



Richard E. Bellman

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1920–1984

By Solomon W. Golomb

On Friday, May 11, 1984, "A Celebration of the Life and Accomplishments of Professor Richard E. Bellman" was held on the Los Angeles campus of the University of Southern California. His colleagues and friends from around the world gathered to share their memories of this remarkable man. Some of their comments were published by the university as "A Tribute to Richard Bellman." We cannot include them all in this volume, but the following excerpts provide an indication of the extraordinary impact Dick Bellman had in his life and work.

Richard Bellman was a towering figure among the contributors to modern control theory and systems analysis. His invention of dynamic programming marked the beginning of a new era in the analysis and optimizations of large-scale systems and opened a way for the application of sophisticated computer-oriented techniques in a wide variety of problem areas, ranging from the design of guidance systems for space vehicles to pest control, network routing, and speech recognition.

Richard Bellman was born in Brooklyn, New York, on August 26, 1920. He received a B.A. from Brooklyn College in 1941 and an M.A. in mathematics from the University of Wisconsin in 1943.

As part of his service in the U.S. Army, he spent two years

at Los Alamos, where he was a member of a group in the Theoretical Physics Division headed by Dr. R. Marshak. Leaving Los Alamos in 1946, he entered Princeton and completed his work toward a Ph.D. in a record time of three months.

In the immediate postwar years, Princeton was a center of defense-motivated research activity in nonlinear differential equations. As a graduate student at Princeton, Bellman became a member of an inner circle of young mathematicians led by Professor Solomon Lefschetz. His doctoral research under Lefschetz resulted in his first major work, entitled *Stability Theory of Differential Equations*, in 1946. This work was subsequently published as a book by McGraw-Hill in 1953 and is regarded as a classic in its field.

After staying on the faculty of the Mathematics Department at Princeton from 1946 to 1948, Bellman left the east coast to become a member of the faculty of Stanford University in 1948 and then joined the newly established Rand Corporation in Santa Monica, California, in 1953. At Rand, he became interested in the theory of multistage decision processes, which was then emerging as an important problem area in the control of both small-and large-scale systems. His invention of dynamic programming in 1953 was a major breakthrough in the theory of multistage decision processes. This breakthrough set the stage for the application of functional equation techniques in a wide spectrum of fields extending far beyond the problem areas that provided the initial motivation for his ideas.

In addition to his fundamental and far-ranging work on dynamic programming, Richard Bellman made a number of important contributions to both pure and applied mathematics. Particularly worthy of note is his work on invariant imbedding, which by replacing two-point boundary problems with initial value problems makes the calculation of the solution more direct as well as much more efficient. His work on quasi-linearization and its applications to system identification

has led to many results of a practical nature in the study of nonlinear systems.

In recent years, Bellman's research activity focused increasingly on the application of mathematics to medicine and biological sciences. His interest in these and related areas reflected his strong conviction that mathematics should not be content with being a beautiful castle with no bridges to the real world. There was a time when Bellman's outspoken criticisms of the elitist attitudes of the mathematical establishment were greeted with hostility and derision. Today, when pure mathematicians are experiencing difficulties in finding suitable jobs, many of those who disagreed with Bellman will concede that he was right.

Bellman left the Rand Corporation in 1965 to join the faculty of the University of Southern California, where he held joint appointments as professor of mathematics, electrical engineering, and medicine—appointments he held until his death on March 19, 1984. A prolific writer, he authored over six hundred published research papers, approximately forty books, and several monographs.

Richard Bellman's fundamental contributions to science and engineering won him many honors and worldwide recognition. Prominent among these are the following: first Norbert Wiener Prize in Applied Mathematics, awarded in 1970 jointly by the American Mathematical Society and the Society for Industrial and Applied Mathematics; first Dickson Prize from Carnegie Mellon University in 1970; the John von Neumann Theory Award bestowed in 1976 jointly by the Institute of Management Sciences and the Operations Research Society of America; and the 1979 Institute of Electrical and Electronics Engineers' Medal of Honor in recognition of the invention of dynamic programming.

His honorary degrees include the doctor of science of the University of Aberdeen, Scotland, in 1973; the doctor of laws of the University of Southern California in 1974; and the doctor of mathematics of the University of Waterloo, Canada,

in 1975. He was elected a fellow of the American Academy of Arts and Sciences in 1975, a member of the National Academy of Engineering in 1977, and a member of the National Academy of Sciences in 1983. [*R. E. Larson and L. A. Zadeh*]

In celebrating his life here today, let us also celebrate his good humor and his steadfast determination to produce, to achieve, to give, and to give joyfully, in the face of circumstances that would have overwhelmed and crushed men of lesser caliber. In these superb human qualities, as in his creative work, I firmly believe that Dick Bellman has lived on a level at least the equal of Beethoven. [*Roger Jelliffe*]

Of his great contributions, I think that he would feel that the students he inspired were among the most important; through them his ideas go on and will be expanded to meet the needs of expanding technology and human need. The only function that Richard Bellman could not bound was his own energy and imagination. [*Fleur Mitchell*]

The measure of a man is the number of people whose lives he has influenced and the contributions he has made. Dick Bellman not only influenced the lives of many people, but he had the rare genius to be able to contribute to many fields. [*Alan Rowe*]

Someone said that the Soviet Union is not just another country—it's another world, another planet. And it, indeed, is. But the stars, we might say, continuing the metaphor, are the same on every planet. They shine for everyone and everywhere. Dick was, and is, such a star. His influence in the Soviet Union is deep and profound. His works penetrated many areas of Soviet academia, industry, and economy in general. From the academic point of view, there is not a single university that does not offer courses based on Dick's works. Hundreds of papers continuing Dick's ideas are published annually in Soviet journals. It is hardly possible to find a researcher in the quantitative sciences and engineering unfamiliar with, at least, the term "Dynamic Programming."

Dick's name is probably cited more at Soviet scientific meetings than at American ones. As an indirect proof of this, let me just mention that Dick was invited to be the main speaker at the first, and only, International Congress of Mathematicians held in Russia, in 1966. More than ten of his books have been translated and published in the Soviet Union. No other American scientist has been given such honors in the USSR.

This is one of the trademarks of Dick's creative work: Truly a mathematician of the twentieth century, he viewed a computer as a tool as well as an important source of mathematical work. His results are always practical and easily applicable. Probably, this is why his mathematical discoveries have important engineering implications in such areas as system science, control, communications, bioengineering, etc. The depth and importance of problems considered, the practical applicability, and the timeliness of his works, this is what, in my view, made the largest impact and defined Dick's influence on Soviet science.

Dick gave all of us, his students and friends in every country throughout the world, an ultimate example of scientific creativity and success, personal courage and strength, friendly devotion and support. [*Semyon Meerkov*]

He was contemptuous of the established order and intolerant of mediocrity. He was strikingly handsome, brilliant, and a master of both the spoken and the written word. Clearly, he was a man of towering intellect and almost equally towering ego. But what I could see was that behind the facade of arrogance and bravado was a man who was capable of great kindness, a man who was decent, straightforward and generous in the extreme.

He died at peace with himself. But his ideas will continue to live, and so will the fond memories of all of us who knew him not only as a brilliant thinker and arrogant personality, but, more importantly, as a man of great nobility of character and a warm, thoughtful, caring human being. [*Lofti Zadeh*]

At the time of his death at age sixty-three, Richard Bellman had just completed his autobiography, *The Eye of the Hurricane*, World Scientific Publications, Singapore, 1984. He is survived by his wife, Nina; his son, Eric; and his daughter, Kirstie.

