RETROSPECTIVE

Ralph J. Cicerone: His scientific legacy and a long friendship

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The discovery of the Antarctic ozone hole and anthropogenic climate change has thrust the atmospheric sciences into the forefront of scientific disciplines, and such findings routinely appear on the front pages of the media and on the desks of world leaders. Two events can be cited as examples of the ascendency of the atmospheric sciences. First was the award of the 1995 Nobel Prize in Chemistry to three atmospheric chemists who performed pioneering work on the stability of the ozone layer. Second was the 2005 election of Ralph J. Cicerone as president of the esteemed National Academy of Sciences (NAS), which counts among its members the nation's preeminent scientists in all of the primary scientific disciplines. Ralph also contributed to the award of the 1995 Nobel Prize in Chemistry through his seminal work with another young scientist, Richard Stolarski, in 1974 (1) on the stability of the ozone layer. With Stolarski, Ralph showed how chlorine radicals were catalytically destroying ozone molecules in the stratosphere. Indeed, the 1995 Nobel committee for the chemistry prize acknowledged the Cicerone–Stolarski discovery of chlorine catalysis.

The grandson of Italian immigrants, Ralph was born in New Castle, Pennsylvania, on May 2, 1943, into a close-knit extended family. He died at his home on November 5, 2016 in Short Hills, New Jersey, in the company of his wife, Professor Emerita Carol Cicerone, and their daughter and two grandchildren. According to Ralph, his primary focus during his junior high and high school years was on sports: "any kind." He went on to the Massachusetts Institute of Technology where he majored in electrical engineering as an undergraduate and was the captain of the baseball team. Ralph's passion for baseball persisted in later years, and as chancellor of the University of California, Irvine (UCI), he revived baseball as an officially recognized sport on campus. In gratitude, the university named its baseball stadium Cicerone Field at Anteater Ballpark. I know his passion for sports first hand; during a dinner at his Irvine, California house in 1990, Ralph proudly told me, with that familiar charming glint in his eyes, about his daughter Sara's achievements in high school tennis.

Ralph was the first in his family to attend college and completed his doctorate in electrical engineering and applied physics at the University of Illinois at Urbana–Champaign. Although he was not particularly fond of chemistry as an undergraduate, Ralph went on to make his seminal contribution in atmospheric chemistry with Stolarski as a postdoctoral fellow at the University of Michigan. Ralph was primarily an atmospheric chemist who became interested in climate change science later in his career.

Ralph J. Cicerone. Photograph by Mark Finkenstaedt and image courtesy of the National Academy of Sciences.

Ralph's first article on climate change was likely the one we wrote together in 1983 (2), about how atmospheric chemistry and atmospheric physics were coupled and the role of this chemistry–physics feedback in global warming. We spent many nights in the basement of the computing center, in between submitting our computer program decks, discussing the scientific underpinnings of climate change. I vividly recall the deep

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worry in Ralph's voice about what we were finding; for me, climate change at that time was mainly an exciting discipline fertile for major new discoveries. Ralph was a scientist with a world view and had an amazing capacity to listen and to carry on a conversation without oppressive monologues; even at that young age he had a philosopher's demeanor you could not avoid noticing. These qualities served him well in his subsequent forays into leadership roles in academia and at the NAS.

By the mid-1980s, it became clear that further improvements in our understanding of climate change required understanding the connections between the various components of the Earth system, including the incredibly complex biosphere, which in turn required knowledge of physics, chemistry, biology, and mathematics: basically a new approach that dismantles the disciplinary stove pipes. Ralph was one of the first to recognize this growing need for an interdisciplinary attack on the climate change problem and he led the effort to form the first academic department in Earth system science at UCI in the early 1990s, which is now a major influence in the field and has international recognition. He took over the reins at UCI as chancellor in 1998 and guided the campus out of a serious academic disciplinary crisis. Ralph then ushered the UCI regents through the actions needed to regain the university's prominent standing; this established him as an academic leader with a continued sense of personal and scientific integrity.

During his chancellorship the campus flourished in academic excellence, community support, donors, and athletics, with an emphasis on diversity and opportunities for all. Through it all, Ralph's passion for science did not diminish, and he maintained an active laboratory that made important measurements of how methane, a major greenhouse gas, was being emitted by various sources. Perhaps his experience at UCI set the stage for Ralph to take on one of his most challenging, visible, and politically complex tasks at the behest of President George W. Bush in 2001, when he had to "speak truth to power."

President Bush was inaugurated in January 2001. The United Nations' Intergovernmental Panel on Climate Change (IPCC) report had just concluded that the planet was warming and the effects of this warming were manifesting in many parts of the climate system, including the land, atmosphere, oceans, and cryosphere. The report made headlines when President Bush's secretary for the Environmental Protection Agency, Christie Whitman, declared to the attendees of the March 2001 G8 Environment Ministers meeting in Trieste, Italy, "the United States considers global climate change to be one the greatest environmental challenges we face" (3). The White House wanted an American scientific opinion and approached the NAS, which in turn commissioned Ralph to chair the committee. Ralph included a famed climate change skeptic in his committee. The report was due within a month, before President Bush's presentation at the G8 summit in July 2001. Ralph's committee produced their report on schedule in June 2001, including a review by the NAS. It clearly and emphatically said that the IPCC 2001 report accurately reflected current scientific opinion. It was for this unflinching integrity that we loved and respected Ralph. The NAS report addressed all of the questions from the White House, yet the White House ignored the report and maintained its skepticism of climate change. We face a similar situation with the current administration, and Ralph set a shining example for us to follow.

Ralph's scientific discoveries on the stability of the ozone layer and his leadership in climate change policy, as well as his academic leadership at UCI, prepared him to step into the presidency of the NAS. Ralph led the NAS with the same integrity, preserving the international respect for the National Academies of Sciences, Engineering, and Medicine in finding solutions to some of the nation's most pressing science and policy questions. He oversaw the restoration and renovation of the historic NAS building on the National Mall, created a $500 million Gulf Research Program after the *Deepwater Horizon* disaster, and was successful in inviting President Obama to address the NAS twice (an unprecedented occurrence for a United States president). Under Ralph's stewardship, the Academies completed a number of influential studies that helped define the causes, extent, and effects of global climate change, including America's Climate Choices (nas-sites.org/americasclimatechoices/other-reports-on-climate-change/), a comprehensive set of reports that called for action on reducing greenhouse gas emissions while identifying strategies to help the nation and world adapt to a changing climate. He spearheaded the creation of the NAS's Science & Entertainment Exchange (www.scienceandentertainmentexchange.org) with the goal of engaging the general public in science. This unique program connects entertainment industry professionals in Hollywood with top scientists and engineers to foster the accurate portrayal of science in film and television. Perhaps his most lasting contribution to the NAS is the pivotal role Ralph played in unifying the National Academy of Sciences—originally signed into existence in 1863 by President Abraham Lincoln—with the engineering and medicine academies formed much later, into a single entity now called the National Academies of Sciences, Engineering, and Medicine.

These are incredible achievements for a kid who started out interested in sports, and are a true inspiration for generations to come. Ralph's unassuming nature, sincerity, and warm smile concealed well the creativity of this remarkable colleague of ours. It was a sheer pleasure and distinct honor to have known Ralph J. Cicerone for the last 36 years.

1 Stolarski RS, Cicerone RJ (1974) Stratospheric chlorine: A possible sink for ozone. *Can J Chem* 52:1610–1615.

2 Ramanathan V, Cicerone RJ, Singhm HB, Kiehl JT (1985) Trace gas trends and their potential role in climate change. *J Geophys Res Atmos* 90:5547–5566.

3 Whitman CT (March 2, 2001) Remarks of Governor Christine Todd Whitman, Administrator, United States Environmental Protection Agency at the G8 Environmental Ministerial Meeting, Meeting with Representatives of International Non-Governmental Organizations. Speech (Trieste, Italy). Available at https://archive.epa.gov/epapages/newsroom_archive/speeches/1e4ce7633567acd38525701a0052e36c.html. Accessed March 13, 2017.