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CHARLES GLEN KING
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A Biographical Memoir by

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Glenn King

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BY JOHN E. HALVER AND NEVIN S. SCRIMSHAW

CHARLES GLEN KING WAS A brilliant research biochemist, well known in the world for his isolation of vitamin C. Glen, as he was known by his friends, was an active pioneer researcher in the young science of nutrition. Through a series of meticulously designed experiments over a period of 10 years, he pursued and finally isolated crystalline ascorbic acid and proved it was the antiscorbutic factor for guinea pigs, and subsequently for humans. In 1942 after winning fame for his biochemical contributions to nutrition, he became the first director of the Nutrition Foundation. In this capacity he had a unique ability to identify young scientists at the beginning of their career and to provide them support through the Nutrition Foundation for their early research. As president of the International Union of Nutrition Sciences from 1950 to 1953, he introduced a system of commissions and committees that permanently converted it from a passive to a proactive organization. He was uniquely effective nationally and internationally with leaders in both the private and public sector because of his dedication and absolute integrity. King held professorships at the University of Pittsburgh and Columbia University. He received honorary degrees from the University of Pittsburgh, Washington State University, Drexel Institute of Technology, Denison

University, and the University of Lignan. He was elected to the National Academy of Sciences in 1951, and received numerous other honors during a long and distinguished career in nutritional biochemistry.

THE EARLY YEARS

Charles Glen King was born on a homestead in Entiat, Washington, on October 22, 1896. He was raised on an apple farm along the Entiat River, a tributary of the upper Columbia River. He attended one-room schools in Entiat and in Ashland, Kansas, where he lived with an aunt for a number of years on a wheat and corn ranch. He returned to Entiat at age 11 and later went to college in Pullman at Washington State College (now a university). At first he majored in geology but in his junior year he changed his major to chemistry. He also had an active interest in religion. With the onset of World War I he interrupted his studies and volunteered to serve his country in the military in a heavy machine gun company. He was almost 22 years old before he received his bachelor of science in chemistry in 1918 from Washington State College (WSC). At WSC he was president of the Lambda Chi Alpha fraternity and excelled in his academic studies.

He married Hilda Bainton on September 11, 1919, after returning from his Army service with the 12th Infantry Machine Gun Company. They moved to Pittsburgh, Pennsylvania, where their three children, Dorothy King Hammel, Robert Bainton King, and Kendall Willard King were born. Hilda King and Marieta Loren, who was married to a close fraternity friend of Glen's, reared their first children near each other in Pittsburgh. Glen became the godfather of Jane Loren, my wife (J.E.H.). "Auntie Hilda" and Glen insisted that the babies receive fresh orange juice each morning even though vitamin C had not yet been isolated and

crystallized. Glen knew it was an important nutrient for children in 1922 when he started his pursuit to isolate and identify vitamin C.

After receiving his B.S. degree, he moved to the University of Pittsburgh and received his master's degree in chemistry in 1920, and his Ph.D. in organic chemistry in 1923. He served as an instructor in the Department of Chemistry at the University of Pittsburgh from 1920 to 1926. During 1926-1927 he was a postdoctoral associate with W. Sherman at Columbia University in New York City, and he spent six months in 1929 as a postdoctoral associate with F. G. Hopkins at Cambridge, England. He returned to the University of Pittsburgh as assistant professor from 1927 to 1930 and a professor from 1930 to 1942. He received his first research grant from the Buhl Foundation and later formed a group of research faculty in chemistry, biology, and physics. In 1942 he moved to New York City to become director of the Nutrition Foundation. He also became a part-time visiting professor at Columbia University from 1942 to 1946 and a professor in the chemistry department from 1946 to 1962.

THE VITAMIN C STORY

In 1927 Albert von Szent-Györgyi reported a reducing substance similar to hexuronic acid isolated from the adrenal gland. In 1930 R. B. McKinnis and C. G. King published a positive suggestion that hexuronic acid could be vitamin C (*J. Biol. Chem.* 87:615). Glen King and his graduate students H. L. Sipple, O. Bessie, F. L. Smith, W. A. Waugh, and J. L. Svirbely were able to prepare vitamin C concentrates from lemon juice and studied the properties of vitamin C fractions from 1929 to 1931. Otto Bessie, from Montana, did not trust J. L. Svirbely, from Hungary, and on one occasion their disagreements ended in physical blows.

Finally a crystalline compound was isolated and the chemi-

cal nature of vitamin C was reported in *Science* on April 22, 1932. The early announcement on the chemical nature of vitamin C was followed by a more lengthy and descriptive report in the *Journal of Biological Chemistry* by Waugh and King in 1932.

Svirbely, who had been King's graduate student for only one year during the isolation of vitamin C, returned to Hungary and was hired by Szent-Györgyi in 1931 to isolate a reducing factor in the adrenal cortex and in cabbage. He used his experience in King's laboratory to isolate these extracts and fed these preparations to growing guinea pigs. No scurvy developed. Fifteen days after King and Waugh published their isolation and crystallization of vitamin C from lemon juice, Svirbely and Szent-Györgyi announced on May 7, 1932, that vitamin C is a single substance and identical to hexuronic acid. It has been suggested that Szent-Györgyi was the first to isolate vitamin C, however King and his students had isolated and crystallized this compound, and published their results, in advance of the Szent-Györgyi team announcement. In 1937 Szent-Györgyi received the Nobel Prize in physiology or medicine for "his discoveries in connection with the biological combustion processes, with special reference to vitamin C and the catalysis of fumaric acid." It was a lifelong disappointment to King that in Europe Szent-Györgyi was credited with the first identification of vitamin C. Subsequently, Glen King and his research team in the period 1932-1942 published over 50 papers on ascorbic acid characteristics, deficiencies, and enzyme activities in various animal tissues. This work came to fruition when Burns and King reported the synthesis of 1-C^{14}-L-ascorbic acid in *Science* in 1950. Glen continued to pursue the role and functions of ascorbic acid until his last publication dealing with metabolic products of L-ascorbic-acid in 1958.

OTHER FIELDS OF ENDEAVOR

In 1942 Glen King became the director of the Nutrition Foundation in New York City and made it the leading private supporter of nutrition research for the next 21 years. In leaving Pittsburgh for New York he shifted his focus from personal biochemical research and became focused on nutrition and public service. He was responsible for strengthening many nutrition departments in U.S. universities and successfully enlisted industry support in these efforts. He had a remarkable ability to inspire action and consensus in his relations with both industry and academia. As director of the Nutrition Foundation he was extraordinarily effective in obtaining funds from industry and in gaining scientific recognition for this fledgling science.

Glen had high standards for his own research and that sponsored by the Nutrition Foundation. He had a unique capacity to identify promising young nutrition researchers and took a direct personal interest in helping their careers. Several subsequent members of the National Academy of Sciences are indebted for this support. He established the Nutrition Foundation Journal, *Nutrition Reviews*, which was unique at the time and contributed importantly to the development of nutrition research in the United States.

In 1951 he was elected to the National Academy of Sciences and soon became active in the agricultural policy of the United States. He helped establish the U.S. Department of Agriculture's Plant, Soil, and Nutrition Laboratory, in Ithaca, New York. He joined the Advisory Council of the National Institutes of Health's Institute of Arthritis and Metabolic Diseases in 1955. After his retirement from teaching in 1962, he became the associate director of the Institute of Nutrition Sciences at Columbia University. He also began serving as a consultant to the Rockefeller Foundation.

The International Union of Nutritional Sciences elected Glen King as its president in 1960. Glen built up an active network of international commissions and committees to deal with the manifold aspects of nutrition. In 1972 the U.S. National Committee for the International Union of Nutritional Sciences formally expressed its appreciation for his outstanding services over his many years of association with the IUNS and international nutrition programs.

Under his leadership the Nutrition Foundation provided the first research support to the newly established Institute of Nutrition of Central America and Panama (INCAP) and followed this with over 10 years of invaluable service on its Technical Advisory Committee (TAC). From 1951 to 1961, accompanied by Hilda, he went to Guatemala for at least a week every year to participate in the TAC review of the research progress of INCAP in the preceding year. Professional staff members had to present their research for evaluation by the committee. During the 1958 TAC meeting when the president of Guatemala called his name and that of two others at a large formal evening reception in the National Palace to come forward, there was no answer because he and another future National Academy of Sciences member, William Darby, whose name was also called, were still at INCAP finishing the committee report. They missed the reception and received the Order of Rodolfo Robles, Guatemala's highest honor for a scientist, rather unceremoniously the next day. After the TAC meetings, he often visited ministries of health in the other Central American countries in support of INCAP. In his exchanges with ministers and directors of health he inspired confidence and displayed the same effectiveness in promoting nutrition issues with them as he did with the members of his Nutrition Foundation Board.

In 1960 he persuaded the president of the Massachusetts Institute of Technology, who was serving as chairman of Glen's board, to establish a department of food science and technology and appoint the director of INCAP as its first department head(N.S.S.). King later served on the visiting committee of this department and was proud that it proved highly successful and internationally recognized. He also encouraged the development of the Department of Nutrition in the School of Public Health of Columbia University in New York and served on its faculty during his entire time in New York.

He was active on the Food and Nutrition Board of the National Research Council and the U.S. National Committee for the International Biological Program. His 20 years of service involved work on National Research Council activities, the Food and Nutrition Board, the U.S. Committee for the IUNS, and the International Biological Program.

His work, in addition to over 80 vitamin C publications, encompassed studies on fats and oils in human diets, and in microbiology of *Clostridium*. He even worked on electrical pasteurization of milk to minimize bacterial contamination and assure a healthy milk supply. His major scientific reviews covered not only recent advances in vitamin C research nationally and internationally but also many other factors involved in good human health practices. As the field of nutrition and health progressed Glen promoted programs in stabilizing food supplies for essential fats and good quality programs for the developing world. He was vitally interested in proper education of both basic and applied nutrition principles in the world populace and in the application of these in clinical nutrition. Food science and engineering were also on his agenda because he was convinced that nutritionally balanced food preparation was ab-

solutely essential for determining population acceptance for better health and vigorous living.

Glen King served in many other leadership roles that focused on the impact of nutrition on sound health. He was past president of the American Institute of Nutrition, American Society of Biological Chemists, and the American Public Health Association. He was an advisor to the Williams Waterman Foundation, a member of the American Association for the Advancement of Science, the Chemist Club, the Masons, Sigma Xi, and Lambda Chi Alpha fraternity. His contributions to research and public service were recognized by the Pittsburgh Award and the Spenser Award of the American Chemical Society, John Scott Award, Bicentennial Award of the city of Pittsburgh, Conrad Elvehjem Award of the American Institute of Nutrition, Nicholas Appert Medal of the Institute of Food Technologists, Grocery Manufacturers of America Award, and the Gold Medal in Biological Sciences from the Czechoslovakian Academy of Sciences. He held honorary memberships in the American Dietetic Association and the British Royal Society of Health. He felt strongly that dieticians were the logical group of professionals to teach the general population about wholesome nutrition.

One of his most important contributions came during his term as president of the International Union of Nutritional Sciences (IUNS). Activities of this global union had been limited to an international congress every three years. His leadership established a network of commissions and committees that drew in scientists from many countries and made the IUNS an effective international contributor to the development of all aspects of nutrition sciences from the laboratory to the community and from plant and animal nutrition to clinical and public health nutrition. It continues to function through active committees and task forces.

He also guided the incorporation of the IUNS on an equal basis with other major scientific unions in the International Council of Scientific Unions, a real breakthrough in the recognition of nutrition science.

Glen loved the outdoors and gardening. His rose garden at his home in Scarsdale was the envy of neighbors and his pride and joy. He had over 100 rose plants. The peach rose was his favorite.

Throughout his career in pioneering definitive scientific research, he maintained his interest and commitment to the church. He consistently attended services at the First Baptist Church of Pittsburgh and served on its Board of Directors. For 35 years he served as a member and deacon or trustee of the Riverside Church. After retirement in 1974, Glen and Hilda moved to a managed retirement community, Kondal at Longwood, at Kenatt Square, Pennsylvania. After three years of searching for a new church affiliation Glen and Hilda joined the Religious Society of Friends (the Quakers).

Charles Glen King was a brilliant research scientist with a generous and gentle heart and soul. He was always interested in the welfare and promotion of others. As a scientific mentor to many searching investigators, he always advised that "any good scientist has so many ideas he can never complete, that these should be shared or given to others to advance understanding in the field of nutritional biochemistry, physiology, and metabolism." He told one of us (J.E.H.) this in 1950 at his first meeting with Glen King after being hired to start the nutrition research and diet development program for the U.S. Fish and Wildlife Service.

His daughter Dorothy became an accomplished pianst, his son Bob became a physician and, following in his father's footsteps, his son Kendall became a well-known nutrition

scientist in his own right. Kendall served as technical secretary of the Williams-Waterman Committee of the Research Foundation before joining the facultyr at Virginia Polytechnic Institute until his premature death. Glen and his wife, Hilda, were steadfast partners in their dedication to science and service. Glen was not tall and was always slender, but the force of his personality transcended his physical size. He always ate his orange every day to get his vitamin C and to the end was convinced that the U.S. Food and Nutrition Board recommendations for this vitamin were too low. He passed away on January 23, 1988, at the age of 91. His mentorship for humanity will be missed but remains a superb example for any young scientist.

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