



Edwin L. Carstensen, Acoustical Society of America Fellow, Helmholtz-Rayleigh Interdisciplinary Silver Medal recipient, and member of the National Academy of Engineering, died at his home in Rochester, NY, on June 24, 2016.

Born and raised in Oakdale, NE, Ed attended Nebraska State Teachers College from 1938 to 1941. His interest in music and physics led him in 1941 to the Case School of Applied Science for graduate studies. He worked under Robert S. Shankland, but when World War II intervened, in 1942 Ed followed Shankland to the Underwater Sound Reference Laboratory (USRL) in Orlando, FL. His pioneering work on sound propagation through bubbly water (Carstensen and Foldy, 1947) stood him in good stead years later when he encountered bubbles in blood and began studies of cavitation in tissue.

Switching from underwater sound, in 1948 Ed began PhD studies in biophysics at University of Pennsylvania, Philadelphia. Herman Schwan became his mentor. Schwan introduced Ed to tissue biophysics, particularly electromagnetic properties of tissue, and Ed threw acoustics into the mix. The result was another pioneering study on ultrasound absorption in blood, focusing on the role of relaxation (Carstensen and Schwan, 1959). Ed finished his PhD degree in physics in 1955 and spent five years at the Army Biological Laboratory, Fort Detrick, MD, where he worked on the dielectric properties of bacteria. In 1961, Ed joined the faculty of the newly formed Department of Electrical Engineering at the University of Rochester (UR), Rochester, NY, where he remained for the rest of his career.

Although his interest in electromagnetic effects in biology continued, in the late 1960s, Ed made a seminal return to acoustics. Using diagnostic ultrasound, Ed's colleague Ray Gramiak (UR Medical Center) observed strong ultrasound echoes accompanying injection of a radiopaque dye into the heart. Ed and his student Fred Kremkau investigated and determined that tiny bubbles produced by the injection caused the echoes (Kremkau et al., 1970). Thus was born ultra-

sound contrast science. A whole slew of influential studies in biomedical acoustics ensued, for example, the discovery of nonlinear acoustics being responsible for the mysterious effects in biomedical ultrasound experiments (Carstensen et al., 1980); the use of intense ultrasound to produce thermal lesions in tumors (a forerunner of high-intensity focused ultrasound); the effects of ultrasound on the lungs (Child et al., 1990), blood, heart, reproductive organs, kidney, and plants; lithotripsy; and bubblelike lung resonance produced by audiofrequency sound. Much of the research occurred after Ed formally retired as professor emeritus in 1990. Indeed, he continued productive research for the rest of his life. Shear strain in tissue, his passion during his last decade, was the subject of his last paper (Carstensen et al., 2016), a fit valedictory to a life spent uncovering the mysteries of nature.

Ed married Pam McDonald in 1947. Their children, Richard, Allen, Laura, Dee, and Christina, seven grandchildren, and two great-grandchildren survive him.

Selected Articles by Edwin L. Carstensen

- Carstensen, E. L., and Foldy, L. L. (1947). Propagation of sound through a liquid containing bubbles. *The Journal of the Acoustical Society of America* 19, 481-501.
- Carstensen, E. L., and Schwan, H. P. (1959). Acoustic properties of hemoglobin solutions. *The Journal of the Acoustical Society of America* 31, 305-311.
- Carstensen, E. L., Law, W. K., McKay, N. D., and Muir, T. G. (1980). Demonstration of nonlinear acoustical effects at biomedical frequencies and intensities. *Ultrasound in Medicine and Biology* 6, 359-368.
- Carstensen, E. L., Parker, K. J., Dalecki, D., and Hocking, D. C. (2016). Biological effects of low-frequency shear strain: Physical descriptors. *Ultrasound in Medicine and Biology* 42, 1-15.
- Child, S. Z., Hartman, C. L., Schery, L. A., and Carstensen, E. L. (1990). Lung damage from exposure to pulsed ultrasound. *Ultrasound in Medicine and Biology* 16, 817-825.
- Kremkau, F. W., Gramiak, R., Carstensen, E. L., Shah, P. M., and Kramer, D. H. (1970). Ultrasonic detection of cavitation at catheter tips. *American Journal of Roentgenology, Radium Therapy and Nuclear Medicine* 110, 177-183.

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