Prasanta Chandra MAHALANOBIS
b. 29 June 1893 - d. 28 June 1972

Summary. A father figure in Indian Statistics, Mahalanobis is well-known for his D^2 statistic and pioneering contributions to large scale sample surveys. He is also remembered for his historic role in modernizing the Indian Statistical System, applications including dams and 5 year economic plans and contributions to Statistical Systems of other countries as Chair of the UN Subcommission on Statistics.

A biographer of Mahalanobis has desribed him as a Renaissance man and scientist. He could also be described as a child of a renaissance. In spirit, if not quite in time, his roots may be traced to the Bengal Renaissance, a social and cultural awakening that shook the province of Bengal in nineteenth century India. Prasanta Chandra Manalanobis's grandfather founded, with others, an organization called the *Sadharan Brahmo Samaj* , which was to become a torch-bearer of the Bengal Renaissance. His father, Probodh Chandra, was an active member of this organization. his mother, Nirodbasini, belonged to a family of considerable academic achievements. Into this family, Prasanta Chandra was born on 29 June 1893.

Prasanta Chandra completed his schooling in Calcutta in 1908. In 1912, he graduated with honors in Physics from Presidency College, Calcutta. He went to England in 1915 and completed Tripos in Mathematics and Physics from Kings College, Cambridge. In Part II of the Tripos, he was the only candidate to get a first class in Physics. King's College awarded him a senior research fellowship. Before starting his research, he came to Calcutta for a short vacation, but never returned to England. The war intervened. Also, he had found a teaching job and plenty of other interesting things to do in Calcutta.

Just before Mahalanobis left Cambridge, his tutor, W.H. Macaulay, drew his attention to *Biometrika*. Mahalanobis found the articles interesting, purchased the whole set of available volumes and brought back to Calcutta. A window was opened to a new area of science, permanently changing the direction of his life.

Among his mentors in Calcutta was Acharya Brojendranath Seal, a philosopher and an encyclopaedist, who was also interested in statistics. Seal was to have a lasting influence on Mahalanobis's life and work. In 1917, Seal, who held the Chair of Philosophy in Calcutta University, sought the help of

Mahalanobis in analyzing examination results of the University. Soon thereafter, Mahalanobis met Nelson Annandale, the then Director of Zoological and Anthorpological Survey of India, who had collected anthropometric measurements on Anglo-Indians of Calcutta. Annandale requested Mahalanobis to analyze the data. The results of statistical analyses of a portion of these data resulted in Mahalanobis's first paper on statistics entitled "Anthropological Observations on Anglo-Indians of Calcutta, Part I: Male Stature", published in *Records of the Indian Museum* in 1922. This paper attracted the attention of Sir Gilbert Walker, Director General of Observatories, who requested Mahalanobis to undertake a systematic study of some meteorological problems. This resulted in an important discovery by Mahalanobis that the region of highest control for changes in weather on the surface of the earth was located about 4 kms. above sea-level. Subsequently, he was appointed Meteorologist in the Alipore Observatory and he held this post from 1922 to 1926.

Some of the early statistical studies he undertook were on experimental designs in agriculture. In 1924, he made some important discoveries pertaining to the probable error of results of agricultural experiments, which put him in touch with R.A. Fisher (q.v.). Later in 1926, he met Fisher at the Rothamsted Experimental Station and a close personal relationship was immediately established which lasted until Fisher's death.

At the request of the Indian Government, Mahalanobis undertook some work on prevention of floods in various regions of the country. His findings and recommendations, though often contrary to engineering wisdom of the time, were accepted by the Government and resulted in alleviation of the problem of flooding to a large extent.

In 1927, Mahalanobis spent a few months in Karl Pearson's (q.v.) laboratory in London, during which period he performed extensive statistical analyses of anthropometric data and closely examined Pearson's Coefficient of Racial Likeness (CRL) for measurement of biological affinities. He noted several shortcomings of the CRL and in 1930 published his seminal paper on the D^2-statistic entitled "Tests and measures of group divergence". Mahalanobis's interest in anthropometry remained strong and two large-scale anthropometric surveys were carried out under his direction in the United Provinces and Bengal. Based primarily on the D^2-statistic, many of the important anthropological inferences drawn from the data collected in these surveys have stood the test of time. For example, the conclusion that Bengal Brahmins resemble other castes of Bengal more closely than they resemble

Brahmins from elsewhere in India, has been corroborated by many subsequent studies.

Mahalanobis's contributions to large scale sample surveys are among his most significant and lasting gifts to statistics. He started his work on sample surveys with estimation of area and yield of jute crop in Bengal in 1937. However, it was not easy for him to get these estimates accepted; controversy between him and the advocates of complete enumeration continued for over a decade. Untimately he was able to demonstrate that estimates based on sample surveys were often more accurate than those based on complete enumeration, and that sample surveys could yield estimates with small margins of error within a short time and at a smaller cost than complete enumeration. He made many methodological contributions to survey sampling that included optimal choice of sampling design using variance and cost functions, and the technique of interpenetrating network of sub-samples for assessment and control of errors, especially non-sampling errors, in surveys. The concept of pilot surveys was a forerunner of sequential sampling developed by Abraham Wald, as acknowledged by Wald in his book. In addition to introducing these concepts, Mahalanobis raised important and difficult philosophical questions on random-ness and representativeness of a sample, which remain relevant and challenging even today. He was elected Chairman of the United Nations Sub-Commission on Statistical Sampling in 1947, and held this post until 1951. His tireless advocacy of the usefulness of sample surveys resulted in the final recommendation of this Sub-commision that sampling methods should be extended to all parts of the world. Mahalanobis received the Weldon Medal from Oxford university in 1944 and was elected a Fellow of the Royal Society, London, in 1945, for his fundamental contributions to Statistics, particularly in the area of large-scale sample surveys.

Mahalanobis believed that statistics in an integral part of the dynamics of national planning. He was acutely aware of national problems and national resources. He took a keen interest and played a key role in formulating India's second five-year plan based on the "four-sector model" developed by him. Broad sectoral allocations of employment, capital investment and increment in national income were worked out and then split into detailed targets. Even though national planning seems to have now fallen out of favour, the need for planning in the initial stages of a nation's development is still acknowledged and Mahalanobis's contributions to Indian national planning continue to be held in high esteem by economists. During the last decade of his life, he devised a statistical method, fractile graphical analysis, for comparison of

socio-economic conditions of groups of people. This technique has now been used in many other branches of science.

The year 1931 marks a watershed in the development of statistics in India. From the fledgling Statistical Laboratory formed in the early 1920's by Mahalanobis within the Physics department of Presidency College, he founded the Indian Statistical Institute on 17 December 1931. He persuaded many bright young physicists and mathematicians to join the Institute. They included Raj Chandra Bose, Samarendranth Roy and C. Radhakrishna Rao. He and his wife, Nirmalkumari, poured in all they possessed to establish the Institute on a firm footing. In 1959, by an act of the Indian Parliament, the Institute was declared as an "Institution of National Importance".

Mahalanobis's role as a planner prompted him to play a pioneering role in the organized collection of official statistics. He established the National Sample Survey in 1950 with the objective of providing comprehensive statistics relating to all economic and social aspects on an all-India basis. He helped in the setting up of the Central Statistical Organization in India, an apex body for coordination of statistical activities in India. he was instrumental in the establishment of formal teaching of statistics in many Indian universities and also in the Indian Statistical Institute. In collaboration with the International Statistical Institute, he established an International Statistical Education Centre at the Indian Statistical Institute.

Mahalanobis became the Honorary President of the International Statistical Institute in 1957, and was elected a Fellow of the American Statistical Association in 1961. Throughout his career he received many other academic honors and awards. He received the highest national honor, *Padma Vibhusan* , from the President of India in 1968.

As a scientist Mahalanobis was, above all, a great applied statistician. Statistics was to be used for better understanding and reporting of scientific and engineering data and decision making for welfare of the society. In Mahalanobis's work on prevention of floods, both aspects of statistics, namely, understanding and decision making, come together. On the other hand in his pioneering work on anthropometric variation in India, it is the first aspect that dominates.

In his work as an applied statistician, Mahalanobis was very innovative, often introducing new concepts or methodologies or systematizations. His work on flood control combined innovative data analysis, understanding and modeling natural phenomena, and a systematization of the whole complex analysis which made his recommendations so readily acceptable to the gov-

ernment. The same gift for innovation and systematization are apparent in his work on large-scale sample surveys and planning. For him, theory grew out of a practical need and thus influenced subsequent practical work. He had nothing but contempt for irrelevant, poorly conceived abstraction which he would dismiss as "aerodynamics in a viscous fluid".

As a science organizer (and a thinker on organization of science), Mahalanobis was one of the very best of our time. The fact that Indian contributions to Statistics have been so noteworthy is due to him, more than to anything else. In spite of being close to India's first prime Minister, Pandit Jawaharlal Nehru, and many other national leaders, Mahalanobis was never a part of any establishment. He disliked all forms of bureaucracy in Indian science. He was an organizer with vision who loved innovation and adventure and was ready to take risks. He was an entrepreneur in science.

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