RETROSPECTIVE

Edward I. Stiefel (1942–2006)

E. I. Stiefel was a bioinorganic chemist whose insights into the roles of metals in living systems have led to practical applications and new research ideas.

François M. M. Morel and John T. Groves

Edward I. Stiefel, an unusual chemist who bridged industry and academia, pure chemistry and applications, and bioinorganic and environmental chemistry, died on 4 September 2006 in Robert Wood Johnson Hospital, New Brunswick, New Jersey. His insights into the functions of metals in living systems led to a new understanding of key biological processes, new technological applications, and a better appreciation of the interactions among the cycles of trace and major elements on Earth, both today and in the past.

Ed grew up in Brooklyn, New York. He received his Ph.D. with Harry Gray at Columbia University in 1967 and then served on the faculty at the State University of New York at Stony Brook, before becoming a senior investigator at the Charles F. Kettering Research Laboratory. In 1980, he joined the Catalytic Materials Group at Exxon's Corporate Strategic Research Center in Annandale, New Jersey. Following his retirement from ExxonMobil in 2001, Ed accepted a position at Princeton University as the first holder of the Ralph W. Dornte Chair, a distinguished visiting lecturer position with the rank of professor.

Ed's research interests involved the bioinorganic, coordination, and environmental chemistry of transition-metal ions, particularly iron and molybdenum. While at Kettering, he codiscovered bacterioferritin, the iron storage protein of prokaryotes (*1*), and made pioneering advances in our understanding of nitrogenase enzymes, illuminating the role of molybdenum in catalyzing the conversion of atmospheric nitrogen to ammonia.

His arrival at Exxon made an immediate impact on the company, vastly increasing the interdisciplinary research by the company's Catalytic Materials Group. He initiated discussions concerning the active centers of nitrogenase and other molybdenum enzymes that bridged "industrial" and "biological" catalysis. This new insight led him to wonder whether tungsten-associated enzymes might exist that would be analogous to known molybdenum enzymes. Stiefel predicted the existence of such enzymes before their discovery in *Pyrococcus furiosus*, a microbe that thrives in the boiling waters of hot springs (*2*).

> "In every problem he tackled, he had **a phenomenal ability to see the big picture.**"
>
> —Harry Gray

While at Exxon, Ed developed many new molybdenum compounds that have proven useful as catalysts and lubricating oil additives. For example, he was the principal inventor of the commercially important "thiomolybdate" additive for lubricating oils. This compound had previously been used as a catalyst for the desulfurization of crude oil and was found to make the oil more slippery and less prone to oxidize.

His knowledge of the bioinorganic chemistry and biology of metalloenzymes proved to be invaluable when he became one of the principal architects of the cleanup after the *Exxon Valdez* oil spill in Alaska in 1989. This massive effort successfully applied the principles of bioinorganic chemistry and microbiology to a very-large-scale environmental remediation project. Ed's interdisciplinary interests also shaped the science agenda and recruitment strategies of Exxon's Corporate Strategic Research Center. Ed's genius lay in his ability to understand complex chemical issues over a wide range of scales, from molecular to cellular to global.

At Princeton, Ed was instrumental in developing three very popular courses: a freshman seminar entitled "Elements of Life"; a graduate-level course on "Metals in Biology" (jointly with J. T. Groves); and, in collaboration with colleagues, an innovative multidepartmental course on "Life in the Universe," which was instrumental in doubling the number of chemistry majors. Students in Ed's courses revered him. The evening freshman seminars kept students on the edge of their seats and often went on well into the night.

Ed held 30 U.S. patents and published more than 150 scientific articles. His review article on "The Coordination and Bioinorganic Chemistry of Molybdenum" has been cited in more than 800 publications. And his contributions to science and his inspiration to students and colleagues are continuing. He is the coauthor of several articles that are in various stages of publication, some of which bring together the various strands of his multifaceted career. One upcoming article deals with the function of iron storage proteins in ocean regions where life is limited by the availability of iron (*3*). He is a coeditor of the book *Biological Inorganic Chemistry: Structure and Reactivity*, which has just been published (*4*) and is destined to become a classic.

Ed Stiefel was a joyful man, a compassionate friend, an inspiring teacher, and a generous colleague. At a recent colloquium at Princeton, his close friend and early mentor Harry Gray most concisely described what it meant to have Ed Stiefel as a colleague: "A discussion of a research problem with Ed was really special. He understood the roles metals play in living systems better than anyone. In every problem he tackled, he had a phenomenal ability to see the big picture. He was a scholar's scholar." He is survived by his wife Jeannette, a frequent visitor and friend of the Princeton Chemistry Department, and their daughter Karen.

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