were found, Val displayed his technical creativity and trained outstanding students.

Val served on the President's Science Advisory Committee in 1970–73, was chair of the Princeton physics department in 1976–81, and was president of the American Physical Society (APS) in 1987 and 1988, the only person since 1932 to serve two years. When an APS panel came under vicious personal attack for a report criticizing the Strategic Defense Initiative, Val rose to the defense, refuting the attackers' technical claims and *ad hominem* diatribes. Val and the report were completely vindicated.

Retirement in 1993 didn't stop him: He led an AGS experiment searching for six-quark states, organized a major conference on Princeton's 250th anniversary, and wrote historical articles on particle physics. We shall never forget Val Fitch, who was by any measure a most exceptional scientist and human being.

James W. Cronin
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Harden Marsden McConnell

Harden Marsden McConnell, a "serial trailblazer" in physical chemistry and biophysics, succumbed to an aggressive cancer on 8 October 2014 in Atherton, California. Throughout his career, he defined and then spearheaded new research directions that resulted in both theoretical and experimental discoveries. Examples include establishing the McConnell equation for electron spin resonance (ESR), inventing spin labeling, and measuring fundamental parameters of lipid membranes.

Harden was born on 18 July 1927 in Richmond, Virginia. After earning his BS in chemistry from George Washington University in 1947, he completed doctoral work in chemistry in 1951 with Norman Davidson at Caltech. During his postdoctoral stint at the University of Chicago with Robert Mulliken and John Platt, he was introduced to powerful new tools of molecular orbital theory. In 1953 Harden joined Shell Oil, which owned one of the first commercial nuclear magnetic resonance (NMR) spectrometers on the West Coast. Through his groundbreaking work, he helped establish NMR as the premiere method for determining the molecular structure and dynamics of organic molecules in solution.

The impact of Harden's work led Davidson, Verner Schomaker, and Jack Roberts to urge Linus Pauling, chair of chemistry at Caltech, to hire "the most exciting chemical physicist on the scene." Years later, German Nobel laureate Manfred Eigen echoed those sentiments with "Das ist der beste Biophysiker, den sie drüben haben" ("that's the best biophysicist they have over there"). Harden joined Caltech in 1956 as an assistant professor.

Harden's seminal 1958 single-author publication "Reaction rates by nuclear magnetic resonance" showed how to modify the Bloch equations to elucidate rate processes and laid the foundation for a new field of measuring reaction rates and conformational changes. Harden's subsequent work in the 1950s provided the foundation for nearly all ESR studies of organic paramagnetic systems: The McConnell equation, $a = Q\rho$, relates a proton's hyperfine splitting a to the spin density ρ in the π orbital of an adjacent carbon. Harden solved a conundrum concerning how hyperfine splitting arises in planar organic free radicals and elucidated the nature of anisotropic hyperfine interactions.

Although difficult to imagine now, the utility of molecular orbital theory was not well established in the early 1950s. Harden's pioneering theoretical work and elegant experimental verification helped establish the emerging theory as a powerful tool for calculating the detailed electronic structure and other properties of organic molecules.

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Harden Marsden McConnell

His interest then turned to the dynamics of paramagnetic spins. Harden was first to recognize that the ESR spectra of ion-radical salts based on tetracyanoquinodimethane were due to triplet excitons. He and coworkers then predicted and experimentally verified the presence of triplet excitons for Wurster's blue perchlorate radicals. Harden's theoretical and experimental studies greatly stimulated the field of solid-state triplet exciton research.

After Harden moved to Stanford University in 1964, he and Shun-ichi Ohnishi cleverly used DNA flowing through a capillary to demonstrate that chlorpromazine radicals intercalate between DNA base pairs. Harden then exploited the superior stability of nitroxide radicals to launch the spin-labeling technique, a now-standard way of characterizing structure and dynamics of biological molecules, particularly hemoglobin and membrane lipids.

Harden's immense contributions to membrane biophysics can be found in most biology textbooks and include the first measurements of lateral fluidity of lipids in membranes, done with Roger Kornberg. Understanding membranes, particularly the role of cholesterol, consumed much of his later career. Harden's 1987 paper on immiscible liquid phases in membranes inaugurated 25 years of his group's discoveries on immiscible liquid phases in membranes and culminated in a paper, published when Harden was 85, that examined diffusion within lipid bilayers near miscibility critical points.

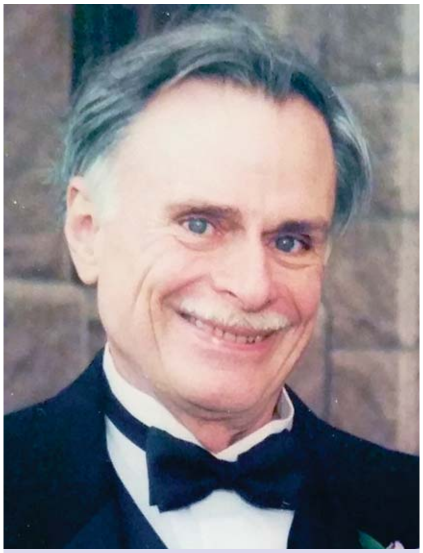
Harden was fearless about entering new fields. His groundbreaking application of physical chemistry tools to immunology became a major research thrust after his 1984 paper provided the first demonstration that the binding of specific peptides to major histocompatibility complex molecules in membranes is sufficient to trigger response from a T cell.

Harden's accomplishments resulted from his drive and focus; he literally dreamt science. He attracted students and postdocs likely to appreciate his intense intellectual investment in them. To thrive in Harden's lab meant to be flattered by remarks like, "You got suntanned. You might know that this causes cancer. It would be better for you to stay in the lab." To the uninitiated, he seemed severe. Gordon Conferences are casual; Harden would have been the only scientist at his conference to wear a tie—if en route he had not also bought a tie for his graduate student. However, colleagues knew he had a sense of humor as deep and dry as his Beefeater martinis. His group members knew his dedication to them; Harden convinced more than one despondent student to finish a dissertation, and he wrote recommendation letters even after being informed of his terminal illness. In total, Harden advised 79 PhD students and 71 postdoctoral fellows. His account of his group's accomplishments is at http://hardenmcconnell.org.

The urgency of time weighed on Harden throughout his life—he had a nervous habit of jingling keys during unstimulating seminars. In the end, he was right. There was not enough time. The day before he died, his characteristically terse and curious email to a former student regarding a manuscript read, "para 2 is not terrible anymore. Anything new?" We miss him profoundly.

Sarah L. Keller
Alvin L. Kwiram
University of Washington
Seattle

John Stewart Waugh



John Stewart Waugh

John Stewart Waugh, a chemical-physics authority recognized as the founder of the field of high-resolution nuclear magnetic resonance (NMR) in solids, died from complications from Alzheimer's disease in Lincoln, Massachusetts, on 22 August 2014.

John was born on 25 April 1929 in Storrs, Connecticut, and was raised near the University of Connecticut, where his father, who sparked his interest in science, was a professor of economics and statistics. After high school, John attended Dartmouth College; he graduated in 1949 with highest distinction in chemistry. He then went to graduate school at Caltech, where his thesis supervisor was Donald Yost and his research focused on a topic discovered about three years earlier—NMR. As part of his thesis, "Line profiles in nuclear magnetic resonance absorption," John assembled a continuous-wave NMR instrument.

After receiving his PhD in chemistry and physics in 1953, John returned to the East Coast to be an instructor in the chemistry department at MIT. He was promoted to assistant professor in 1955 and rose through the academic ranks; in 1989 he became an institute professor, the highest honor that MIT bestows on its faculty.

During his first 15 years at MIT, John focused his research on various intriguing problems in chemistry and physics that arose during the early years of NMR. For example, he explained the anomalous chemical shifts in ^{1}H NMR spectra of aromatic molecules, coupling in strongly interacting spin systems, and relaxation in liquids and gases. In 1968 he introduced a method for using Fourier-transform spectroscopy to measure spin–lattice relaxation times T_1 in complex spin systems. That "inversion recovery" technique remains the method of choice for calculating spin–lattice relaxation rates in gases, liquids, and solids.

In 1966 John and engineer Edward Ostroff, who worked at spectrometer manufacturer Magnion, serendipitously discovered that applying a train of intense RF pulses to a spin system in a solid would extend the length of a free induction decay. That led in 1968 to a series of three articles by John, with various coauthors, on multiple-pulse NMR; those papers laid the foundations for high-resolution NMR in solids. One of them, now famous as the WAHUHA experiment, described the initial suppression of the homonuclear dipolar interactions in calcium fluoride and observation of the underlying chemical shifts and their spatial anisotropy, the feature of NMR spectra that renders the technique so useful to physics, chemistry, and biology.

Equally important, John and Ulrich Haeberlen introduced a theoretical framework to understand the experiments: the average Hamiltonian theory (AHT), an especially powerful form of time-dependent perturbation theory. Today AHT provides the intellectual underpinnings for spin decoupling, recoupling, and many other stimulating ideas in magnetic resonance and other fields. It is considered an intellectual triumph and the most important theoretical approach in the field.

In the early 1970s, John, together with graduate students Alexander Pines and Michael Gibby, published a paper demonstrating that high-resolution NMR experiments could be extended to observe carbon-13, nitrogen-15, phosphorus-31, and other nuclei with smaller dipolar couplings. The experiment's central feature was the transfer of polarization from abundant spins, namely ^{1}H, to the other nuclei. That circumvented the problematic long T_1 of the nuclei. A second feature they incorporated was ^{1}H decoupling, which ensures high resolution. Today that seminal approach to high-resolution NMR is routinely used in labs worldwide.

Subsequently, John and his colleagues combined the experiment with multiple-pulse NMR in a manner that reintroduced high-resolution dipole couplings into NMR spectra. That approach allows measurement of internuclear distances. Integration of magic-angle spinning led to what is today known as dipole recoupling, which permits the determination of protein structures in membranes and amyloid fibrils.

John is remembered fondly for his well-developed sense of humor. He called the method outlined in his seminal paper on multiple-pulse NMR the WAHUHA experiment after the three authors: Waugh, Huber, and Haeberlen. Following the abandonment of "cycles/second" for the hertz in the early 1970s, John rescued "radian/second," the preferred unit in all magnetic resonance calculations, by defining a new unit, the As, so that 1 Hz = 2π As. Aficionados of magnetic resonance use the As to express angular velocity in inverse seconds, or an "Avis."

An avid sailor, John owned many sailboats, including one aptly named *Magic Angle* and a dinghy called *Spin Echo*. With Susan, his wife of 31 years, he sailed the coast of Maine, traveled, and raised a succession of beloved Labrador retrievers.

John Waugh was a towering figure in NMR and electron paramagnetic resonance, and his intellect, achievements, and wonderful sense of humor were an inspiration to those who knew and worked with him. He will be sorely missed by all of us in the magnetic resonance community.

Robert G. Griffin
Massachusetts Institute of Technology
Cambridge ■