

OBITUARIES

Paul Josef Crutzen

Paul Josef Crutzen, for decades the creative, global leader in atmospheric chemistry, died in Mainz, Germany, on 28 January 2021, after a protracted struggle with Parkinson's disease. Having made astonishing discoveries from Earth's surface to the mesosphere and from the tropics to the poles, Paul profoundly influenced global and national environmental policy, but he never lost his childlike wonder at the natural world, and he delighted in guiding young scientists and students.

Born on 3 December 1933 in Amsterdam to a Dutch father and a German mother, Paul was in grade school during the *Hongerwinter* of World War II; he recalled a nagging belly and neighbors reduced to eating tulip bulbs. After the war, he studied engineering and spent a short time working in bridge construction. In 1954, while on vacation in Switzerland, he met Terttu Soininen, a student of Finnish history and literature at the University of Helsinki who would become his lifelong partner, foil, and inspiration.

In 1958 Paul took a job as a computer programmer at Stockholm University, where his fascination with the atmosphere blossomed. He joined the department of meteorology and earned a PhD in 1968, with Bert Bolin as his adviser, and a DSc in 1973, with John Houghton and Richard Wayne as advisers. His research for both degrees shocked the scientific world.

DNA-based life is possible on Earth's surface only because the atmospheric ozone layer shields us from harmful UV radiation. The approximate amount and location of that ozone has been known since at least 1912, when Charles Fabry and Henri Buisson first measured it, but the chemistry and physics leading to its steady state remained a mystery until Paul's 1970 paper showed that oxides of nitrogen, NO_x , were responsible for most of the destruction and that man-made

pollutants were a threat to life's delicate balance. Paul shared the 1995 Nobel Prize in Chemistry with F. Sherwood Rowland and Mario Molina, who had discovered the role of chlorine compounds in ozone destruction. The Nobel citation reads, "The three researchers have contributed to our salvation from a global environmental problem that could have catastrophic consequences."

After his stint at Stockholm, Paul took a postdoc at the University of Oxford and then moved to Colorado to work at the National Center for Atmospheric Research (NCAR), where he was director of the atmospheric chemistry division when I met him in 1977. He always found time to help us graduate students put our work in perspective and offer insightful guidance. He taught us that even enormously complicated systems usually have key, controlling processes—and it was our job to find them.

Paul loved sports. We played on the NCAR softball team, named the NO_xSO_x . One evening after a game, Paul was being driven back to work—he was too much a theorist to be behind the wheel—when he suddenly shouted, "That's it! That's it!" An agricultural fire had been set to clear away winter wheat stubble. Paul realized that was the solution to the missing source of carbon monoxide in his global model. Biomass burning of tropical forest was indeed the major source of CO and other pollutants, as predicted by his numerical simulation, and is now recognized as a serious threat to global ecosystems and climate.

Ozone has been called the godfather of atmospheric chemistry. In the 1960s ozone in the troposphere, outside large cities, was viewed as a basically inert gas descending from the stratosphere and blowing around until destroyed by contact with Earth's surfaces. Paul and his colleagues proved that photochemistry was not only the dominant sink but also the dominant source for ozone in the troposphere—and subject to adverse changes as man-made pollutants reached global proportions.

In 1980 Paul moved to the Max Planck Institute for Chemistry in Mainz, Germany, where he served as director of the air chemistry division until his retirement in 2000. He issued an early warning about the global climate consequences of nuclear war that inspired work on "nuclear



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winter" and popularized the term Anthropocene to describe the current geological era dominated by humans. He recommended studying geoengineering to avert a climate disaster, but only as a last, desperate measure if humans are unable to shake off their addiction to fossil fuels. He held adjunct professorships at the University of Chicago and the Scripps Institution of Oceanography. With support from an NSF Science and Technology Center, Paul co-led INDOEX (the Indian Ocean Experiment), which showcased the interaction of clouds, chemistry, and climate and brought international attention to the Asian brown cloud.

Approachable, communicative, and modest, Paul once remarked, "You Americans are easily impressed. Someone speaks five languages, and you think he's a genius." He was comfortable speaking in English, French, German, and Swedish, in addition to his native Dutch. But Finnish got the better of him; he lost a bet with Terttu that he could become fluent in it, and he had to give up his beloved spicy foods. Despite his myriad accomplishments, Paul never took himself too seriously. He showed kindness, humility, and a sense of humor that goes with knowing that even if you have added many pieces, the puzzle will never be complete.

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