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OBITUARIES

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Ralph J. Cicerone

Ralph J. Cicerone, born in New Castle, Pennsylvania, on 2 May 1943, was the first of his family to attend college and became a trailblazer in researching global environmental change. He died on 5 November 2016 at his home in Short Hills, New Jersey, in the company of his family.

After completing his BS in electrical engineering at MIT in 1965, Cicerone received his MS in 1967 and PhD in 1970, both from the University of Illinois at Urbana-Champaign. His thesis, on ionospheric photoelectrons, was done under Sid Bowhill.

Cicerone came of age scientifically in the 1970s, a heady but turbulent era for atmospheric science. A new class of synthetic chemicals called chlorofluorocarbons (CFCs) provided more efficient, nontoxic chemicals for refrigerants, spray-can propellants, foam blowing, and medical applications. But scientists recognized that chlorine atoms could destroy stratospheric ozone; that CFCs could deliver chlorine to the stratosphere; and that the current use of CFCs would lead to their accumulation in the atmosphere over the coming century.

The specters of global ozone depletion and predicted cancers from increased UV sunlight created a Jekyll and Hyde-like conflict with the myriad new technologies being sold under the guise of improving our daily lives. The CFC-ozone connection was the first example of a society-initiated atmospheric change that could cause global environmental damage. The resulting contentious interactions of Cicerone and the other early scientific explorers with the chemical industry has been dubbed the ozone wars.

One of the hardest ideas to get across to the public and policymakers was how CFCs would reach the stratosphere, build up chlorine atoms, and destroy the ozone layer. Cicerone and others who recognized the CFC problem—including Paul Crutzen, Chuck Kolb, Michael McElroy, Mario Molina, Sherry Rowland, Steve Wofsy, and one of us (Stolarski, then his colleague at the University of Michigan)—led the charge; they

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Ralph J. Cicerone

communicated not merely through scientific journals but also directly to the public. Cicerone pushed the science from the local to the national level, and he was responsible for the 1974 Ann Arbor City Council ban on CFC use in spray cans. That was followed by other local bans on CFCs, proposed amendments to the US Clean Air Act in 1977, and eventually the US and Nordic bans on such spray cans.

The ozone wars were long and brutal, but they were finally resolved by international scientific ozone assessments, detection of the Antarctic ozone hole and ozone depletion globally, and the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. The scientific accomplishments of those early explorers were recognized with the awarding of the 1995 Nobel Prize in Chemistry to Crutzen, Molina, and Rowland.

Cicerone's career shows lessons learned from the ozone wars: Scientific integrity is tantamount, facts must not be subjugated to political favor, collegiality among scientists is key, and global environmental and societal change is the story of the coming century.

Cicerone is best known in the scientific community for his leadership in ushering in the modern era of atmospheric chemistry and biogeochemical cycles

of the Earth system and for coupling that knowledge to societal effects of ozone depletion and climate change. His research led to new ways of understanding global atmospheric changes and identifying the causal chain that implicated humans. When most scientists involved in atmospheric chemistry were not interested in the biosphere, Cicerone studied methane and the complex systems that produce it, consume it, and sometimes release it to the atmosphere. His investigation of methane emissions from rice paddies was one of the first biogeochemical research projects; he studied the natural biogeochemistry of a human-made compound to better understand its environmental threat. The new information was critical for assessing the damage to the ozone and climate from agricultural chemicals and influenced the national debate on regulating them.

Beyond his scientific accomplishments, Cicerone was unique in organizing and energizing scientists. As director of the atmospheric chemistry division at the National Center for Atmospheric Research in 1981–89, he influenced a generation of scientists. In 1990, working with Rowland at the University of California, Irvine, he founded the new Earth system science (ESS) department—the first at a university to focus primarily on global change. Cicerone became Irvine's dean of physical sciences in 1994 and chancellor in 1998. Throughout his career, he maintained the perspective that the best science is accomplished by the best scientists working together as a community.

In 2005 Cicerone was elected president of the National Academy of Sciences (NAS), from which he just retired this past summer. As NAS president, he emphasized objective scientific studies in support of public policy. Among them are ones on climate change impacts, past temperature reconstructions, active remote sensing, and solar observations. In the face of an administration and Congress that doubted climate change, Cicerone used NAS funds to organize an independent review of the Intergovernmental Panel on Climate Change's 2001 assessment; it affirmed the IPCC's findings. When the IPCC became involved in another major controversy, Cicerone organized the international group of national science academies, and the resulting review helped save the international climate

OBITUARIES

assessments and maintain the pressure to act on climate change.

Cicerone's natural leadership was evident in the scientific problems he pursued or convinced others to pursue. Recognizing societal aspects was a hallmark of his work. His intellect, insight, kindness, and collegiality made him a pleasure to work with. Cicerone's vision of biogeochemistry and global change has altered graduate education internationally and influenced the way many of us approach global-change research. We will miss his regular questions and curiosity about the planet.

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David Ritz Finkelstein

Theoretical physicist David Ritz Finkelstein, professor emeritus at Georgia Tech, died at home in Atlanta on 24 January 2016.

Finkelstein was born in New York City on 19 July 1929. He graduated from City College of New York with honors in both physics and mathematics, and in 1953 he received a physics PhD at MIT, for a thesis supervised by Felix Villars. He worked at Stevens Institute of Technology from 1953 to 1960, at Yeshiva University until 1976, and then at Georgia Tech until his death.

In a 1955 paper, Finkelstein addressed the question of whether an anomalous spin- $\frac{1}{2}$ state had been overlooked for the gravitational field. His discovery of the topological origin of such anomalous spins and a speculation that all physical variables may be topological in origin was the thread that led him in the 1950s and 1960s to kinks, the unidirectional membrane, and anyons, antecedents of anomalous quantum numbers in the fractional Hall effect and in high-temperature superconductivity.

A 1957 seminar Finkelstein gave on extending Schwarzschild's metric—a basic ingredient of the current understanding of black holes—was a revelation to Roger Penrose. Afterward, Penrose explained to Finkelstein his spin networks, and for years thereafter the two men exchanged their research subjects. Finkelstein saw quantum spins as a possible route into the quantum nature of reality

and took such ideas to unusual depths.

In 1958 Finkelstein was the first to describe what is now known as a black hole—his “unidirectional membrane.” The work influenced Lev Landau, Penrose, and eventually John Wheeler, and it was instrumental in bringing general relativity into mainstream physics. Although today it is considered his key contribution, for Finkelstein it was only a step in his overarching program to bring topology into quantum physics. He, together with Charles Misner in 1959 and Julio Rubinstein in 1962, discovered kinks—particles extended over a finite volume rather than concentrated at a point—topological charges, and topological spin-statistics theorems.

Finkelstein was among the earliest scientists to understand the role of quantum vacua, and he wrote some of the earliest papers on solitons in quantum theories. His 1962–63 papers with Josef Jauch, Samuel Schiminovich, and David Speiser were the first to formulate a unified $SU(2)$ gauge theory of massive vector bosons and light and thus introduced electroweak unification before Sheldon Glashow, Abdus Salam, and Steven Weinberg. Or, as Finkelstein put it, “I'm afraid I'm another one of the infinite number of people who did the Higgs field before Higgs.”

Even while making such seminal contributions to theory, from 1955 to 1971 Finkelstein pursued a parallel career as a plasma physicist. He is remembered as an exquisite experimentalist and was proud of the theory he developed with

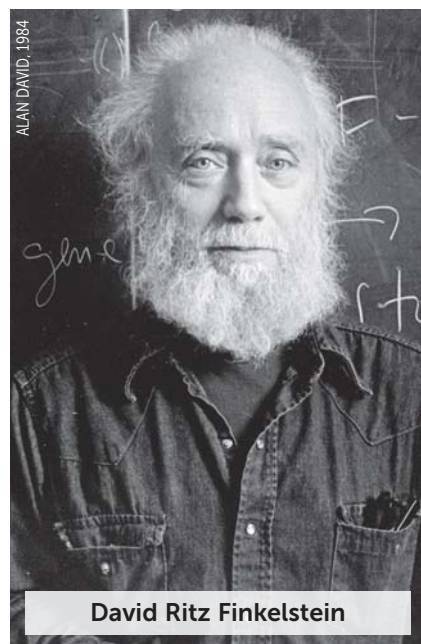
Rubinstein and James Powell for ball lightning.

During the summer of 1965, at the height of the civil rights movement, Finkelstein took his family to Mississippi after receiving a temporary NSF–American Physical Society appointment as a visiting scientist with the physics department of Tougaloo College, a historically black school. His efforts as acting department head included expanding the physics program and helping found Public Radio Organization, whose goal was to offer African Americans in central Mississippi unbiased news reporting and a community forum. The courage of the people he worked with in Mississippi influenced him profoundly.

In 1979 Finkelstein became the chair of Georgia Tech's school of physics, with the goal of raising the department to the level of its MIT sister department. When he failed to submit a budget, he was deposed by senior faculty. He soon realized that his failure as an administrator freed him to pursue his dream, so he started his second life, in which he dedicated himself to formulating a universal physical theory consistent with both quantum theory and gravity.

A charismatic mentor, Finkelstein involved numerous dedicated students in his efforts to quantize geometry. In 1946 he'd already realized that while classical logic was commutative, quantum physics was not. Hence, before a correct quantum spacetime theory could be formulated, the foundations of mathematics and logic itself had to be replaced by quantum logic. (For a full exposition, see his *Quantum Relativity: A Synthesis of the Ideas of Einstein and Heisenberg*, Springer, 1996.) A decade ago he reminisced, “When I began my own research I took it for granted that it had three stages: I would first find a theory in which I could at least potentially believe, then compute its consequences, test it against experimental data, and return to stage 1 for an improved version. After about forty years I could not help noticing that I was still in the first stage.”

In Sidney Coleman's words, Finkelstein “was a brilliant scientist with a passion for long shots. This meant that nine times out of ten he devoted his talents to ideas that do not pay off, but, one time out of ten, they *do* pay off. When this happened, Finkelstein's work was found to be of a great significance, extraordinary penetration, and ten years ahead of everyone else's, as was the case when



David Ritz Finkelstein