Dedication: Britton Chance, M.D., Ph.D., D.Sc.

Lin Z. Li, Shoko Nioka, and Kyung A. Kang

Abstract Professor Britton Chance was one of the most outstanding scientists in the world. He was born on July 24, 1913 in Wilkes-Barre, PA, USA and passed away on November 16th, 2010 in Philadelphia at the age of 97. He has left with us

L.Z. Li (✉)
Department of Radiology, University of Pennsylvania, 250 Anatomy Chemistry, Philadelphia, PA 19014, USA

Johnson Research Foundation, Department of Biochemistry and Biophysics, University of Pennsylvania, Philadelphia, PA 19104, USA
e-mail: linli@mail.med.upenn.edu

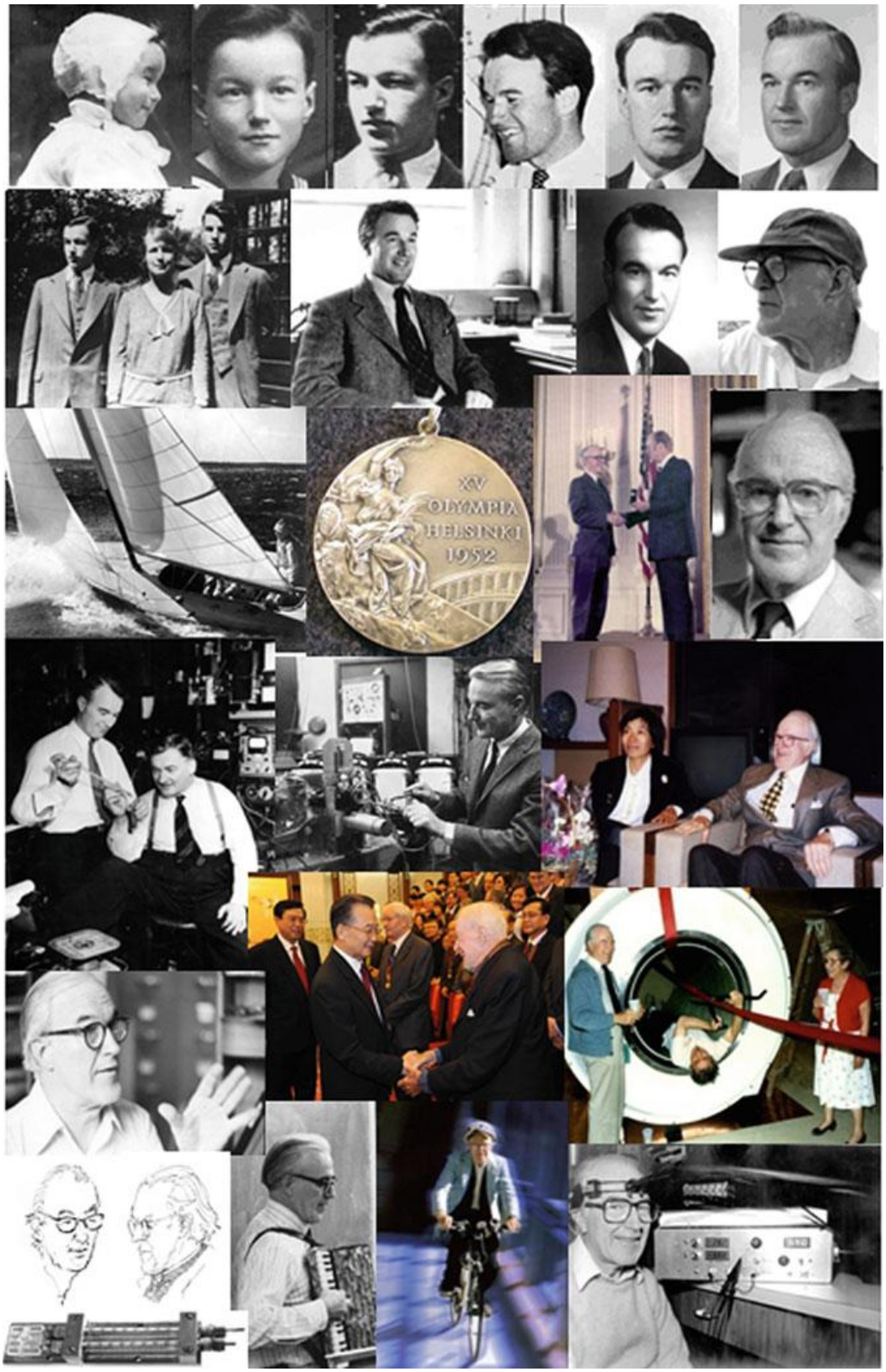
S. Nioka
Johnson Research Foundation, Department of Biochemistry and Biophysics, University of Pennsylvania, Philadelphia, PA 19104, USA

K.A. Kang
Chemical Engineering Department, University of Louisville, Louisville, KY 40292, USA

a tremendous legacy that many other extraordinary human beings cannot match. As a scientist and an engineer, he has invented and developed numerous physical instruments and employed them to answer some of the most pressing research questions in biology and medicine, ranging from enzyme kinetics through bioenergetics and electron transport in mitochondria, reactive oxygen species, quantum tunneling in biology, in vivo NMR, to biophotonics for brain functional studies and the detection, diagnosis, and treatment of diseases. He had a high impact on every major research field in which he worked and was regarded as a founding father for mitochondrial bioenergetics, redox sciences, in vivo NMR, and biophotonics. With his keen capacities in electronics, he worked in the MIT Radiation Lab on precision bombing and radar systems that were used in World War II and contributed to the development of the world's first general purpose computer, ENIAC, at the University of Pennsylvania. As an athlete, he won an Olympic gold medal (5.5 m sailing) in Helsinki in 1952 and several World Championships in the late 1950s–1960s. He was a member of the National Academy of Sciences in the USA and an academician in five other countries. He won the National Medal of Sciences in 1974. As an educator, he tirelessly trained thousands of students and researchers and many of them have become established leaders in various fields of scientific research. He had been an ISOTT member since the founding of the Society and was President of ISOTT in 1976. In his 90s, he traveled to China, Singapore, and Taiwan for various research and educational activities and helped local scientists to develop cutting-edge research projects and institutions. In 2008 and 2009 he received the two highest honors for foreign scientists from the Chinese government.

Keywords Olympic gold medal • radiation lab • mitochondria redox • biophotonics, NMR

Selected Photos of Dr. Chance



The Life, Times and Legacy of Dr. Chance in Science

Education

1935 B.S., University of Pennsylvania, Philadelphia, PA
1936 M.S., University of Pennsylvania, Philadelphia, PA
1940 Ph.D., University of Pennsylvania (Physical Chemistry), Philadelphia, PA
1942 Ph.D., Cambridge University (Biology "B", Physiology), England
1952 D.Sc., Cambridge University, England

Honorary Degrees

1962 M.D., Karolinska Institute
1974 D.Sc., Medical College of Ohio at Toledo
1976 D.Sc., Semmelweis University
1977 D.Sc., Hahnemann Medical College
1985 D.Sc., University of Pennsylvania
1990 D.Sc., University of Helsinki
1991 M.D., University of Dusseldorf
1993 M.D., University of Buenos Aires
1995 M.D., University of Copenhagen
1997 M.D., University Degli Studi Di Roma "Tor Vergata"

Academic Career

1940–1941 Acting Director, E.R. Johnson Foundation, University of Pennsylvania
1941–1949 Assistant Professor of Biophysics and Physical Biochemistry, School of Medicine, University of Pennsylvania, Philadelphia, PA
1949–1977 Professor of Biophysics and Physical Biochemistry, Graduate Group of Biophysics, School of Medicine, University of Pennsylvania, Philadelphia, PA
1964–1975 Professor, Eldridge Reeves Johnson Professor of Biophysics, Department of Biophysics, School of Medicine, University of Pennsylvania, Philadelphia, PA
1949–1975 Chairman, Department of Biophysics and Physical Biochemistry, School of Medicine, University of Pennsylvania, Philadelphia, PA
1975–1983 Professor, Biochemistry and Biophysics, School of Medicine, University of Pennsylvania, Philadelphia, PA
1949–1983 Director, E.R. Johnson Foundation, School of Medicine, University of Pennsylvania, Philadelphia, PA
1982–1990 Director, Institute for Structural and Functional Studies, University City Science Center, Philadelphia, PA

1990–1999	Director, Institute for Biophysical and Biomedical Research, University City Science Center, Philadelphia, and Scientific Director to the President, University City Science Center, Philadelphia, PA
1983–1992	Eldridge Reeves Johnson University Professor Emeritus of Biochemistry and Biophysics and Physical Biochemistry, School of Medicine, University of Pennsylvania, Philadelphia, PA
1998–2006	President, Medical Diagnostic Research Foundation (MDRF), Philadelphia, PA
1983–2010	Eldridge Reeves Johnson University Professor Emeritus of Biochemistry and Biophysics and Physical Chemistry and Radiologic Physics, School of Medicine, University of Pennsylvania, Philadelphia, PA
2007–2010	Professor of Department of Biomedical engineering, Drexel University Philadelphia, PA

Postgraduate Training and Fellowship Appointments

1941–1946	Massachusetts Institute of Technology, Radiation Laboratory: (1941–1945) Research Associate (1941–1945) Group Leader (1942–1945) Associate Division Head (1942–1945) Steering Committee (1945–1946) Editorial Board, Radiation Lab Series (1954–1956) Visiting Committee (Biology)
1941	Office of Scientific Research and Development, Investigator
1946–1948	Guggenheim Fellow, Nobel Institute, Stockholm and Moleno Institute, Cambridge
1966	Foreign Fellow, Churchill College, Cambridge

Special Appointments

1948	U.S.N Consultant to Attaché for Research, London
1948	American Red Cross and National Research Council Committee on Blood and Blood Derivatives
1951–1956	National Science Foundation Consultant (Molecular Biology)
1955–1959	Bartol Research Foundation, Visiting Committee
1959–1960	President's Scientific Advisory Committee
1971–1975	Council Member, National Institute on Alcohol Abuse and Alcoholism
1973	Council Member, Working Group on Molecular Control, National Cancer Institute
1983	NIH Panel Member, Biotechnology Research Resources Program, Division of Research Resources

Awards and Honors

1950	Paul Lewis Award in Enzyme Chemistry, USA
	U.S. President's Certificate of Merit, USA
1954	Harvey Lecturer, The New York Academy of Medicine, USA
1956, 1965	Phillips Lecturer, University of Pittsburgh, PA, USA
1957	Pepper Lecturer, University of Pennsylvania, PA, USA
1961	Morlock Award, Institute of Electrical & Electronics Engineers (IEEE), USA
1965	Genootschapps Medaille, Dutch Biochemical Society, The Netherlands
1966	Keilin Lecturer, England
	Harrison Howe Award, Rochester Section, American Chemical Society, USA
	Franklin Medal, Franklin Institute, Philadelphia, USA
	David P. Hackett Lecturer, University of California, USA
1968	Pennsylvania Award for Excellence (Life Sciences), USA
1969	Philadelphia Section Award, American Chemical Society, USA
1970	Nichols Award, New York Section, American Chemical Society, USA
	Heineken Medal, Netherlands Academy of Science and Letters, The Netherlands
	Redfearn Memorial Lecturer, University of Leicester, England
1972	Gairdner Award, Canada
1973	Post-IUB Symposium on Energy Transducing Membrane Function, Dedicated to B. Chance on the Occasion of his 60th Birthday, Sweden
1974	Semmelweis Medal, Hungary
	National Medal of Science, USA
1975	Presidential Lecturer, University of Pennsylvania, PA, USA
1976	35th Richtmeyer Memorial Lecture of American Association of Physics Teachers, USA
	2nd Julius L. Jackson Memorial Lecture, Wayne State University, USA
	ISCO Award for Significant Contributions Field of Biochemical Instruments, USA
	DaCosta Oration, Philadelphia County Medical College, USA
1978	Phillip Morris Lecturer, USA
1979	Rudolf-Lemberg Memorial Lecture Series, Australia
1980	Distinguished Lecturer, Society of General Physiologists International Congress of Physiological Sciences, Hungary
	Plenary Lecturer, First European Bioenergetics Congress, Urbino, Italy
	Hastings Lecturer, Scripps Clinic & Research Foundation, USA
1981	Plenary Lecturer, VII International Biophysics Congress/II Pan American Biochemistry Congress, Mexico

1981	Radvin Lecturer, American College of Physicians and Surgeons, USA
1984	Troy C. Daniels Lectureship Award, University of California, USA
	IEEE Philadelphia Section Award, USA
	Sober Lectureship Award, American Society of Biological Chemists, USA
	Plenary Lecturer, Pan American Association of Biochemical Societies (PAABS) Congress, Argentina
	Invited Speaker, Symposium on Bioscience, Biomedical Imaging Sponsored by the Takeda Science Foundation, Kyoto, Japan
	Plenary Lecturer, International Symposium on Fast Reactions in Biological Systems, Kyoto, Japan
1986	Elizabeth Winston Lanier Award, American Academy of Orthopedic Surgeons Kappa Delta Awards, USA
	Senior Investigator Award, American Heart Association, USA
1987	Gold Medal Distinguished Service to Medicine, College of Physicians, USA
1987	Biological Physics Prize, The American Physical Society, USA
1988	Gold Medal, Society of Magnetic Resonance in Medicine, USA
1989	J. Henry Wilkinson Award, International Society for Clinical Enzymology, USA
1990	The Benjamin Franklin Medal for Distinguished Achievement in the Sciences, American Philosophical Society
1992	Christopher Columbus Discovery Award in Biomedical Research (National Institutes of Health, USA)
1992	John Scott Medal Award, City of Philadelphia
1995	Stellar-Chance Laboratories, University of Pennsylvania, Philadelphia, PA. Dedicated June 28, 1995
1999	American College of Sports Medicine Honor Award, USA
2003	Senior Science Advisor, International Association of Yan Xin Life Science and Technology
2005	International Society for Optical Engineering (SPIE) Lifetime Achievement Award
2005	ICAS Liberty Award, USA
2006	Gold Medal, American Roentgen Ray Society
2006	Distinguished Achievement Award, American Aging Association
2008	Britton Chance Reading Room, The Library of American Philosophical Society. Dedicated in April, 2008
2008	The Friendship Award, China
2008	The Chime Bell Award, Hubei Province, China
2009	The International Science and Technology Cooperation Award, China

Elections to Honorary Societies

National

1954	National Academy of Science, USA
1954	Harvey Society, New York Academy of Medicine
1955	American Academy of Arts and Sciences, Fellow and Member, Rumford Committee
1958	American Philosophical Society Wistar Association (1969–Present) Secretary (1969) Vice-President (1984–1990)
1959	Biophysical Society, Founder and Councillor (1959–1962)
1957	Society of General Physiologists, Councillor (1957–1960)
1966	American Association for the Advancement of Science, Vice President and Chairman, Section of Medical Sciences
1974	Philadelphia College of Physicians, Fellow
1975	Optical Society of America, Fellow
1989–1990	The Oxygen Society, Honorary President

International

1959	Royal Academy of Arts and Sciences, Member
1960	Royal Society of Arts, Benjamin Franklin Fellow
1968	Royal Swedish Academy of Sciences, Foreign Member Medical Sciences
1970	Bavarian Academy of Sciences, Munich, Member
1971	International Federation of Institutes for Advanced Study, Member of Board of Trustees (1971–1982)
1971	Leopoldina Academy, Halle, Germany
1972	International Union of Pure and Applied Biophysics Vice President (1972–1975) President (1975–1979) Honorary Vice President (1979–2010)
1973	International Society of Oxygen Transport to Tissue President (1976)
1974	Max-Planck-Gesellschaft zur Förderung der Wissenschaften, Foreign Member
1975	Argentine National Academy of Sciences, Member
1987	National Academy of Lincei, Foreign Member
1981	Royal Society (London), Foreign Member
1988–1990	Society for Free Radical Research (International) (SFRR), President

Short Summary of Scientific Contributions

1. Study of enzyme–substrate kinetics and the first experimental demonstration of the existence of an enzyme–substrate complex using the micro stop-flow device he developed.
2. Development of electronic analog calculators and precision targeting radar/computing systems in the World War II and the contribution to ENIAC, the world's first general purpose computer at the University of Pennsylvania.
3. Development of the dual beam (dual wavelength) spectrometer widely used for studying turbid biological samples.
4. In-depth study of the bioenergetics, redox state, and electron transport in mitochondrial respiration.
5. First discovery of the generation of reactive oxygen species (hydrogen peroxide) in mitochondrial metabolism.
6. First experimental demonstration of electron tunneling phenomena in biological systems.
7. Ground-breaking development of in vivo nuclear magnetic resonance spectroscopy and applications for perfused organs, animals, and human subjects (patients and athletes).
8. Founding the field of biophotonics by developing novel near-infrared spectroscopy and imaging methods including time-resolved spectroscopy (TRS), photon diffusion tomography (PDT), and their biomedical applications to study brain functions (fNIR) and various diseases including breast cancer, etc.
9. Development of mitochondrial metabolic/redox state fluorescence imaging (redox scanning) and its biomedical applications such as tumor biomarkers.
10. Invention of a number of scientific instruments, some of which have been widely used in research and industry throughout the world until the present, including the micro stop-flow device, the dual beam (dual wavelength) spectrometer, NADH fluorometer, redox scanner, RunMan, and a handheld NIR breast cancer detector. These instruments have made it possible for many key developments in biochemistry, biophysics, molecular biology, biomedical research, and clinical practice. In addition, he inspired the development of multiple NMR technologies and made important contributions to the instrumentation development for simultaneous optical and multinuclear NMR spectroscopy/imaging studies.
11. Over 1500 manuscripts published. According to ISI Science Citation Indexes accessed on July 10, 2011, the H index of Dr. Chance was 123. He had six papers cited more than 1,000 times, including two on mitochondrial bioenergetics, two papers on hydrogen peroxide, one on the assay of catalases and peroxidases, and one on the time-resolved measurement of tissue optical properties. A review paper on the metabolism of hydrogen peroxide published in 1979 has the highest citation rate at 3,600 times.
12. Contributions to the development of scientific research communities all over the world. He had trained thousands of students, postdocs, and researchers, with

many of them becoming leaders in scientific research. He devoted himself to a Summer Science Program for Minority High School Students in Philadelphia from 1996 to 2006. He tirelessly promoted academic exchanges between the East and West, and supported and facilitated the development of biomedical photonics in Asia, particularly in China, during the last 10 or so years of his life.

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