A Life Sketch

Prof. C. R. Rao

Sc.D. (Cantab), F.R.C.
Padma Vibhushan Awardee, India
Member, National Academy of Sciences, USA.
National Medal of Science Laureate, USA
Eberly Professor Emeritus of Statistics, PSU, USA

Early life:

Calyampudi Radhakrishna Rao (C. R. Rao) was born on 10th September, 1920 in Huvanna Hadagali, Karnataka, India. He is the eighth child in a family of six brothers and four sisters who were raised by his parents, C.D. Naidu and Lakshmikantamma, and was named Radhakrishna following the tradition of naming the eighth child in a family after God Krishna, who is the eighth child. He studied in schools at Gudur, Nuzvid, Nandigama and Visakhapatnam, in Andhra Pradesh and completed his M.A. degree in mathematics at the Andhra University in Waltair, Andhra Pradesh. He did his M.A. degree in statistics from Calcutta University in Kolkata, West Bengal. He received an M.Sc. in mathematics from Andhra University and an M.A. in statistics from Calcutta University in 1943. He was among the first few people in the world to hold a Master's degree in Statistics.

Academic Qualifications:

Rao received MA degree in mathematics with a first class and first rank from Andhra University (1941) and MA degree in statistics from Calcutta University (1943) with a first class, first rank and a record of marks unbeaten till now, and a gold medal. He started working in the ISI at Calcutta as a research scholar in1943. He was invited to work on a project at the Museum of Anthropology and Archaeology at Cambridge University, UK, which required the statistical methodology developed by P.C. Mahalanobis, the founder of ISI. Based on the work he did, he earned his Ph.D. in 1948 from Cambridge University with R.A. Fisher, the father of modern statistics, as his thesis advisor. A few years later, in 1965, the university awarded him the prestigious Sc.D. degree based on a peer review of his research contributions to statistics.

Honorary Doctoral Degrees:

He received 31 Honorary Doctoral Degrees from universities in 18 countries spanning six continents.

Academic career:

Rao worked at the Indian Statistical Institute and the Anthropological Museum in Cambridge before acquiring a Ph.D. degree at King's College in Cambridge University under R.A. Fisher in 1948, to which he added a Sc.D. degree, also from Cambridge, in 1965. He held several important positions, as the Director of the Indian Statistical Institute, Jawaharlal Nehru Professor and National Professor in India, University Professor at the University of Pittsburgh and Eberly Professor and Chair of Statistics and Director of the Centre for Multivariate Analysis at the Pennsylvania State University. As Head and later Director of the Research and Training School at the Indian Statistical Institute for a period

of over 40 years, Rao developed research and training programs and produced several leaders in the field of Mathematics. On the basis of Dr. Rao's recommendation, the Asian Statistical Institute (ASI) now known as Statistical Institute for Asia and Pacific was established inTokyo to provide training to statisticians working in government and industrial organizations.

Among his best-known discoveries are the Cramér–Rao bound and the Rao–Blackwell theorem both related to the quality of estimators. Other areas he worked in include multivariate analysis, estimation theory, and differential geometry. His other contributions include the Fisher–Rao Theorem, Rao distance, and orthogonal arrays. He is the author of 14 books and has published over 400 journal publications. Rao has received over 37 honorary doctoral degrees from universities in 19 countries around the world and numerous awards and medals for his contributions to statistics and science. He is a member of eight National Academies in India, the United Kingdom, the United States, and Italy. Rao was awarded the United States National Medal of Science, the nation's highest award for lifetime achievement in fields of scientific research, in June 2002. The latest addition to his collection of awards is the India Science Award for 2010, the highest honor conferred by the Government of India in scientific domain. He has been the President of the International Statistical Institute, Institute of Mathematical Statistics (USA), and the International Biometric Society. He was inducted into the Hall of Fame of India's National Institution for Quality and Reliability (Chennai Branch) for his contribution to industrial statistics and the promotion of quality control programs in industries.

Positions Held:

He held such prestigious positions as the Director of ISI, Jawaharlal Nehru Professor, and National Professor, all in India, University Professor at the University of Pittsburgh and Eberly Professor of Statistics and Director of the Center for Multivariate Analysis at Pennsylvania State University in USA.

Development of Statistics in India:

As Head and later Director of the Research and Training School at the ISI for a period of over 40 years, Rao developed research and training programs and produced outstanding students which put India not far from the center of the statistical map of the world, and earned for ISI the name of Indian School of Statistics. During this period he also directed the training programs at the International Statistical Educational Center, which led to the development of statistics in the South East Asian region. Rao was the Chairman of a UN Committee, which examined the demand for statistical personnel in Asian countries and recommended the establishment of an Institute for statistical development in South East Asia. On the basis of his recommendation the Asian Statistical Institute now known as Statistical Institute for Asia and Pacific was established in Tokyo to provide training to statisticians working in government and industrial organizations.

C.R. Rao played an important role, under the direction of the doyen of Indian statistics, P.C. Mahalanobis, in setting up state statistical bureaus in different states of India and developing a network of statistical agencies at the district level for collection of data. Together with the Central Statistical Organization and the National Sample Survey in planning of which, C.R. Rao played a significant role, India has one of the best

national statistical systems. He founded the Indian Econometric Society, which has been active in promoting quantitative studies in economics for planning purposes. C.R. Rao was the founder of Indian Econometric Society and Indian Society for Medical Statistics which hold conferences every year to discuss problems of current interest.

Work in USA

C.R. Rao accepted University Professorship at the University of Pittsburgh after he took mandatory retirement from the ISI in India at the age of 60. He worked for eight years at the University of Pittsburgh and moved to the Pennsylvania State University as Eberly Professor of Statistics, where he continues to work as the Director of the Centre for Multivariate Analysis (CMA). The CMA, established at his initiative serves as a meeting place for research workers in multivariate analysis from all over the world. He directed the research work of several students for the Ph.D. degree in USA. He edited a series of Handbooks on Statistics in various fields of applications for the benefits of researchers and consultants.

Contributions to Statistical Theory and Applications:

C. R. Rao is among the world leaders in statistical science over the last six decades. His research, scholarship, and professional services have had a profound influence on theory and applications of statistics. Technical terms such as, Cramer-Rao inequality, Rao-Blackwellization, Rao's Score Test, Isher-Rao and Rao Theorems on second order efficiency of an estimator, Rao metric and distance, Analysis of Dispersion (MANOVA) and Canonical Variate analysis and G-inverse of matrices appear in all standard books on statistics. Cramer-Rao Bound and Rao-Blackwellization are the most frequently quoted key words in statistical and engineering literature. Special uses of Cramer-Rao Bound under the technical term, Quantum Cramer- Rao Boundhave appeared in Quantum Physics. Rao-Blackwellization has found applications in adaptive sampling, particle filtering in high-dimensional state spaces, dynamic Bayesian networks etc. These results have led to contributions of strategic significance to signal detection, tracking of non-friendly planes and recognition of objects by shape. Other technical terms bearing his name appearing in specialized books are Rao's F and U tests in multivariate analysis, Rao's Quadratic Entropy, Cross Entropy and Rao-Rubin, Lau-Rao, Lau-Rao-Shanbhag and Kagan- Linnik-Rao theorems on characterization of probability distributions. Two of his papers, one on estimation leading to many technical terms and key words and another on score test which had a high impact on the development of statistical theory appear in the book Breakthroughs in Statistics: 1889-1990. Rao has made some significant contributions to combinatorial mathematics for use in design of experiments, the most important of which is Orthogonal arrays (OA). The basic paper on the subject appeared in Proc. Edinburgh Math. Soc. (the referee of the paper reported that it is a fresh and original piece of work). The Japanese Quality Control Expert, G.Taguchi made extensive use of OA's (described by Forbes Magazine as "new mantra" for industries), in industrial experimentation. Rao defined a generalized inverse (g-inverse) of a matrix (singular or rectangular) and demonstrated its usefulness in the study of linear models and singular multivariate normal distributions. He is the author of 14 books and about 350 research papers. Three of his books have been translated into several European, Chinese and Japanese languages.

C.R. Rao is an Indian American mathematician and statistician. He is currently professor emeritus at Pennsylvania State University and Research Professor at the University at Buffalo. Rao has been honored by numerous colloquia, honorary degrees, and festschrifts and was awarded the US National Medal of Science in 2002. The American Statistical Association has described him as "a living legend whose work has influenced not just statistics, but has had far reaching implications for fields as varied as economics, genetics, anthropology, geology, national planning, demography, biometry, and medicine." The Times of India listed Rao as one of the top 10 Indian scientists of all time.

Areas of research contributions:

- Estimation theory
- Statistical inference and linear models
- Multivariate analysis
- Combinatorial design
- Orthogonal arrays
- Biometry
- Statistical genetics
- Generalized matrix inverses
- Functional equations

Awards and medals:

- Guy Medal in Gold (2011) of the Royal Statistical Society.
- India Science Award 2010 (the highest award in a scientific field presented by government of India).
- International Mahalanobis Prize (2003) of the International Statistical Institute
- Srinivasa Ramanujan Medal (2003) of the Indian National Science Academy
- President George W. Bush, on June 12, 2002, honored him with the National Medal of Science, the highest award in U.S. in the scientific field, as a "prophet of new age" with the citation, "for his pioneering contributions to the foundations of statistical theory and multivariate statistical methodology and their applications, enriching the physical, biological, mathematical,economic and engineering sciences."
- Padma Vibhushan (2001) by the Government of India
- Mahalanobis Centenary Gold Medal of the Indian Science Congress.
- Wilks Memorial Award (1989) of the American Statistical Association
- Megnadh Saha Medal (1969) of the Indian National Science Academy
- Guy Medal in Silver (1965) of the Royal Statistical Society
- S. S. Bhatnagar Award (1963) of Council of Scientific and Industrial Research
- JC Bose Gold Medal of the Bose Institute
- Gold Medal of the University of Calcutta
- He was also awarded an honorary Doctor of Science by the University of Calcutta in 2003. Also honorary doctorates from a number of universities and institutes around the world.

In his honor:

- The Pennsylvania State University has established C. R. and Bhargavi Rao Prize in Statistics,
- C.R. Rao Advanced Institute of Mathematics, Statistics and Computer Science
- National Award in Statistics established by Ministry of Statisticsand Programme Implementation(MoSPI), Government of India.
- The road from IIIT Hyderabadcrossroads to Alind Factory,Lingampally is named as "Prof. C.R.Rao Road".