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F. Sherwood Rowland

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Atmospheric chemist who linked human activity to ozone depletion.

Chlorofluorocarbons (CFCs) were a triumph of the chemical industry and a mere curiosity in atmospheric science when Sherwood (Sherry) Rowland, with his postdoc Mario Molina, recognized in 1973 that these seemingly inert gases posed a threat to Earth's ozone layer. Returning home one evening, Rowland remarked to his wife Joan that the research "is going very well, but it may mean the end of the world".

In their laboratory at the University of California, Irvine, Molina and Rowland had discovered that CFC-11 ($CFCl_3$) and CFC-12 (CF_2Cl_2), then widely used as refrigerants and aerosol propellants, readily absorbed ultraviolet light and broke down to release reactive chlorine. This work was the first step in tracing the causal chain linking industrial production of CFCs with global ozone depletion — and won Rowland and Molina the 1995 Nobel Prize in Chemistry, shared with Dutch chemist Paul Crutzen.

Surrounded by his family at his home in Corona del Mar, California, Rowland died on 10 March, aged 84, from complications of Parkinson's disease. He was born in Delaware, Ohio; his mother was a Latin teacher and his father taught mathematics at Ohio Wesleyan University in Delaware, where Rowland attended college after graduating from high school at 15. When he was old enough, he enlisted in the US Navy. As a lanky athlete, he readily found a home in sports teams in the Navy and later in graduate school at the University of Chicago, Illinois, where he played baseball for the university and for a semi-professional team.

Rowland earned his PhD in nuclear chemistry at Chicago under chemist Willard Libby and was taught by four other faculty members; counting Sherry, all six would later receive Nobel prizes. He met Joan at Chicago, and they moved to take up his early jobs at Princeton University in New Jersey and at the University of Kansas in Lawrence. In 1964, Rowland accepted an offer to start up the chemistry department at a new University of California campus in the then-unbuilt city of Irvine. Later, with atmospheric chemist Ralph Cicerone, he also helped to found the Earth system science department.

The elegance of Molina and Rowland's 1974 *Nature* paper remains impressive to today's atmospheric chemists, who live in a world of satellite observations and supercomputers. Stratospheric chemistry at the time was based on balloon-borne samplers of trace gases and on one-dimensional models that could now easily run on a smart phone.

Nonetheless, the pair measured the ultraviolet cross sections of CFC-11 and -12 in the lab, calculated their photolytic destruction rates in the atmosphere and derived their atmospheric lifetimes as 50–100 years. They reviewed industrial production and emission of CFCs, projected the build-up and release of chlorine atoms in the stratosphere and concluded that ozone depletion

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was likely and would be long-lived, even with remediation. This work has been borne out, in detail, by nearly four decades of research.

Rowland and Molina's work started an environmental movement that began with scientists, led by Rowland, urging the elimination of CFCs. It remains the best success story for global cooperation on a worldwide environmental threat. The activism led to the 1978 ban by the US Environmental Protection Agency on CFC use in aerosol cans, and finally in 1990 to the complete phasing out of CFC production by the Montreal Protocol and its amendments.

In his unwillingness to back down from the implications of his work, Rowland became a role model to many of us, and remains so. This was a threat to some — particularly the CFC industry, but also, less understandably, to some scientific colleagues. For many years, Rowland experienced personal threats as well as irrational attacks on the science.

Rowland's science always stood tall, as did he, and seemed inerrant. He kept up his interests in ozone and environmental policy, but his research moved on. Soon after the ozone hole was discovered over Antarctica, he made major contributions with his graduate student Neil Harris to the detection of ozone depletion over the Northern Hemisphere. This work was crucial in persuading DuPont and other chemical companies to abandon CFCs in favour of hydrochlorofluorocarbons, which are less damaging to the ozone layer.

In the late 1970s, Rowland initiated a programme to monitor background concentrations of various gases, and that continues today. Six of its group members were working in the field when he passed away. His curiosity demanded an objective approach, and so it was when, working with his former student and then fellow professor (D.R.B.), he identified in 1995 that the unusual mix of high ozone and hydrocarbons in Mexico City was due to leaking propane stoves and heaters, rather than traffic. In 2011, he was involved in discussions regarding the mix of atmospheric hydrocarbons resulting from the Deepwater Horizon oil spill in the Gulf of Mexico.

Over almost five decades, Rowland was active in his research lab as well as teaching, playing tennis and having collegial discussions over lunch. When not travelling, he could be seen carrying his briefcase in one hand, with a pile of papers under the other arm, to and from his office. He was a prolific note-taker, filling a notebook in a week. This practice intimidated one of us (M.J.P.), who, while giving a talk at an international conference, first encountered Sherry in the front row, taking assiduous notes and then asking a terrifying, brutal, yet constructive question.

Rowland treated everyone like a colleague. He disarmingly considered questions from any listener with the depth and profundity due a scientific peer. This trait was appreciated by students, friends and family. To Sherry, the question was of foremost importance; it was at the core of his scientific quest. His passing ended a unique career that merged chemistry and atmospheric sciences, leading to a new partnership between science and policy for the protection of our planet. ■

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