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# SPECIAL SECTION IN MEMORY OF PROFESSOR BRITTON CHANCE

## Celebrating the Life and Legacy of Britton Chance

Photograph by Hide Koizumi, Courtesy of Shoko Nioka and the Johnson Foundation of the University of Pennsylvania.

Britton Chance, an Olympic gold medalist in sailing (Helsinki, 1952), was also one of the best and most legendary sailors in science.

Britton Chance was born in Wilkes-Barre, Pennsylvania, USA on July 24th, 1913. He received a B.S. degree in 1935, an M.S. in 1936 and a Ph.D. degree in Physical Chemistry in 1940, all from the University of Pennsylvania. From Cambridge University he received his second Ph.D. degree in Physiology in 1942, and a D.Sc. (Doctor of Science) degree in 1952. He became a faculty member at the University of Pennsylvania in 1941, and conducted research and teaching there for 70 years. After he became the University Professor Emeritus in 1983, Chance continued active and fruitful research for nearly 30 years till the last few days of his life. He passed away peacefully on November 16th, 2010 at the Hospital of the University of Pennsylvania.

The research activities of Britton Chance spanned from physics, chemistry, engineering, biology, to medicine, and he had set the best example for innovative and high impact research. His innovations had advanced many frontier research fields at the time, with both the development of new methods/devices and the answers to key biological/biomedical questions. In late 1930s to early 1940s he developed the micro stop-flow method for studying fast enzyme−substrate kinetics with visible light. With this method he provided the first direct experimental evidence for the existence of enzyme−substrate complex. He spent five years (1941−1945) in the Radiation Laboratory at Massachusetts Institute of Technology working on radar precision-guiding circuits used for bombers in the World War II. He developed analog electronic computers

for calculating non-linear processes and helped the development of the world's first general purpose computer ENIAC at the University of Pennsylvania. His invention of the dual-wavelength spectrophotometer (1947−1951), which has been widely used for studying biological samples until today, made it possible for many key developments in biochemistry, biophysics, and molecular biology in different labs throughout the world. Since 1950s, he studied the intrinsic fluorescences such as from NADH, flavoproteins and cytochrome in mitochondria and made extraordinary contributions to the understanding of the electron transport and respiration in mitochondria, redox state and metabolic control in biological systems. In 1960s, he identified the first electron tunneling phenomena in biological systems in an experiment using laser to activate photosynthetic bacteria under cryogenic temperature. In 1970s, he discovered hydrogen peroxide generation by the Complex III in mitochondria. This phenomenon, now more widely called the generation of reactive oxygen species, is a key process for many diseases including cancer, diabetes, and aging conditions. In late 1970s, he developed the 3D cryogenic redox scanner for imaging the *ex vivo*/*in vivo* redox state at submicron resolution on the basis of the intrinsic NADH and flavoproteins fluorescence signals in tissue. He was also one of the pioneers carrying out the first *in vivo* $^{31}$P-NMR spectroscopy in intact organ tissues and human subjects for studying tissue bioenergetics and related diseases. The technique was grown into a key component in the magnetic resonance imaging/spectroscopy, widely used in the clinic today.

Britton Chance was regarded as the founder of the biomedical photonics. Since late 1980s Chance and his collaborators had developed various NIR spectroscopy and photon diffusion imaging methods on the basis of the spectroscopic properties of hemoglobin binding oxygen. These methods and related medical devices invented have been used by Chance for various biological applications including the measurement of blood oxygenation, volume and flow, brain function and activities, muscle functions, and cancer detection and diagnosis. Due to his pioneering work, today biomedical photonics has grown into a huge research field spanning physics, biology, and medicine. The innovative work of Britton Chance in more recent years of 2000s included developing novel molecular imaging beacons for cancer detection and diagnosis, predicting cancer aggressiveness by imaging mitochondrial redox state thus linking mitochondrial redox state to tumor progression for the first time, and developing an oral optical metabolometer that may detect changes in nutritional status in human subjects noninvasively. Chance had nearly 1,500 publications indexed by ISI Citation (March 26, 2011) with a total citation of 67,999 times and an average citation of 1,015 times annually. Six of his papers have been cited for more than 1,000 times.

For his scientific achievements Britton Chance had received numerous honors and awards including the Morlock Award of the Institute of Electrical & Electronics Engineers (IEEE) in 1961, the Benjamin Franklin Medal of Franklin Institute in 1966, the Heineken Medal of the Netherlands Academy of Science and Letters in 1970, the Canada Gairdner Award in 1972, the United States National Medal of Science in 1974, the Gold Medal for Distinguished Service to Medicine from the College of Physicians, USA in 1987, the Max Delbruck Prize in Biological Physics of the American Physical Society in 1987, the Gold Medal of the Society of Magnetic Resonance in Medicine, USA in 1988, the Benjamin Franklin Medal for Distinguished Achievement in the Sciences of the American Philosophical Society in 1990, the Christopher Columbus Discovery Award in Biomedical Research of National Institutes of Health, USA in 1992, the American College of Sports Medicine Honor Award, USA in 1999, the International Society for Optical Engineering Lifetime Achievement Award in 2005, the Gold Medal of American Roentgen Ray Society and the Distinguished Achievement Award of American Aging Association in 2006.

Britton Chance was elected as academicians of sciences in six countries: United States, United Kingdom, Sweden, Germany, Italy, and Argentina. He was awarded honorary Ph.D. and M.D. degrees from over ten international institutions. Chance served on numerous scientific societies, councils, committees and advisory boards and he was appointed as honorary president or advisor for a number of organizations. He was on US President Eisenhower's Scientific Advisory Committee from 1959 to 1960. He was the Vice President for American Association for the Advancement of Science in 1966, the Vice President of American Philosophical Society from 1984 to 1990, the President of the International Union of Pure and Applied Biophysics from 1975 to 1979, the President of the International Society of Oxygen Transport to Tissue in 1976, the President for the Society for Free Radical Research International from 1988 to 1990. He was also the

cofounder for Biophysical Society and the cofounder and the Honorary Advisor for the *Journal of Innovative Optical Health Sciences* (JIOHS).

Britton Chance has been regarded as a great teacher, big scientist, precious friend and/or colleague by many people around the world. He has trained numerous students, technicians and postdoctoral fellows. Many of them have become outstanding researchers and/or physicians in wide-ranging biomedical fields from bench to bedside. Since 2007 Chance had traveled to Singapore, Mainland China, and Taiwan to do biophotonic research and promote technology transfer to clinic. His contribution to scientific exchange and cooperation between the West and the East was recognized by China's Friendship Award in 2008 and the International Science and Technology Cooperation Award in 2009.

For the JIOHS special sections dedicated to the memory of Britton Chance, we have received a number of submissions of original biophotonic research papers ranging from basic science to clinical studies. We have also received reviews and/or reflections on the work and life of Britton Chance. Five papers in this issue include a micro-Runman study of muscle physiology by R. Maikala *et al.*, a review on noninvasive probing neurovascular system in bone/bone-marrow with NIR light by T. Binzoni *et al.*, two research papers on integrating NIR technique with MRI for human brain functional study by the group of M. Wolf and for breast imaging *in vivo* by the group of B. W. Pogue, and lastly a paper by P. Kosterin *et al.* on the intrinsic fluorescence changes in nerve terminals modulated by Krebs cycle substrates. More papers will be published in the incoming July issue.

With these special sections we commemorate and celebrate the life and legacy of Britton Chance, and advance the innovative scientific causes Chance had led us to.

*Guest Editor*

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