the like. Many universities have included biochemistry within the chemistry department, but for many more, biochemistry is a separate department. Why are these various versions of chemistry teaching and research spread all over campus? Why did the academic chemistry establishment not embraced these evolutionary offshoots as they arose? Physics departments did and still do (cryophysics, nuclear physics, astrophysics, etc.). The American Chemical Society, reflecting the broader industry, certainly has (polymer, agriculture and food, toxicology, environmental, nuclear, etc.).

When a department is run by divisions competing with each other for limited resources, how could it invite in or make room for a new area? Having fought hard for each available faculty hire, divisions tend to want a card-carrying member of their discipline to strengthen their area. Fringy research areas are too risky and perhaps that person would not teach the traditional courses well,

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or so goes the argument. So, the cross-over researcher and the new field finds a home created by other disciplines developing a chemical slant. I am afraid that too many departments have turned away applicants working on the boundaries and have, as a result, lost the opportunity to host some of the most ground-breaking work. Just think; all those students and faculty who are in these exciting areas of applied chemistry could have been enriching chemistry departments. This, in turn, would have resulted in an evolution of the chemistry curriculum to better reflect these extensions and bring more of the exciting forefront of chemistry into our courses. Instead, the chemistry curriculum has changed little over the more than 50 years I have been associated with it. It is tediously bottom-up and largely lacking in conveying any of the fascinating challenges that lie ahead for career chemists of any type. With biology and physics, it is clear to all that we are just part way up an exciting learning curve. Far too often chemistry is taught like it is the end of the story and it was all discovered decades ago.

Chemistry is often touted as the “central science” and so most chemistry faculty consider their department to be indispensible. There are ominous signs that this is not so. A substantial number of graduate programs in chemistry at major universities in England were defunded some years back as being among the least cost-effective. Most of the credit hours generated by chemistry departments are undergraduate service courses which could just as easily be moved to the departments that require them. And, as pointed out above, it would not mean the end of research in chemistry since so much of it is going on in other departments already. Physicists and engineers are leapfrogging right past chemistry into biology. It is my opinion that insisting that colleges must have a chemistry department to teach the chemical principles needed in other disciplines is sticking ones head in the sand rather than dealing with the central issue of regaining the relevance and excitement of careers in chemistry.

In general, analytical chemists have not been so parochial. Over my career, analytical chemistry departments have adopted electroanalytical chemistry, fundamental studies in spectroscopy, the theory and practice of chromatography, and the development of novel mass spectrometry instrumentation and applications and more. Analytical texts and instrumental methods courses have expanded to include these modern developments. In my opinion, this has contributed immensely to the current vibrancy of the field. At the same time, analytical chemistry is still vulnerable to attacks that it is more a set of techniques than a science and modern texts do little to dispel this perception. Organic and inorganic chemists have found fundamental principles that underlie the structures and behavior of their compounds, saving them from teaching just a series of synthetic reactions. Analytical chemists have not adopted an equivalent, i.e., a theory of chemical detection and quantitation that would rationalize existing methods and serve as a template for future developments. I regret that my own effort in this direction based on the “differentiating characteristic of the analyte” was offered in the format of a textbook that did not gain traction.

My upbeat appraisal of the past and future of the field of analytical chemistry is strangely at odds with its ranking among the chemical divisions and my perception of the broader chemistry discipline as a increasingly diffused light among the general sciences. But there are some ways forward. Departments could realize the self-defeating nature of their internecine struggles and move to collaborate with and adopt chemists in emerging areas. In any case, I strongly encourage younger generations of analytical chemists to continue to evolve and extend themselves into providing solutions to measurement challenges in biological, materials, and physical science. It is equally important that some immerse themselves into aspects of those sciences where their insights can enable significant advances. In this way, analytical chemists can do what the academic departments as a whole have not managed to do, which is to embrace and enhance chemical measurement science wherever it is emerging.

While aspects of this letter may seem bleak, I am very optimistic about the continued explosion of analytical science and very grateful to have found this field in which to spend my creative years. Among all the sciences, it was indeed the perfect fit for me. Electronics had been an interest of mine before secondary school. I started college in 1951 and quickly got hooked on chemistry. In my junior year, I was introduced to electrochemistry. This combination of my two scientific interests felt like a great match. This continued through graduate school at The University of Illinois, Champaign/Urbana where my thesis with Herbert Laitinen was in electroanalytical chemistry and my teaching included helping Howard Malmstadt develop the first lab course in electronics for chemistry graduate students. This evolved into the Electronics for Scientists book and Heath Company educational laboratory equipment. Subsequent books with Stan Crouch as coauthor followed electronic instrumentation through vacuum tubes, transistors, integrated circuits and computers while my research moved through array detector spectroscopy and then into mass spectrometry where I have spent the last several decades. The science has been exciting and the teaching a wonderful and rewarding aspect of the work. I have also made many close friends in the analytical community over the years and now look forward to meetings just as much for the interactions as for the science.

My very best wishes to you all,

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