RETROSPECTIVE

Richard E. Smalley (1943–2005)

W. Wade Adams and Ray H. Baughman

Richard Errett Smalley, who died on 28 October 2005 after a 7-year fight with cancer, unselfishly used his stature and wisdom to inspire a worldwide nanotechnology revolution. His breakthroughs, his inexhaustible enthusiasm for exciting young people about science, and his awakening the world to possible nanotech solutions to the energy crisis have all left an enduring legacy. In only 40 years of applying his powerful intellect to science and technology, his work led to entirely new types of materials and fields of study, revolutionary apparatus for scientific investigations and commercialization, and a deep understanding of behavior on nano and molecular scales. Along the way he shared the 1996 Nobel Prize in Chemistry for codiscovering the soccer-ball shaped C_{60} fullerene molecule.

Born in Akron, Ohio, on 6 June 1943, Smalley's interest in science began in his early teens as he and his mother collected single-cell organisms from a local pond and studied them with a microscope. He learned from his father how to build and fix mechanical and electrical equipment and from his mother mechanical drawing, so that he could be more systematic in design work. Many decades later, Rick's passion for creative design was still evident on his office walls—diagrams showing his most recent improvements on equipment for producing carbon nanotubes. Although his contributions to physics and engineering were landmarks, chemistry was his first love. The detailed periodic table of the elements that he drew on rafters in the attic where he studied as a youngster marked his early fascination with chemistry.

He pursued this love, from undergraduate studies at Hope College and the University of Michigan to the Shell Chemical Company, where he worked as a quality control chemist in a polypropylene plant. Rick said, "These were fascinating days, involving huge volumes of material, serious real-world problems, with large financial consequences." He learned about industrial-scale processes and the importance of efficient catalysts, which were useful much later when he initiated scale-up of carbon nanotube synthesis. After 4 years, he resumed academic studies and earned his Ph.D. in 1973 from Princeton University, focusing on the chemical physics of condensed phase and molecular systems with thesis adviser Elliott Bernstein.

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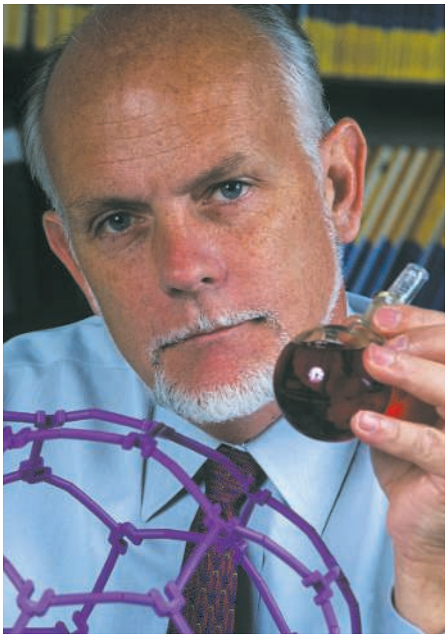

During postdoctoral study with Donald Levy and Lennard Wharton of the University of Chicago, and later with Daniel Auerbach, Rick helped develop a powerful technique: supersonic beam laser spectroscopy. As a result, chemical physicists can now drastically simplify the spectroscopy of complex molecules. Using the coldest part of the expanding gas, researchers could achieve temperatures below 1 K, thereby freezing the rotations of moderate-sized molecules and complexes. After joining the faculty of Rice University in 1976, Smalley worked together with Robert Curl to produce a sequence of pioneering advances applicable for making and characterizing very cold supersonic beams of large molecules, radicals, and atomic clusters having precisely known numbers of atoms.

In August 1985, Smalley and Curl were joined by Harold Kroto from the University of Sussex for a short summer project to study interesting carbon cluster distributions found by Andrew Kaldor at Exxon using an apparatus constructed by Smalley's group. After a legendary late night of taping together cardboard cutouts of hexagons and pentagons on his kitchen table, using Kroto's insights into the importance of five-carbon rings, Smalley presented the carbon "soccer ball" as the only sensible way that 60 carbon atoms could be assembled to produce the observed spectra. A new field of scientific investigation was thus born, and then fueled by a seemingly continuous barrage of exciting new results from both Rick's laboratory and others across the world, which showed the diversity of carbon cage types, how their production could be scaled up, the diverse ways they can be modified, and their novel physical and chemical properties.

In 1993, Rick redirected much of his group's work to carbon nanotubes, which can be viewed as cylindrical versions of the carbon cage molecules, and Rick and his co-workers became leaders in the field. His experimental skills were again critical as his team developed the laser ablation and the high-pressure carbon monoxide processes for making single-walled carbon nanotubes. Rapid worldwide scientific progress was assisted by Rick's providing access to these high-quality nanotubes, first through a non-profit effort at Rice University, and then through the successful company he founded in 1999, Carbon Nanotechnologies, Inc.

Many call Rick the grandfather of nanotechnology. He was the most cited author in nanotechnology in the last decade, and his pivotal scientific and technological breakthroughs have inspired worldwide commercialization efforts. Because of Rick's key role in creating the National Nanotechnology Initiative, he was the only academic invited to the November 2003 Oval Office signing ceremony. His vision of using nanotechnology to help solve the energy crisis and to improve health through nanomedicine is motivating governments to fund effective programs. Many will dedicate themselves to a goal that Rick focused upon during his last 4 years of life: a carbon nanotube quantum wire cable much stronger than steel that would carry a current 10 times as high as that carried by copper wire and weigh one-sixth as much.

With his passing, the world lost a great intellect in chemistry, physics, and engineering, but we also lost a great advocate for science and technology and a great educator and mentor. Robert Curl said that "Rick was a visionary, and his charisma and logic made those he worked with buy into the vision. Rick convinced us that we could be better, stronger, and take more chances if we just tried. I hope that we don't forget—then his legacy…will make a lasting transformative difference." In his humble way, Rick simply said that science and life go on.

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