obituaries

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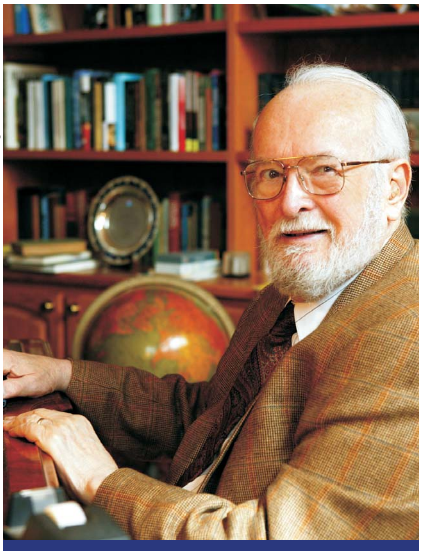
Paul Christian Lauterbur



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Paul Christian Lauterbur

Paul Christian Lauterbur, cowinner with Peter Mansfield of the 2003 Nobel Prize in Physiology or Medicine for their independently developed nuclear magnetic resonance (NMR) imaging methods, died of kidney disease on 27 March 2007 at his home in Urbana, Illinois. His conception and early development of magnetic resonance imaging led to the MRI techniques now used an estimated 15 million times each year for medical diagnosis and for fundamental research ranging from studies of brain function to elucidation of solid-state structures.

Paul was born in Sidney, Ohio, on 6 May 1929 and received his BS in chemistry at the Case Institute of Technology in 1951. He was responsible for many innovative advances in physics and chemistry; his conception of MRI was only one of his accomplishments. Following an early interest in a possible biology based on silicon, he took a job at the Mellon Institute in Pittsburgh, Pennsylvania, with a group supported by Dow Corning to synthesize and test organosilicon compounds and polymers. His research there led him to learn about NMR, which was just beginning to be used in chemistry—an application that was developed further at the Army Chemical Center, where he was assigned during the Korean War.

After military service he returned to Mellon and persuaded the Dow Corning group to purchase an NMR spectrometer to study silicon-29. Despite the low NMR sensitivity and low natural abundance of the isotope, Paul published ^{29}Si NMR spectra in 1956 and soon recognized that carbon-13 NMR would be even more interesting but also more difficult experimentally. Nevertheless, in 1957 he published the first study of ^{13}C NMR in more than 100 compounds. In 1958 he followed with the first NMR spectra of compounds containing tin-119.

Paul was widely known and respected in the NMR community for these innovative studies long before he took the time to get his PhD in 1962 at the University of Pittsburgh. His thesis covered applications of ^{13}C NMR to studies of the electronic structures of molecules. In 1963 Paul accepted a faculty position at the new State University of New York at Stony Brook. He measured chemical shift anisotropies in single crystals and studied ^{13}C-labeled proteins and hydrogen-3-labeled steroids while developing increasing interest in biological applications of NMR.

Paul's research changed dramatically as a result of spending part of the summer of 1971 at NMR Specialties, a small company near Pittsburgh that manufactured a pulsed NMR spectrometer and invited potential customers to use its facilities. Paul observed an interesting experiment being done by Leon Saryan, a postdoctoral fellow from Don Hollis's group at the Johns Hopkins University. Saryan was trying to duplicate and extend work recently published by Raymond Damadian, who had found in tissues excised from rats significant differences in the ^{1}H NMR relaxation times in normal tissue and implanted tumors. Paul reasoned that the information being obtained probably existed in the living animal and might be studied by NMR—if only one could localize the results rather than averaging them over the entire animal. As Paul said in his article in the *Encyclopedia of Nuclear Magnetic Resonance* (Wiley, 1996), "That same evening I realized that inhomogeneous magnetic fields labeled signals according to their spatial coordinates, and made a leap of faith to the conclusion that the information could be recovered in the form of pictures." From long experience operating NMR spectrometers, he realized that the gradient controls normally used to optimize the homogeneity of the magnetic field for a small chemical sample could deliberately be mis-set in a controlled manner to generate linear field gradients along each orthogonal axis. The data could then be back-projected to generate an image. He also calculated that the signal-to-noise ratio from a small volume in a large object would be adequate for reasonable measuring times. Paul went on to say, "I had confidence that whatever physics allowed, engineers could achieve."

After failing to convince various people and institutions that this idea was good enough to patent, Paul did an experiment with a commercial NMR spectrometer at Stony Brook in 1972, using two capillary tubes of water and demonstrating clearly that the idea worked. His seminal paper was published in *Nature* in 1973 (volume 242, page 190). The incentive for his work was the biological application, but typical of his fundamental approach to problems and his appreciation of the basic physics, he focused initially on the anomaly of resolving 1-mm features with an RF wavelength of 5 m (foreshadowing later developments in near-field microscopy). Paul pointed out that his NMR experiment succeeded because of the coupling of the static magnetic field to the RF field. He described this new technique as "zeugmatographic" imaging, from the Greek word *zeugma*, "joining."

This first paper went on to forecast boldly a broad range of potential applications, all of which have now been achieved: pictures of distribution of

Recently posted death notices at http://www.physicstoday.org/obits:

Pierre-Gilles de Gennes
24 October 1932 – 18 May 2007
Walter M. "Wally" Schirra Jr.
12 March 1923 – 3 May 2007
Stanley Bashkin
20 June 1923 – 1 May 2007
Charles Malich
4 February 1919 – 28 April 2007
Leslie Colin Woods
6 December 1922 – 15 April 2007
Michael Stephen
7 April 1933 – 15 April 2007
Gilbert Jerome Perlow
16 February 1916 – 17 February 2007

stable isotopes within an object; images dependent on NMR relaxation times; images of organisms that show soft structures and tissues; in vivo study of malignant tumors based on relaxation times; images displaying chemical compositions or diffusion constants; NMR zeugmatography of solids; electron spin resonance zeugmatography; and internal structures, states, and compositions of microscopic objects. In fact, Paul soon demonstrated many of these applications, including the first image of a living animal (a 4-mm-diameter clam), use of paramagnetic contrast agents, and chemical-shift imaging.

Paul made many further advances in NMR imaging at Stony Brook and at the University of Illinois at Urbana-Champaign, where he moved in 1985. During the past few years, Paul returned to his early interest in the origin of life—this time not in a hypothetical silicon-based biology but in the real world of organic carbon compounds. He described the potential role of molecular imprints and the ways that free-energy-driven processes can lead to molecular evolution.

A book could be written about Paul's curiosity-driven research, his innovative approach to problems, and his many accomplishments only hinted at here. Those of us who knew him as a valued and warm colleague, the next generation of scientists who were inspired by his brilliance and enthusiasm, and the millions who have benefited from the application of his work in medicine are fortunate that Paul Lauterbur passed our way.

Edwin D. Becker
National Institutes of Health
Bethesda, Maryland

Kenneth Ingvard Greisen


RUSS HAMILTON/CORNELL UNIVERSITY

Kenneth Ingvard Greisen

Kenneth Ingvard Greisen, professor of physics emeritus at Cornell University, died of cancer in Ithaca, New York, on 17 March 2007. Greisen's career in experimental cosmic-ray physics extended from his graduate work at Cornell to innovative experiments in the 1960s and 1970s. He will be most remembered for his realization that the cosmic microwave background limits the high-energy end of the spectrum of cosmic-ray protons that travel astronomical distances.

Born in Perth Amboy, New Jersey, on 24 January 1918, Greisen graduated from Franklin and Marshall College in Pennsylvania in 1938. He entered Cornell for graduate work in physics, where he was the first US graduate student of Bruno Rossi. His 1942 PhD thesis was titled "Intensity of Cosmic Rays at Low Altitude and the Origin of the Soft Component." His joint 1941 review article with Rossi, "Cosmic-Ray Theory" in *Reviews of Modern Physics* (volume 13, page 240), was a standard for many years.

From 1943 to 1946 Greisen was a member of the group of physicists who worked on the Manhattan Project at Los Alamos. As one of the leaders of the detonation team, he was an observer at the Trinity test on 16 July 1945. His eyewitness report of that world-changing event is an important historical record. His comment "My God! It worked!" was typical of him.

Greisen returned to Cornell in 1946 as an assistant professor and thus initiated his 40-year career as a physics researcher, physics educator, mentor of students and postdocs, and public servant to the university community.

Greisen's investigations of cosmic rays ranged from using detectors on high mountains and far underground in salt mines to using balloons to send gamma-ray detectors into the high atmosphere. With a gas Cherenkov detector in a 1971 balloon flight, he and his colleagues observed gamma rays from the Crab Nebula that were synchronized with its pulsar.

After the 1965 discovery of the cosmic microwave background, Greisen (and independently Georgii Zatsepin and Vadim Kuzmin) realized that the number of cosmic-ray protons at energies above 6×10^{19} eV is greatly reduced due to interactions with the microwaves. This GZK cutoff would virtually eliminate the highest-energy protons that travel cosmological distances.

Due to the extremely low rate of air showers with energies above 10^{19} eV, detectors of enormous size are required to detect cosmic rays above the GZK limit. Greisen and his group at Cornell designed a method of observing air showers that uses the fluorescent light created as the shower proceeds through the atmosphere. Near Ithaca in 1964–71, they observed the night sky with arrays of phototubes arranged in a "fly's eye" configuration. This method was significantly refined and improved by physicists at the University of Utah and became the basis for the High Resolution (HiRes) Fly's Eye experiment. In March 2007 the HiRes collaboration reported observation of the suppression of cosmic rays with energies above the GZK limit (see PHYSICS TODAY, May 2007, page 17). Fluorescence detectors are one of the two principal components of the Pierre Auger Observatory, currently nearing completion in Argentina to study cosmic rays near and beyond the GZK limit.

Along with Cornell colleagues Philip Morrison and Hans Bethe, Greisen contributed to the work of the MIT-based Physical Science Study Committee (the source of the PSSC high-school physics curriculum) in the late 1950s. In 1969 he presided over a team from the Cornell department of science education and a group of physics colleagues working on a major revision of a 400-student introductory physics course. The result was an innovative, self-paced, auto-tutorial course that retains that format today. His service to the wider Cornell community included a term as university ombudsman from 1975 to 1977 and a term as dean of the university faculty from 1978 to 1983.

In 1971 Greisen cofounded the high-energy astrophysics division of the American Astronomical Society, and he was its first chair. He was elected to membership in the National Academy of Sciences in 1974.

In both the world of physics and the wider world, Greisen displayed a deep sense of responsibility to the people around him. His students and postdocs remember him as a brilliant physicist who was kind and generous and who encouraged them by respecting their competence. At a time when very few women attempted careers in physics, Greisen was exceptionally supportive of those who did.

Greisen enjoyed the outdoors and music; he played the flute and sang in choirs. Following his retirement in 1986, his persistent concern for the welfare of others led him to do volunteer work with various local organizations that served people in the community