

# MEMORIAL RESOLUTION

## ARTHUR KORNBERG

(1918-2007)

Arthur Kornberg, who had a life long love affair with enzymes, died on October 26 surrounded by his wife and three sons and their families and mourned by his extended family of students and colleagues. Only two weeks before, he had been actively working on a review article summarizing years of work on what had become his passion; the biochemistry of polyphosphate or as he lovingly referred to it as polyP.

In his autobiography "For the Love of Enzymes", Arthur described his entry into science and his evolution from clinician to nutritionist to biochemist. He was enormously influenced by the great biochemists of the 1930's and 40's; F.G. Hopkins, Otto Warburg, Otto Meyerhoff and then by Carl and Gerti Cori and Severo Ochoa in whose laboratories he worked after leaving nutrition research. Their work revealed the power of enzyme purification in reconstituting and thereby revealing a pathway of metabolism typified by glycolysis.

He first exploited that approach with insightful success in his investigations of coenzyme, phospholipid and nucleotide biosynthesis. Using what he called "the hammer of enzyme purification" he undertook the very formidable problem of the enzymatic synthesis of DNA. Very early on he discovered the first DNA polymerase and established that DNA synthesis is a template driven process, a finding for which he shared the 1959 Nobel Prize in Physiology or Medicine.

Together with an extremely talented group of students and post docs, he succeeded in recreating an infectious bacteriophage chromosome with purified enzymes, substrates and cofactors, an accomplishment some described as the creation of life in the test tube. Unfazed by that success, his laboratory proceeded to reconstitute the exceedingly complex process of bacterial chromosome replication in vitro. That monumental achievement influenced a generation of biochemists to undertake problems seemingly as intractable as gene expression, signal transduction, intracellular protein transport and many others. The ability to clone, amplify and sequence genes, and the "biological revolution" that followed is in large measure possible because of the polymerases, ligases, nucleases and related enzymes that emerged from these studies.

In the early 1990's Arthur turned from DNA replication to the study of poly P, a subject that had intrigued him since the 1950's when he and his first wife Sylvie isolated an enzyme, polyphosphate kinase (PPK), capable of synthesizing polyphosphate. His studies of poly P and PPK, which as he put it "disinterred a molecular fossil" led to the discovery of poly P's role in bacterial growth and survival, quorum sensing, biofilm formation, virulence, and a wide variety of responses to stress and stringencies. He was convinced that future work would reveal the clinical significance of poly P and its importance in microbial infections.

Arthur's great influence extends well beyond his scientific achievements. Equally influential has been the force of his personality and his considerable expository gifts and the ability to project his ideas as exemplified by his superb textbook "DNA Replication" which educated a generation of molecular biologists. Fred Sanger conceived of the idea for the "dideoxy" DNA sequencing method while reading the chapter on DNA polymerase I in "DNA

Replication". In addition to three editions of "DNA Replication" and "For the Love of Enzymes", Arthur drew on his experience as a founder of the DNAX Research Institute of Molecular and Cellular Biology to write "The Golden Helix: Inside Biotech Ventures." His last book just published entitled "Germ Stories" is a collection of poems originally written for his young children and then his grandchildren that would reveal the wonders and hazards of the microbial world.

Arthur's contributions to science did not go unrecognized. In addition to the Nobel Prize, he was a recipient of the National Medal of Science, the Cosmos Club Award and the Gairdner Foundation Award, among others. He served as President of the American Society of Biological Chemists and was elected to membership in the US National Academy of Sciences, the American Academy of Arts and Sciences, the American Philosophical Society and was a Foreign Member of the British Royal Society. He was also awarded honorary Doctorates from twelve universities.

Arthur revealed his gift as a leader by organizing the Enzymes and Metabolism Section of the National Institute of Arthritis and Metabolic Diseases. He assembled and led an outstanding Department of Microbiology at the Washington University School of Medicine and subsequently organized the Department of Biochemistry at Stanford. Accompanying him in the move to Stanford were Paul Berg, Melvin Cohn, David Hogness, Dale Kaiser and Robert Lehman from Washington University and Robert Baldwin from the University of Wisconsin. It is a tribute to Arthur's leadership that five of the six faculty members who accompanied him from St. Louis in 1959 have remained at Stanford and achieved national renown.

An unusual and much admired arrangement initiated by Arthur at Washington University and maintained at Stanford was mixing the department's graduate students and postdoctoral fellows in common laboratories so as to maximize interaction and collaboration between the various research groups. These interactions were particularly important for promoting interactions among research groups and sharing critical reagents and new methods. This practice greatly facilitated the development of recombinant DNA technology at Stanford.

Arthur was born in Brooklyn, New York on March 3, 1918, the son of parents who had emigrated from Eastern Europe and ran a small hardware store. He graduated from high school at age 15 and entered the City College of New York where he majored in Chemistry and Biology. After receiving an M.D. from the University of Rochester, he interned at the Strong Memorial Hospital then entered the US Public Health Service and served briefly as a ship's doctor during World War II. Arthur's paper on elevated levels of bilirubin in otherwise normal medical students led to his transfer to the National Institute of Health (NIH) and a change from a career in medicine to research in biochemistry.

After a brief period of research when he demonstrated the nutritional requirement for folic acid he sensed the growing excitement of work in intermediary metabolism. That led him to spend brief sabbatical periods in the Cori laboratory at Washington University and with Severo Ochoa at New York University. Returning to the NIH, he organized the Enzymes and Metabolism Section with Bernard Horecker, Leon Heppel and Herbert Tabor.

Arthur's first wife of 43 years, Sylvy Ruth Levy Kornberg, with whom he had three sons died in 1986. He was then married to Charlene Walsh Levering Kornberg and, after her death in 1995 he married Carolyn Frey Dixon Kornberg. Perhaps Arthur's greatest legacy and certainly the one of which he was most proud, was his extraordinary family of three sons and eight grandchildren. His sons are: Roger Kornberg, a Professor of Structural Biology at Stanford,

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winner of the 2006 Nobel Prize in Chemistry, Thomas Kornberg, Professor and Vice-Chairman of Biochemistry and Biophysics at the University of California, San Francisco and Kenneth Kornberg, founder of Kornberg Associates, an architectural firm, that specializes in laboratory design.

On a personal note, both of us knew Arthur for more than fifty years, from the time we joined his laboratory at Washington University as postdoctoral fellows. But our relationships with him went beyond that of student and mentor for we were soon embraced as members of his family and shared many of the special occasions and achievements they celebrated. Arthur's style of doing science, his passion for experimentation rather than theory and the excitement of discovery inspired us enormously. Each of us remembers the late night calls inquiring about how our experiments had fared after he had left the lab. He was a serious and superb teacher and a generous and compassionate leader. The striking success of the faculty he assembled attests to his gift for forsaking the limelight and actively encouraging, promoting and enabling his colleagues to flourish on their own. Above all, Arthur was especially devoted to his students and colleagues and fiercely loyal to his family and friends. We will miss him greatly.

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