Ralph J. Cicerone

1943–2016

BIOGRAPHICAL *Memoirs*

A Biographical Memoir by
Barbara J. Finlayson-Pitts,
Diane E. Griffin,
V. Ramanathan,
Barbara Schaal,
and Susan E. Trumbore

NATIONAL ACADEMY OF SCIENCES

RALPH JOHN **CICERONE**

May 2, 1943–November 5, 2016

Elected to the NAS, 1990

By Barbara J. Finlayson-Pitts, Diane E. Griffin, V. Ramanathan, Barbara Schaal, and Susan E. Trumbore

Baseball afficinado; scientific visionary; natural leader; statesman of great integrity; convincer par excellence; half of an incredible team...this is the human treasure that was Ralph J. Cicerone. It is an enormous challenge to capture adequately Ralph's essence and the many ways he left the world a better place. We hope in the following we have some small measure of success in this endeavor.

Ralph Cicerone's is a very American story. His grandparents were immigrants from Italy and he was born in New Castle, Pennsylvania on May 2, 1943. His father, Salvatore, was an insurance salesman who, when working in the evenings, left math problems for Ralph to solve. Ralph, who had a natural affinity for sports, became the first in his family to attend college. At MIT, he was captain of the baseball team while majoring in electrical engineering. Graduating with a B.S. in 1965, he moved to the University of Illinois for his Master's (1967) and Ph.D. (1970) degrees in electrical engineering (minoring in physics). Ralph's start at Illinois proved to be life-changing; while standing in line to register for the class Theory of Complex Variables, he met his future life partner, Carol, and they married in 1967. He would often say she was the academic leader in the family, and they forged a formidable partnership for the next 50 years.

After completing his Ph.D. on ionospheric photoelectrons, he was invited by Andrew Nagy to join the Space Physics Lab at the University of Michigan as a postgraduate researcher. Between 1971 and 1978 at Michigan, Ralph expanded into new areas. In the early 1970s there was concern over the possible adverse consequences of perchlorate emissions into the upper atmosphere from the solid rocket boosters used in space shuttle launches. In a side project with fellow researcher Richard Stolarski, he explored the idea that chlorine atoms, if generated in the upper atmosphere (stratosphere), could lead to destruction of the protective ozone layer. This would happen by initiating a chain reaction in which one chlorine atom could lead to the destruction of many ozone molecules:

$$Cl + O_3 \rightarrow ClO + O_2 \quad (1)$$

$$ClO + O \rightarrow Cl + O_2 \quad (2)$$

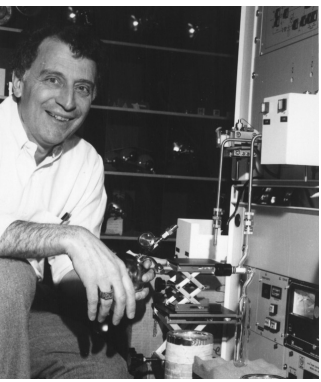
$$\text{Net: } O_3 + O \rightarrow 2\,O_2$$

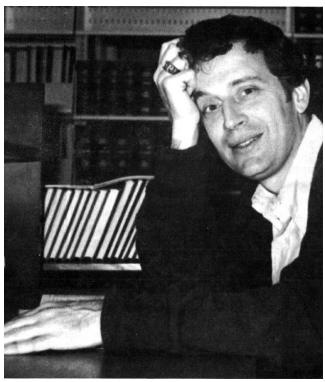
These ideas were presented at a 1973 conference in Canada, and submitted to *Science* shortly thereafter. Although rejected by *Science*, they were published in 1974 in the *Canadian Journal of Chemistry* along with other conference papers. Cicerone and Stolarski subsequently became aware of a paper by Molina and Rowland that was submitted to *Nature* and published there in 1974 that identified man-made chlorofluorocarbons as a source of stratospheric chlorine. Cicerone and Stolarski added a note in proof to their *Canadian Journal of Chemistry* paper regarding the *Nature* paper. The Cicerone/Stolarski paper was cited as a seminal contribution to the 1995 Nobel Prize awarded to Molina, Rowland, and Crutzen for their research in the role of chlorofluorocarbons and nitrous oxide in the destruction of stratospheric ozone.

The research into ozone destruction began as a side project for Cicerone and Stolarski. This was Ralph's first foray into atmospheric chemistry, part of a life-long pattern of applying his keen intellect to problems that intersected different fields and disciplines. Ralph always credited his training in electrical engineering with fostering a "systems thinking" approach that benefitted his ability to frame problems in the Earth system. An example of the success of this approach came when the American Geophysical Union recognized Ralph with its James B. Macelwane Medal in 1979. The Macelwane Medal is an award given to early career scientists who have made "significant contributions to Earth and space science." This was unusual for a young scientist who less than a decade earlier had been an electrical engineer!

Ralph left the University of Michigan to follow Carol to her new job as an assistant professor at the University of California San Diego. Ralph was fond of telling the story that when his attempt at becoming an announcer for the San Diego Padres baseball team was unsuccessful, he settled for continuing as a researcher at the Scripps Institution of Oceanography, where he remained for the next three years. There, he continued identifying new and exciting research problems in atmospheric chemistry. In a prescient 1981 review of halogens in the atmosphere, he noted the potential importance of halogen chemistry in tropospheric photochemistry, as well as in the stratosphere. The role of halogens in the oxidation cycle of the lower atmosphere was subsequently explored by

others and is now a well-accepted sub-discipline in the field. It is fascinating that in an essay he wrote at 17 years of age, he said: "The halogen family of elements, chlorine, fluorine, bromine, and iodine, are particularly interesting to me." Little could he know at that time how the halogens would shape his career.





As a researcher and Director of the Atmospheric Chemistry Division at NCAR.

In 1980, Ralph became the Director of the Atmospheric Chemistry Division at the National Center for Atmospheric Research (NCAR) which flourished under his leadership. Carol, by then an internationally known expert on the cognitive aspects of human vision, was at the time a professor at UC San Diego. Together, they decided it was best for their daughter, Sara, if Carol remained at UC San Diego while Ralph and Sara moved to Boulder, Colorado. Their ability to make this open-ended arrangement work for an unanticipated six-year duration is a testament to the strength of their team.

At Scripps and NCAR, Ralph expanded the scope of his research in recognition of the links between changing atmospheric composition and climate. At NCAR, Ralph became a close friend and collaborator of Veerabhadran Ramanathan (known as "Ram"), a pioneering climate scientist, who had shown that CFCs are potent greenhouse gases. Ralph had a deep understanding of the physics and chemistry of climate change science and the two of them co-authored a major study on the radiative forcing of all major anthropogenic trace gases. Ralph began investigating methane, a greenhouse gas that also plays a role in stratospheric ozone destruction and tropospheric chemistry. While the major loss mechanisms for atmospheric methane were reaction with hydroxyl radicals and chlorine atoms, there were many different sources, including those associated with anaerobic fermentation processes occurring in wetlands and microbes living in the guts of livestock and termites, as well as from natural gas emissions to the atmosphere. Methane concentrations were increasing rapidly in the atmosphere, and Ralph teamed with micro-biologist Ronald Oremland to write a seminal paper summarizing what was then known

of the global methane budget. This paper was published in 1988 in one of the first issues of a new American Geophysical Union Journal, *Global Biogeochemical Cycles*.

In the late 1980s, the University of California, Irvine (UCI) held a competition to create new campus programs. One of the winners was a program to bring to the campus a quantitative Geosciences program addressing global questions. F. Sherwood (Sherry) Rowland and then Dean of Physical Sciences Harold Moore approached Ralph to become founding chair of the program in Geosciences. They quickly decided to focus on how humans were altering the Earth at a global scale, and on the consequent impacts. At the same time, Carol Cicerone was offered a faculty position at UCI, bringing to a close their long-distance challenge. Ralph was fond of saying that since Carol received the official offer from UCI first, he was again the trailing spouse.

Ralph rapidly filled the five initial faculty positions, and was proud to note that each faculty member had their Ph.D. in a different discipline, a pattern that held until there were nine faculty. The early faculty recall long and energetic discussions when writing the proposal to become a Department, including whether it should be "Earth System Science" or "Earth Systems Science" or "Earth System Sciences." Ralph's view that the goal was to understand the Earth as an integrated system (singular) encompassing the atmosphere, biosphere, land and oceans, ultimately prevailed.

Founding members of ESS at UCI on becoming a department. Ellen Druffel, Michael Prather, Ralph, Bill Reeburgh, Sue Trumbore, and Darin Toohey.

Ralph's leadership, especially his emphasis on hiring faculty who, as he put it, "leave their egos at the door" was essential for the great success of the nation's first Earth System Science Department.

As a leader, Ralph's style was to listen respectfully, absorb different perspectives, and chart a way forward that all understood had given serious consideration to their often-disparate views. His leadership capabilities did not go unnoticed, and he was tapped to become Dean of the School of Physical Sciences, and subsequently the fourth Chancellor of the University of California Irvine.

Installation as Chancellor at UCI.

Even while assuming these time- and energy-consuming positions, Ralph continued to explore new areas of science and mentor students and postdoctoral fellows. He would be in his office early almost every morning to meet with his research group before crossing campus to the Chancellor's office, often stooping to pick up and dispose of any trash he found littering the campus. His students continued research on the sources of methane and methyl halides related to agriculture. This included the role of rice plants, but also involved an investigation of the fate of methyl bromide used as a fumigant to kill pathogens affecting strawberries (then still grown in Irvine.) This work contributed to a growing understanding of the importance of agricultural practices in atmospheric change.

As Chancellor, Ralph's love of baseball and sport reasserted themselves. In high school, Ralph was a member of the golf team, quarterback on the football team, and not only captain of the baseball team, but also of the basketball team. Little did the UCI students know what they were up against in a free throw competition, where he managed to sink 28 consecutive free throws! Ralph's genuine interest in students made him popular, and he would often drop by and visit with a group of students in the cafeteria to chat with them about what they were doing.

Captain of MIT baseball team, throwing the first pitch on Cicerone Field, and visiting with the baseball team, May 19, 2009.

In his time at UC Irvine, Ralph elevated the role of research at UCI, oversaw the appointment of outstanding faculty, and encouraged the involvement of the Orange County community in the life of UCI. Ralph also provided strong scientific leadership, especially on the importance of climate change as a significant and pressing problem. A key example stemmed from a White House request under President George W. Bush for NAS to carry out a review, on an expedited time scale, of the validity of climate change assessments in the 2001 IPCC third assessment report. Bruce Alberts, President of NAS, asked Ralph to chair the committee, which supported the rigor and veracity of the science and conclusions in the IPCC report.

In 2005, Ralph was elected President of the National Academy of Sciences, ultimately serving for two terms. Under his guidance, what might have seemed impossible to many took place: the NAS approved the name change for the Institute of Medicine to the National Academy of Medicine. This facilitated the integration of the NAM report-generating activities into the National Research Council and the unification of the National Academy of Sciences, the National Academy of Medicine and the National Academy of Engineering into "The National Academies of Sciences, Engineering and Medicine." This has been described as the largest change since the founding of the National Academy of Sciences by Abraham Lincoln in 1863, and has positioned the combined academies to better tackle the challenges of this century.

During his tenure as NAS President, along with Barbara Schaal and Diane Griffin who served with him as Vice-Presidents of the Academy, Ralph continued to foster studies on the importance of global environmental and climate change, including potential U.S. responses. He oversaw the start of the Deepwater Horizon research fund. Other studies on K-12 education, graduate student mentorship, the tension between science and creationism, the vulnerability of the electrical grid, the scientific basis of forensic evidence, the assimilation of immigrants in the U.S., and the implications of human gene editing research were all carried out under his leadership. Ralph had wide influence among elected leaders in Washington and played a major role in the AMERICA COMPETES Act.

Throughout his professional career, Ralph supported increasing diversity in the sciences. The ESS department at UCI has maintained a high percentage (30-50%) of women faculty and he mentored and encouraged female students and postdoctoral fellows at a time when the field was overwhelmingly male. Under his leadership at NAS, more slots for election to the Academy were opened up and processes developed to widen the net

With President Obama and OSTP science advisor John Holdren at NAS Annual meeting in 2009.

that was cast for nominations, particularly to women, people of color and younger candidates. This resulted in a significant shift in the membership. For example, women comprised approximately 9% of the NAS membership in 2005 when Ralph became NAS President, but 15% at the end of his term.

Ralph was the epitome of the ideal science communicator, able to explain very complex, multi-faceted and interwoven issues with great authority and amazing clarity. There are few scientists who can communicate so well that one has both a broad understanding of principles and appreciates that the science is far deeper. Ralph was one of that elite group. This skill was an important part of bringing disparate groups together to work for the common good, something that stood him in good stead throughout his career, and especially as President of NAS.

David Attenborough, presenter of BBC natural history programs who was once called the "most trusted man in Britain," credits Ralph with convincing him that climate change is real and that the facts and consequences of climate change deserved airing on Attenborough's program. In an article in *Carbon Brief*, Attenborough says that Ralph's Einstein Award Lecture in 2004 made him aware of the scientific foundations of climate change research and that climate change is an urgent concern.

Another innovative thrust in communication by the NAS is the Science and Entertainment Exchange, conceived by Ralph to put scientific expertise to work so that, for example, makers of movies such as *Black Panther* are advised on scientific veracity.

Ralph accrued so many top honors that listing them would take most of this space. A few include election to the National Academy of Sciences (1990), the American Academy of Arts & Sciences (1991) and the American Philosophical Society (2000). He received the United Nations Environment Program Ozone Award (1997), the Franklin Institute Bower Award and Prize for Scientific Achievement (1999), the American Geophysical Union Revelle Medal (2002), and the World Cultural Council Albert Einstein Award

of Science (2004). He was elected to many foreign academies of science, including the Accademia Nazionale de Lincei of Rome (2005), the Russian Academy of Sciences (2008), the Korean Academy of Science and Technology (2009), the Taiwan Academia Sinica (2010), the Spanish Real Academia de Ciencias (2011) and the Royal Society (2012). In addition, he was awarded Honorary Doctorates by many institutions, including those where he launched his career, the University of Illinois (2015) and the University of Michigan (2014).

Signing the NAS Great Book, with Home Secretary Peter Raven and President Frank Press.

Ralph's quiet and calm manner belied a wonderful sense of humor and "pranksmanship." One favorite story from his time at Irvine was when he learned that Sherry Rowland had taken a short flight on December 31 to achieve 100,000-mile "super-flier" status by the end of the year. Ralph concocted an elaborate scheme for a prank phone call that evening, ostensibly from the airline, to tell Sherry that his flight did not count. He almost had Sherry convinced to run out and take another flight before midnight!

Ralph was an avid reader. He had a large first-edition collection of Perry Mason books, and would browse through old bookstores in search of first editions. He was known to share this hobby with some colleagues, swapping lists and dates read.

Ralph Cicerone was also a proud husband, father, and grandfather. Although he was very humble himself, he clearly reveled in opportunities to speak glowingly about Carol, their daughter Sara, and grandchildren Zoe and Ari. This photograph from a vacation in Carol's home state of Hawaii captures his pride and devotion to his family.

With Sara, Carol, and grandchildren Ari and Zoe on vacation in Hawaii in March, 2012.

Carol's selfless contributions to UCI both as a leading faculty member and as "First Spouse," and to the Academies as an unpaid Ambassador-at-Large cannot be overstated. In the latter roles, she generously set aside her own research career to contribute to the broader institutional goals that have had long-lasting impact. For example, she played a significant role in the restoration of the NAS building, which was recognized by a plaque in the West Court from the NAS Council that honors the Carol-

Ralph team. And her welcoming and kind approach to the Academies staff set a tone that complemented Ralph's and made it a rewarding place to be.

At memorials held to honor Ralph's legacy, there were many insightful and revealing comments and descriptions of Ralph from speakers, as well as communications from others who knew Ralph. To cite just a few:

> *...an accomplished scientist, an inspiring teacher, a visionary leader, and a steady voice of reason even during unsteady times." (Victor Dzau, National Academy of Medicine)*
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> *...a towering intellect, a person of strong convictions and moral courage... not afraid to take a strong stand, but he knew how to do so in a way that resulted in respect and a way forward." (Jane Lubchenco, Oregon State University)*
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> *He always had trouble getting members of the National Academy to serve on NRC committees. He was pleased that I did that. Then he went for my wallet, my ring and my fillings." (Philip Needleman, Washington University)*
>
> *He was not a showy scientist who tried to dazzle by brilliance, yet he accomplished more in science and for science than nearly all his contemporaries." (Martin Rees, Cambridge University and the Royal Society)*
>
> *The NAS presidency is not a job, it is a calling...Ralph's devotion to science and its service to the nation is reminiscent of President Lincoln. Both men were self-effacing yet highly accomplished. And both men sacrificed their health—and their lives—to serve our nation and improve our lives." (Bruce Darling, National Research Council)*
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> *...trust is the glue that holds society's powerful institutions together... to serve the national interest. Trust, however, is an increasingly rare commodity, but Ralph radiated trust in all his relationships to the great benefit of the National Academy, the world of scholarship and our country....Ralph (was)...a national treasure." (Harold T. Shapiro, Princeton University)*

In a characteristic listening mode.

Ralph Cicerone's leadership and skill in advancing humanity's understanding of our planet through innovative scientific discovery will be greatly missed." (Al Gore)

Cicerone had a remarkable—and all too rare—habit of listening and of aiming to maintain a tone of civility, even as the atmosphere around science, and particularly climate science, grew heated and polarized." (Andy Revkin, New York Times)

Ralph was able to logically, and without judgement, establish instant rapport and clearly communicate…I think he could do this even with a fence post (!).....a skilled community builder." (Thomas Tierney, Emeritus UCI Trustee at UCI)

His passion and spirit, endlessly inquisitive, and devoted to breaking barriers, reflect the spirit of our country." (President Barack Obama)

In short, for those of us with the honor of preparing this memoire, Ralph Cicerone exemplified the integrity we expect of the highest scientific achievements along with the ability to select problems that matter and are important for society. His natural ease with people and his own modest origins meant that he treated everyone, from the janitor to President Obama with respect. Ralph was very much in the mode of Rudyard Kipling's poem: "If you can talk with crowds and keep your virtue, Or walk with Kings—nor lose the common touch…." These characteristics, his vision, and his ability to lift people up and encourage them to be their best will endure in what he has passed on to both current and future generations.

Perhaps a quote from Ralph himself captures him best. It was a comment during an interview for a series "Conversations with History" with Harry Kreisler at UC Berkeley. This quote now adorns Croul Hall at UCI, a building that was conceived, designed, funded, and built under Ralph's leadership:

Science is a beautiful pursuit. It allows great freedom and requires great responsibility. It requires self-criticism. It requires perseverance and self-confidence. It is progressive. It is self-correcting.

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