ACS central science

EDITORIAL

Several Centuries of Centrality

As Carolyn Bertozzi mentioned in her inaugural editorial,[1] the relationship of "Central Science" to "Chemistry" became popularized over 40 years ago with the publication of the first edition of Brown and LeMay's *Chemistry: The Central Science*,[2] now in its 13th edition. Yet as late as 2003, Prof. Sason Shaik at The Hebrew University claimed "popularization of chemistry remains scant." He goes on to share [his] "own experience of popularizing chemistry by delivering the following universal message of our science, that Chemistry is the window given to Mankind to glimpse into its material essence."[3]

As it turns out, "centrality" has been a recurring theme since the mid-19th century, and Brown and LeMay's title can, in a sense, be understood over time in two different ways. In short: you can either view chemistry as the central science because all material is molecular or view that chemistry links other science on the "purity" continuum.

The molecular approach is spelled out in their ninth edition: "... chemistry, by its very nature, is the central science. Our interactions with the material world raise basic questions about the materials around us. What are their compositions and properties? How do they interact with us and our environment? How, why, and when do they undergo change? These questions are important whether the material is part of high-tech computer chips, an aged pigment used by a Renaissance painter, or the DNA that transmits genetic information in our bodies. Chemistry provides answers to these and countless other questions."

Taken literally, this description is at odds with the current public perception of physics and biology as the scientific icons of the 20th century for having produced the atomic bomb and genetic code respectively, in spite of the fact that each field can be seen as logical applications of nuclear and biological chemistry. This sort of interpretation actually dates much further back to Justus von Liebig (1803–1873), who posited that "chemistry was the fundamental, or central, science".[4] He posits that he actually had "managed to create a new image of chemistry: no longer the servant of pharmacists and physicians, it must be considered the most useful of all sciences and the most popular." Liebig wanted everybody to believe that chemistry commanded every phenomenon in living nature: "Alles ist Chemie."[5]

When it comes to more modern studies, one can still see this fundamental view. Ronald Breslow particularly raises the molecular science to a heroic pedestal when he sees "chemistry as 'central' to the human effort to move above the brutish existence of our caveman ancestors into a world where we can exist not only in harmony with nature, but also in harmony with our own aspirations."[8]

A few years later, Bartow Culp (in a review of collection development in chemistry libraries) stated, "the humble study of material at the molecular level has had such an impact on other natural and applied sciences that it is known as 'the central science.'" He expands Liebig's list of those influenced by chemistry to reflect modern marvels: "chemistry affects everyone, and its achievements, from the elucidation of the double helix structure of DNA ... to the recent discovery of a new form of carbon, the "buckyball," have changed the world."[6]

A driving force in highlighting the fundamentality of chemistry may, surprisingly, be our drive toward applications-based science. Dennis Livesay, on the College of Computing and Informatics University of North Carolina at Charlotte's faculty, echoes Culp's point of view when he discusses the interdisciplinary nature of biomacromolecular research and states, "Chemistry, often referred to as the central science, is critical to a fundamental understanding of the world around us. Chemical concepts have traditionally been central to the canonical sciences (i.e., biology, physics, and geology). As a chemist, it is gratifying to see the importance of chemistry continue in newer disciplines as well."[7]

The other definition is found in their 13th edition and stands as yin to the 9th's yang: "Chemistry is central to a fundamental understanding of governing principles in many science-related fields." Going back to the earlier discussion of chemistry's role in the travails of physics and biology, rather than focusing on their dually molecular nature, you can instead picture how chemistry bridges the physical and biological sciences, and further connects these basic sciences with applications in the engineering disciplines as well as medicine. It occupies a central position in a hierarchical chain of science that interconnects the hard and soft sciences.[9]

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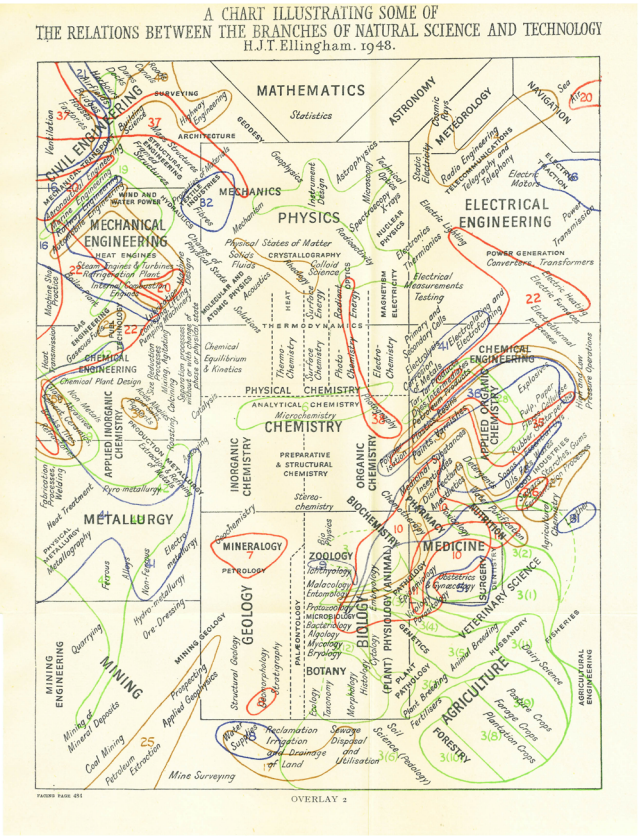

Figure 1. H. J. T. Ellingham's chart illustrating some relations between the branches of natural science and technology. Reprinted with permission from ref 11. Copyright 1948 The Royal Society.

This same concept of bridging the physical, life, and applied sciences was described during the same era of that first Brown and LeMay's text in the 1965 Westheimer Report,[10] and shown visually in H. J. T. Ellingham's 1948 "Chart illustrating some of the relations between the branches of natural science and technology", Figure 1.[11]

Just as in the first definition, we may go even further back, to see that Harold Urey, in the first issue of *Journal of Chemical Physics*, asserted in 1933 that "the boundary between the sciences of physics and chemistry has been completely bridged";[12] and John Slater, discussing the relationship between chemistry and physics in 1939, strongly felt that "Now that statistical mechanics has led to quantum theory and wave mechanics, with its explanations of atomic interactions, there is really nothing separating them anymore."[13]

You could even say that, in a sense, bridging dates back to the late 1800s, with Auguste Compte, who "found that there were five great groups of phenomena of equal classificatory value ... these he gave the names astronomy, physics, chemistry, biology, and sociology."[14] Also, see ref 15 for an excellent overview of the "bridging of boundaries between chemistry and the other 'classical' disciplines of science, physics, and biology; and chemistry's connection to mathematics and technology."

No matter which definition you prefer, the molecular nature of our universe, or that chemistry is fundamental to all our scientific pursuits, its centrality will continue to guide the frontier and diversification of science.

Perhaps, this is best demonstrated with a case study. For an illustrative experiment, I queried the 159 articles from my home institution in those journals with titles beginning "ACS" and discovered their authors came with more than 20 different affiliations. The following list indicates the breadth of subject matter that could actually be considered chemistry:

Artificial Photosynthesis
Bioengineering
Biology and Biological Engineering
Chemical Engineering
Chemical Physics
Chemistry
Composite Materials and Structures
Computational and Neural Systems
Computer Science
Control and Dynamical Systems
Electrical Engineering
Engineering
Engineering and Applied Science
Infectious Disease Epidemiology
Innovative Materials
Materials and Process Simulation
Materials Research
Materials Science and Engineering
Microbiology and Immunology
Molecular and Genomic Medicine
Nanoscience
Physics
Systems and Synthetic Biology

Or, as Liebig would say, "Alles ist Chemie."

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Biography
Dana Roth is currently a Special Projects Librarian at Caltech, following over 45 years as Chemistry Librarian. He also served as a library advisor at the Indian Institute of Technology in Kanpur (1971–1972), and participated in an exchange program at the University of Stirling library in Scotland (1975–1976). Mr. Roth was inducted into the Special Libraries Association Hall of Fame in 2008 and was made a Fellow of the Royal Society of Chemistry in 2014.

Notes
Views expressed in this editorial are those of the author and not necessarily the views of the ACS.

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