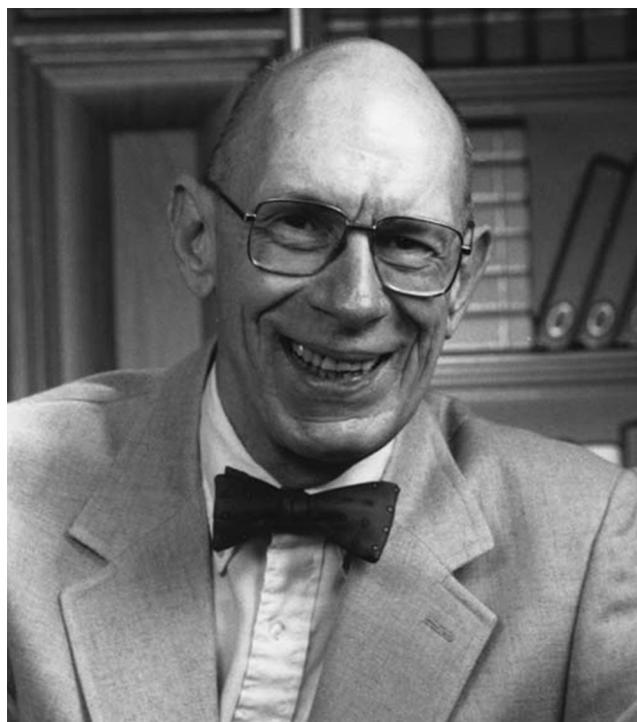


OBITUARY

Frank H. Field (1922–2013)

Until the 1960s, electron ionization was the dominant means for producing ionized molecules for mass spectrometric analysis. Although the method was effective for ionizing volatile molecules, the energetic electrons used for this purpose induced large amounts of fragmentation, so that the intact ionized species were often either completely absent from the mass spectrum or just a minor component. Frank Field, working in collaboration with Burnaby Munson, changed all this through their development of “chemical ionization,” wherein ionization is accomplished through the transfer of charge to (or from) the neutral molecules of interest using reactant species such as CH_5^+ . By adjusting the amount of energy conferred to the molecules of interest during the proton-transfer reaction through judicious choice of the reactant ion species, they were able to tune the degree to which fragmentation occurred. In this way, they observed mass spectra where the “quasi-molecular” ion species was a large, easily recognized feature of the mass spectrum. This development proved seminal in the progression of mass spectrometry from a technique whose utility was limited to the analysis of relatively low molecular weight, volatile molecules to its current status as a method of choice for characterizing even the most massive involatile molecular species, including biomolecules.

Frank Field was born on 27 February 1922 in Keansburg, a small resort town on the Raritan Bay in New Jersey. Orphaned at age eleven, he was raised by relatives in Cliffside Park, New Jersey, just across the Hudson River facing New York City. After discovering a passion for chemistry during his youth, Field entered Duke University just prior to the Second World War, obtaining a BS and MS in chemistry and a PhD in magnetochemistry. In 1947 he went on to a tenure track position at the University of Texas in Austin, planning to continue his work in magnetochemistry, but through fortuitous circumstances came into possession of a Westinghouse LV 90° sector mass spectrometer donated to the University of Texas by the Humble Oil and Refining Company in Baytown, Texas. The instrument was in bad repair, so that Field had to jump in at the deep end to get the instrument fixed and working. From this point on he was hooked on mass spectrometry and never looked back, rising eventually to become one of the most influential ion chemists of his era. Joe Franklin, recognizing a rare talent, lured Field to Humble Oil in 1952, where they began their fundamental studies in the gaseous ion chemistry of hydrocarbons. Along the way, they



wrote their important and much used book – *Electron Impact Phenomena and the Properties of Gaseous Ions*, 1st Edition (Academic Press: New York, 1957). Another significant contribution during this period was Field’s investigation of low energy electrons to selectively ionize unsaturates in petroleum with low amounts of fragmentation [1]. At the time, the core group doing fundamental research at Baytown was Joe Franklin, Frank Field, and Fred Lampe, who together produced a series of landmark papers on gaseous ion chemistry [2–5].

Field spent the 1963–1964 academic year as a Guggenheim Fellow at the University of Leeds, working with Michael Henchman. Receiving such a fellowship was highly unusual for a member of an industrial research laboratory and provides an indication of Field’s considerable international stature during this period. Around this time, Field and Munson began an extensive study of “ultra” high-pressure mass spectrometry [6] that led to the development of “chemical ionization mass spectrometry.” This involved construction of a very large custom mass spectrometer specifically configured to study gaseous ionic interactions. In those days, it was usual to maintain the pressures of gases to be ionized in the ion source at low enough pressures—typically less than 10^{-2} Torr—so as not to unduly

increase the pressure in the mass analyzer. However, by careful use of differential pumping they were able to maintain source pressures as high as 2 Torr and, in the process, began to access novel regimes in gaseous ion chemistry. Initially, almost everything that they investigated with this high pressure ion source provided new information. In Field's own words [7] "We saw all sorts of interesting phenomena. One of these was when we made an elaborate study of methane, just increasing the pressure, and looking at the different ions that formed, and how they varied in intensity. What we discovered was that in methane in our apparatus at something like 1 Torr, the relative intensity of major ions such as CH_5^+ and C_2H_5^+ didn't change as the pressure was increased further.....But then we discovered that in order to get this stability, we had to make sure that we used bone-dry methane. It couldn't have any water in it at all or else we ended up with the hydronium ion. One thing led to another, and all of a sudden, it clicked. Well, let's see what happens if we add other substances to this methane as a carrier at high pressure. Of course, what we found was that a new kind of spectrum developed and that was the chemical ionization spectrum. We wrote that up, and submitted it to *Journal of the American Chemical Society* and got a scathing review back," where one referee stated that the paper was ".....a serious waste of a reviewer's time" [8]. They overcame the criticisms and the paper—now a classic—was published during 1966 in the *Journal of the American Chemical Society* [9]—a "contribution from the Esso Research and Engineering Co., Baytown Research and Development Division."

At this point, Field moved with his large mass spectrometer to the main Esso Research and Engineering Co. in Linden, New Jersey, where he continued to make fundamental contributions on chemical ionization. During this period, Field began to have doubts as to whether the basic research that he was carrying out was doing anything meaningful for the oil company's bottom line—a worry that illustrated his deep integrity and a core value system that required him to provide what he considered sufficient value for the money that they were paying him. This unease led to his decision to move across the Hudson River to a remarkable institute, The Rockefeller University. Founded in 1903, it is the birthplace of several of the most important ideas in modern cell biology, biomedicine, and disease—so much so that 24 Nobel Prizes have been awarded to scientists associated with this small institution on the East side of Manhattan. Field's recruitment to Rockefeller was unusual in two respects—First, he came from industry rather than academia and second, he had no background in biological research. Nevertheless, Lyman Craig, a legendary analytical chemist at The Rockefeller University, appreciating the potential value of mass spectrometry for investigating natural products and proteins and at the same time recognizing Frank's groundbreaking progress in gaseous ion chemistry to potentially enable the then elusive goal of obtaining mass spectra of biomolecules, lured him to the

University in 1970. There, Field immediately got going on two research streams. The first was a continuation of his groundbreaking work in chemical ionization. The second was in biological mass spectrometry, a field at that time very much in its infancy.

At Rockefeller, Field and his colleagues extended their fundamental studies of chemical ionization and greatly expanded its utility to all manner of biomedical problems. Early on, he also set up, with funding through the National Institutes of Health, a biomedical mass spectrometry resource that he designed to be open nationwide to biological researchers and which in time would become a world leader in developing enabling biological mass spectrometric tools and technologies. At this Resource, for example, Field and Chait constructed the first open access "plasma desorption" mass spectrometer [10] based on an improbable discovery made by two Texas-based nuclear physicists, Ronald Macfarlane and David Torgerson [11]. Macfarlane and Torgerson's invention of Californium-252 fission fragment ionization, a revolutionary new method for volatilizing and ionizing involatile biomolecules, had come completely out of "left field" and was so unconventional as to be largely ignored by the established mass spectrometric community. Not so by Field, who immediately recognized the importance of their discovery and who did not give a hoot that the spectra looked quite ugly by conventional standards or that he did not have experience in their technologies or that he would have to handle the transuranic isotope Californium-252, arguably one of the more dangerous substances pound for pound on the planet. He simply looked past all of that and just saw the possibilities.

Indeed, one of Field's great talents was not to get hung up on the uncertainties and minutiae that so often cloud the issue at hand, but rather to go straight to the core of the problem. In his laboratory, he created an atmosphere of intense discovery, deep, unrelenting hard and honest questioning, with nobody, including himself, getting off easily, pretty grueling sometimes, but ultimately extraordinarily rewarding for all who took part. In several ways, Frank Field was "larger than life" brimming with big ideas, a big man with an extraordinary active inspiring mind, and a big heart. We will miss him.

References

1. Field, F.H., Hastings, S.H.: Determination of unsaturated hydrocarbons by low voltage mass spectrometry. *Anal. Chem.* **28**, 1248–1255 (1956)
2. Field, F.H., Franklin, J.L., Lampe, F.W.: Reactions of gaseous ions. 1. Methane and ethylene. *J. Am. Chem. Soc.* **79**, 2419–2429 (1957)
3. Field, F.H., Franklin, J.L., Lampe, F.W.: Reactions of gaseous ions. 2. Acetylene. *J. Am. Chem. Soc.* **79**, 2665–2669 (1957)
4. Lampe, F.W., Franklin, J.L., Field, F.H.: Cross sections for ionization by electrons. *J. Am. Chem. Soc.* **79**, 6129–6132 (1957)
5. Lampe, F.W., Field, F.H., Franklin, J.L.: Reactions of gaseous ions. 4. Water. *J. Am. Chem. Soc.* **79**, 6132–6135 (1957)

6. Field, F.H., Franklin, J.L., Munson, M.S.B.: Reactions of gaseous ions. 12. High pressure mass spectrometric study of methane. *J. Am. Chem. Soc.* **85**, 3575–3583 (1963)
7. Oral History of Frank H. Field conducted by Michael A. Grayson, Chemical Heritage Foundation. Available at: <http://www.chemheritage.org/discover/collections/oral-histories/details/field-frank-h.aspx>. Accessed 12 Mar 2014
8. Field, F.H.: The early days of chemical ionization—a reminiscence. *J. Am. Soc. Mass Spectrom.* **1**, 277–283 (1990)
9. Munson, M.S.B., Field, F.H.: Chemical ionization mass spectrometry. I. General introduction. *J. Am. Chem. Soc.* **88**, 2621–2630 (1966)
10. Chait, B.T., Agosta, W.C., Field, F.H.: Fission fragment ionization (Cf-252) mass-spectrometry—positive and negative spectra and decomposition mechanisms for seven compounds. *Int. J. Mass Spectrom. Ion. Phys.* **39**, 339–366 (1981)
11. Macfarlane, R.D., Torgerson, D.F.: Californium-252 plasma desorption mass-spectroscopy. *Science* **191**, 920–925 (1976)

Brian Chait

*The Rockefeller University,
New York, NY, USA*