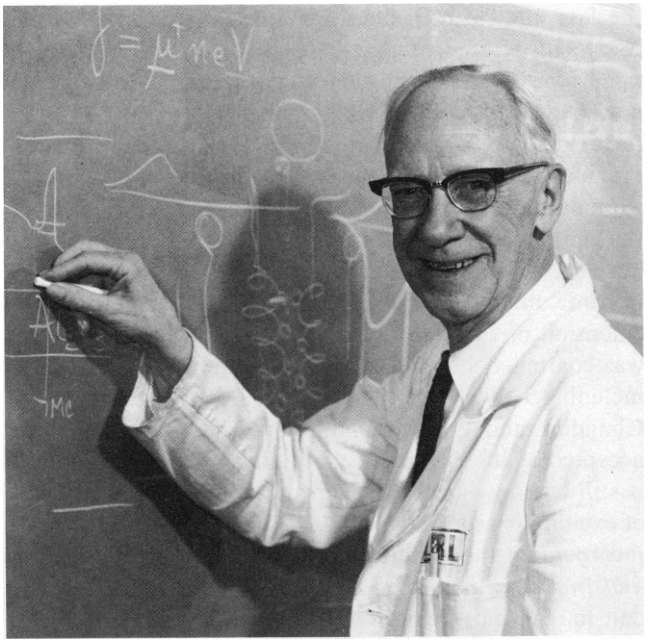
KENNETH S. COLE
1900–1984

The death of Kenneth S. Cole on April 18, 1984, brought to an end the career of a remarkable scientist. He was a pioneer in the application of physical science to biology; he exerted a profound influence on approaches to many biological problems; he was a founding member of the Biophysical Society; he was the recipient of many honors and was much sought after as a consultant. Here there is room only for a brief summary.



"Kacy" Cole was born on July 10, 1900, graduated from Oberlin College in 1922 and received a Ph.D. in physics with F. K. Richtmyer from Cornell University in 1926. He had some early summer training with Hugo Fricke and Irving Langmuir and worked for two summers at the Marine Biological Laboratory in Woods Hole where he was greatly influenced by W. Osterhout and E. N. Harvey. His first research on a biological problem was published, with C. G. Rogers, in 1925 while he was still a graduate student and dealt with the heat production of *Arbacia* eggs. From 1926 to 1928 he was a National Research Council research fellow at Harvard University where he became active in studies of the electrical properties of living cell membranes. He then spent a year in Leipzig, Germany, with Peter Debye. On his return to the United States he became assistant and then associate professor of Physiology at Columbia University where he was also a consultant on physical problems in radiology, surgery, and other branches of medicine. He spent the academic year of 1941 as a Guggenheim Fellow at the Institute for Advanced Study at Princeton where he worked on theoretical aspects of nonlinear electrical properties of excitable membranes. After wartime service at the Metallurgical Laboratory of the University of Chicago where he was in charge of research on the biological effects of ionizing radiation and radioactive materials, he became Professor of Physiology at the University of Chicago and chairman of its Curriculum Committee on Biophysics. From 1949 to 1954 he was Technical Director of the Naval Medical Research Institute in Bethesda, MD, from which he moved across the road to found the Laboratory of Biophysics of the National Institute of Neurological Diseases and Blindness at the National Institutes of Health where he remained as Chief until 1966. During a sabbatical year, 1963–64, he was Regents Professor at the University of California, Berkeley. For the next 10 years he was Senior Biophysicist at the Laboratory, retiring finally in 1976. He then moved to San Diego where he held an honorary appointment and tapered off his professional activities very gradually indeed. During this late period he often referred to himself as a "membrane watcher."

The bulk of his biophysical research was carried out over many summers at the Marine Biological Laboratory. From his early work on the electrical impedance of cell membranes he went on to study the squid giant axon to which he was introduced in the mid-1930's by J. Z. Young. He, H. J. Curtis, and others had measured the impedance of a variety of membranes including muscle, *Nitella*, and the eggs of several species. The important similarities in the findings led to the characterization of cell membranes as having an equivalent circuit consisting of a capacitance of $\sim 1\ \mu f/cm^2$, with a phase angle somewhat $<90°$, and a parallel resistance of the order of $1{,}000\ \Omega cm^2$, and that there was a marked transient decrease in resistance associated with electrical activity. He and his brother, Robert H. Cole, then published this as related to dispersion and

absorption in dielectrics in general, both animate and inanimate. This Cole-Cole plot was also of considerable importance to physical chemists and other physical scientists. In 1945 or 1946 he suggested to J. H. Bartlett voltage clamping the iron wire. The work on squid was extended in the late 1940's to include first, the design, with George Marmont, of a nerve chamber with an electrode arrangement for space clamping. He subsequently developed the now universally known voltage clamp procedure. This in turn led to the development by A. L. Hodgkin and A. F. Huxley of an analysis of the electrical behavior of the squid axon during activity, which permitted them to reconstruct the action potential from the equations that they had developed for sodium and potassium currents as functions of time and membrane potential. The validation and extension of these concepts and their experimental basis was continued step by step with the help of collaborators including J. W. Moore, R. FitzHugh, R. E. Taylor, W. K. Chandler, and W. J. Adelman, Jr. All this is now widely accepted by the scientific community and has led—indeed, is still leading—to further advances in the understanding of excitability and its role in biological activity. Kacy later incorporated the material into his book *Membranes, Ions and Impulses,* published in 1968, a book considered difficult to read but greatly rewarding to those who make the effort. He wrote a number of reviews and book chapters on various aspects of bioelectric phenomena in cell membranes.

He was a member of 25 scientific organizations, both in the United States and abroad. Among these were, for example, the Biophysical Society of which he was a founding member and later president, and the Society of General Physiologists of which he was a charter member and a member of its council. He was a member of the corporation of the Marine Biological Laboratory and was a trustee for a number of years. He was a member of the National Academy of Sciences and a foreign member of the Royal Society of London. The list could be extended to include associations in Brazil, Chile, and France, as well as other American groups. In addition, he served from time to time as a member of committees, boards, councils, etc., for both the government and the scientific community. He was sought after as a distinguished lecturer by many universities. He was the recipient of honorary degrees from Oberlin College, the University of Chicago, and the University of Uppsala, Uppsala, Sweden and received the Bicentennial Silver Medallion from Columbia University. He was made an "Official" of the National Order of the Southern Cross of Brazil in 1967 and was, in the same year, awarded the National Medal of Science by President Johnson. Several publications in his honor have appeared: In 1965, *Physical and Mathematical Approaches to the Study of the Electrical Behavior of Excitable Membranes;* in 1970, *Perspectives in Membrane Biophysics;* in 1975, *Colloquium on Membranes, Ions and Impulses;* and in 1980, *The Biophysical Approach to Excitable Systems.*

In a series of lectures given in 1944 at the Instituto do Biofisica in Rio de Janiero, Brazil, Kacy defined Biophysics as the framing of reasonable physical questions to biological systems. For this activity his talent amounted to genius. Most of his career was in research laboratories and he did relatively little classroom teaching. He had a knack for providing intellectual stimulus to his colleagues, toward whom, as well as his postdoctoral and graduate students, he displayed a great warmth and kindness. He was proud of his rating as an Able-Bodied Seaman, which he acquired in early life aboard a Great Lakes freighter. He was known to all those who worked with him by his loud, cheerful, and tuneless humming as he went about his research activities. He will be greatly missed by his colleagues, former students, and the scientific world.

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