

In memory of Perry L. McCarty, seminal founder of Environmental Biotechnology

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Perry L. McCarty 1931–2023

Perry L. McCarty passed away on June 4, at the age of 91. He was a revered leader in Environmental Engineering and Biotechnology.

Dr. Perry L. McCarty passed away peacefully and with his family on June 4, 2023. Perry was a world leader in Environmental Engineering, with special emphasis on Environmental Biotechnology, in which we form partnerships with microbial communities that provide services to make human society more sustainable. I was one of Perry's Ph.D. students, and we worked together on research, service, and publishing throughout my career. I have deep and personal knowledge of how Perry and his students developed the fundamental principles that have allowed Environmental Biotechnology to flourish and advance humans' sustainability.

Academic life and recognition

Perry McCarty earned his B.S. degree in Civil Engineering from Wayne State University in 1953 and his

M.S. and Sc.D. degrees in Sanitary Engineering from the Massachusetts Institute of Technology in 1957 and 1959, respectively. He then joined the faculty at MIT. The turning point for Perry was when Rolf Eliasson recruited Perry to become a professor at Stanford University in 1962. Stanford was just beginning to create its Environmental Engineering program. Perry McCarty brought to Stanford his unique approach that linked microbiological and chemical fundamentals with engineering practice. That focus and Perry's personal style propelled Stanford's Environmental Engineering and Science Program to its "number one" status worldwide. At his passing, Perry was the Silas H. Palmer Professor of Civil Engineering Emeritus.

The accolades for Perry's achievements are many and wide-ranging. At the top of the list are winning the Stockholm Water Prize in 2007, election to the U.S. National Academy of Engineering in 1977, and elevation to Distinguished Member of the American Society of Civil Engineers in 2012. Other special awards are the John and Alice Tyler Prize for Environmental Achievement in 1992 and the Athalie Richardson Irvine Clarke Prize for Outstanding Achievements in Water Science and Technology in 1997. Showing the cross-disciplinary respect for Perry are his elections as a Fellow of the American Association for the Advancement of Science, American Academy of Arts and Sciences, and American Academy of Microbiology. To recognize Perry's unparalleled contributions to all aspects of Environmental Engineering, the Association of Environmental Engineering and Science Professors (AEESP) established the Perry L. McCarty AEESP Founder's Award in 2011.

Forming the bedrock of Environmental Biotechnology

Perry McCarty formed the bedrock for the field of

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Environmental Biotechnology, which today encompasses principles and methods from environmental and chemical engineering, microbiology, molecular biology, microbial ecology, and mathematics. On the scientific side, Environmental Biotechnology is the perfect example of the multi-disciplinarity that Perry embraced and was a hallmark of the Stanford program. On the practical side, Environmental Biotechnology is used today to treat wastewater, generate renewable energy, bioremediate contaminated water and soils, and help improve human health in direct and indirect ways. No one had a greater impact than Perry for establishing mechanistic and quantitative understandings of how microorganisms live and can work to make human society more sustainable.

Perry's earliest work focused on anaerobic processes that can be used for transforming the biochemical oxygen demand (BOD) in wastewaters and biosolids into renewable methane gas. His landmark four-paper series on methanogenic processes, published in *Public Works* in 1964, established the science and technology foundation for anaerobic digestion; this series remains as relevant today as it was in 1964. Later in his career, Perry worked with one of his PhD graduates, Dr. Jaeho Bae of Inha University in South Korea, to develop the Staged Anaerobic Fluidized Bed Membrane Bioreactor (SAF-MBR) process, which makes direct anaerobic treatment of domestic sewage practically possible; it is a means to turn wastewater treatment into a net energy generator. Besides Perry's many publications on the SAF-MBR, he convinced Stanford University to install the system on its Palo Alto campus.

About the time I joined Stanford University as a PhD student (in 1975), Perry embarked on a new research path: bioremediation of hazardous organic compounds in groundwater. I was fortunate to work on Perry's first big project in this area: looking at the fate of organic pollutants after groundwater recharge of treated wastewater effluent. This work ultimately led Perry and his colleagues to make seminal advances in what now are some of the most-prominent areas of Environmental Biotechnology: biofilm kinetics, fate-and-transport in the subsurface, and reductive dechlorination of compounds like trichloroethene (TCE). His ground-breaking work led to the discovery of the only bacterium known to fully dechlorinate TCE to harmless ethene; appropriately, that bacterial species was named for him: *Dehalococcoides mccartyi*.

Around 1970, Perry developed his method of computing the stoichiometry of microbial reactions based on thermodynamics of the electron donor, electron acceptor, carbon source, and nitrogen source. I came to know this method as a Ph.D. student at Stanford. I was flabbergasted by its intellectual insight and practical value. Today, my students and I use it all the time in traditional and novel ways, and it always works! I consider Perry's energetics-and-stoichiometry method to

be the single greatest achievement in Environmental Engineering.

Perry was a prolific contributor to the technical literature. He authored or coauthored more than 350 peer-review publications, which have more than 54,000 citations. His impact on the field is amplified by the two textbooks he coauthored: *Chemistry for Environmental Engineering and Science* (with Clair Sawyer and Gene Parkin) and *Environmental Biotechnology: Principles and Applications* (with me). Both are used worldwide in university classes and in practice.

Immense impact on the environmental community

Perry took many leadership roles within Stanford University. He served as the Director of the Western Region Hazardous Substance Research Center (1989–2002), one of the first research centers in the United States. This center led to many scientific discoveries and technology developments for microbial biodegradation and detoxification of hazardous substances in groundwater. Perry also was Chair of Stanford's Department of Civil and Environmental Engineering from 1980 to 1985. The Perry L. McCarty Directorship of the new Stanford Woods Institute for the Environment, now part of Stanford's Doerr School of Sustainability, was named to honor Perry. Stanford University also declared Perry an "Engineering Hero" in 2016.

Perry provided exceptional service to governments, industries, and other universities. He served on many committees of the U.S. National Research Council and the State of California, where he provided expert guidance on groundwater remediation and wastewater reuse. He also was a high-level expert to China, South Korea, Singapore, and other countries as they sought to expand their water and university infrastructures.

Perry's impact on people in the field is immense. He had about 40 Ph.D. graduates, and his academic family—Ph.D. students, post-docs, grad-students, and great-grand-students—exceeds 1400. His international collaborations also were powerful for advancing Environmental Engineering throughout the world: e.g., Tsinghua University in China; Inha University in South Korea; and Nanyang Technological University in Singapore.

Everlasting love and reminiscence

Perry was born in 1931 in Grosse Pointe, Michigan. As an undergraduate student at Wayne State University, Perry discovered his love of Nature and the power of synthesizing chemistry, biology, and mathematics. This

led Perry to Environmental Engineering, and he never left. Before beginning graduate school at MIT, Perry served in the U. S. Army, where they wisely made him an “intelligence” officer. Perry loved to recollect that he could demand and get meetings with military generals, even though he was a young man, just graduated from college.

Perry had valuable influences beyond engineering and biotechnology. At the top of that list is meeting Martha, his soon-to-be wife. The two were together for 70 happy years, and they had four children.

When Perry received the Stockholm Water Prize in 2007, his citation focused on his pioneering work in developing a scientific approach for design and operation of water and wastewater systems. The citation is true, but it is only the “tip of the iceberg.” Perry was modest, kind, and always interested in furthering the well-being of others: his students, his colleagues, and society in general. Perry was famous around Stanford for his dedication to

teaching, along with his daily blue dress shirt. What stands out for me is the integrity that Perry had for his work and relationships. Perry McCarty was my role model for research and for life. I will dearly miss Perry, but I always will treasure all that he did for me and for all of us.

Conflict of Interests Dr. Bruce E. Rittmann is an Editorial Board Member of *Frontiers of Environmental Science & Engineering*.

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