

**Talk by S. Naranan at the lunch hosted by Venil and Sumantran
for his 80th birthday on 21 March 2010 at the Madras Race Club.**

I would like to begin narrating an event I will never forget – actually an embarrassing experience.

About 50 years ago (early 1960's), I was working at the Cosmic Ray Laboratory of the Tata Institute of Fundamental Research (TIFR) in the Kolar Gold Fields. For the inauguration of the new experiment we had built, my senior colleague B.V. Sreekantan had invited our Director Dr. Homi J Bhabha. We had invited many top engineers and officials of the Kolar Gold Fields to attend. At the end of function I had to give the vote of thanks. My speech lasted less than a minute. I simply thanked all the members of the audience for taking the time to attend.

Later, after many years I realized the big bloomer I had committed. While casually mentioning to my father that I gave a vote of thanks, he remarked that it is one of the most difficult tasks. One has to be sure to thank every individual who contributed to the success of the function, by name. Now recalling the KGF inauguration, I realize how naïve I was about 'vote of thanks'. I did not thank by name even Dr. Bhabha, or the top management of the Mines –all busy men – who came for the meeting. More amazing was the fact that no one pointed out my folly, not even Sreekantan or Bhabha. It was as though I did the right thing, which was certainly not true.

So, I am a poor thanks-giver. But now, I thank all of you for attending this excellent lunch hosted by my daughter Venil and her husband Sumantran. I learn that the idea came from Sumantran. Venil tells me she had lot of help from Bhama in arranging the lunch. So, my special thanks to these three.

Sundari persuaded me to give this talk since I have rarely talked to any one about my life as a scientist. At age 80, perhaps it is appropriate that I talked about it a little.

Now, I would like to recall a few memorable moments, “feel-good moments” as a student.

I missed my first rank in my University (Utkal) in Intermediate Science (I.Sc) in 1946 but never knew about it. Fact was that I never cared about my rank. Later, Prof. P.S. Sundaram, a Professor of English, a family friend and a member of the University Academic Council, told me that he tried hard to convince the Council that I deserved to be declared as first rank. The ambiguity about choice for top rank arose as follows. Some colleges offered an extra course, in addition to the compulsory subjects English, Mathematics, Physics and Chemistry, such as Economics and Civics. A student taking the extra course was eligible for bonus marks, which was calculated as the excess over 35 %. So if a student got 50 % in Economics, 15 bonus points would be added to his aggregate marks. But only a few big colleges offered the option and my college was not among them. Prof. Sundaram argued that for the choice of top rank the bonus marks should not be counted. But the Academic Council did not agree and I missed being the top rank. Prof. Sundaram felt so strongly about the injustice done that every time I met him in later years, he would refer to it.

The second memorable moment is my getting the University First Rank in B.Sc in 1948. Unlike many other universities, Utkal had no ‘Main’ or ‘Subsidiary’ subjects: Mathematics, Physics and Chemistry all carried equal weight. I scored high marks in one of the Chemistry papers, Inorganic Chemistry. I learnt that this was responsible for my top rank.

There is an interesting story behind this. The Professor who was the examiner and also set the Inorganic Chemistry question paper gave his report

about students' performance at the Academic Council meeting. He mentioned that there was one very outstanding answer paper from student # 17. My father who attended the meeting (as Prof. of Mathematics) later introduced himself to the Chemistry professor, as the father of # 17.

But how did I score high in Inorganic Chemistry ? Inorganic Chemistry as taught in colleges, was the most boring subject and required memorizing lots of chemical reactions and manufacturing processes. I ignored the subject. But a few months before the exam, I had picked up an Inorganic Chemistry textbook from a vendor of waste paper. (It was one of a few excellent textbooks I bought from the vendor). The book by Caven and Landor was an eye-opener. The subject was propounded in terms of the Periodic Table of Elements, which was actually Modern Physics, and properties of elements and compounds were discussed with reference to the Groups I, II, III, IV to which they belonged. For example, Hydrogen, Lithium, Sodium and Potassium ... would be discussed in the same chapter (Group I) and their properties discussed in terms of valency, chemical bonds etc. I thoroughly enjoyed reading the book, knowing well that it would not be of any help for my exams.

There were no model question papers to test ones preparedness. It just happened that the question paper for Inorganic Chemistry that year, was inspired by the methodology of Caven and Landor! I was just lucky and so scored better relative to other students in that paper.

I was very proud of the reference made by the examiner to my answer paper. It meant more than my getting the first rank.

The third memorable event is my getting first rank in M.Sc.(Physics) in the Benares Hindu Univeristy (BHU) in 1950, but missing the University Gold Medal for all M.Sc. subjects put together. Normally the topper in M.Sc. (Physics) would also win the Gold Medal. One would expect that M.Sc. (Maths) students had better

chances of Gold Medal but unfortunately M.Sc. (Maths) was the last preference for students to enroll and did not attract bright students. But that year (1950) was an exception. I had heard about a brilliant Maths student, one Mishra, who was tipped for the Medal and got it too. He was also from Orissa like me.

Now, I will mention a few memorable events from my professional academic life as a scientist.

I worked in TIFR (Mumbai) for 42 years from 1950 to 1992. The first half was devoted mostly to Cosmic Ray Astrophysics (Experimental). Research in Cosmic Rays was truly an adventure, working at mountain altitudes (Ooty) and in Gold Mines (Kolar). The depths at which we worked in KGF ranged up to 3 km (10,000 ft.) even greater than the altitude of Ooty 2.2 km (7200 ft.). We also worked with detectors under water in the Mettur Dam. The later half of my career was devoted to X-ray Astronomy, a field that burgeoned as a distinct new discipline only in early 1960's. I was in this research from 1967 to 1992, for 25 years. Experiments had to be done with instruments above the atmosphere. We used balloons (up to 40 km), rockets (150-200 km) and satellites (300 km). Huge balloons that can carry a ton of load were flown from Hyderabad, rockets from Thumba near Trivandrum and satellites from Sriharikota. Earlier in my career I worked on experiments launched on rockets and satellites by NASA in the U.S.A. I had the privilege of working with pioneering groups in the forefront of X-ray Astronomy such as M.I.T (Boston), Naval Research Laboratory (Washington D.C.), NASA Laboratories in Washington D.C area and Huntsville, Alabama, and the Max Planck Institute in Munich, Germany. I spent a total of 7 years with the groups. There are numerous memorable events such as the first successful rocket experiment from Thumba, the first successful balloon experiment from Hyderabad and the first successful satellite experiment from Sriharikota. There is a particularly special event: invitation from the Naval Research Laboratory as a

visiting scientist for one year in 1973. NRL's work was mostly classified and only US citizens were admitted. But Dr. Herbert Friedman, Director of Space Science Division of NRL was keen on getting me as a visiting scientist and it took him nearly a year to get the clearance from the Navy.

Now I will talk about my research in areas outside Physics and Astronomy starting from late 1960's. My first foray was in Bibliometrics (also known as Scientometrics or Information Science). Its aim is to study the 'Science of Science' – its growth, practice etc. A well-known law in the field was Bradford's Law. The law is about the distribution of scientific papers in a field (say Immunology) among journals. A large number of journals carried few papers each, whereas a small number of journals carried many papers each. The latter are the core journals. The law is the forerunner of the famous '75%-25% law' in behavioral sciences. For example in Economics: in a group of rich people, 75 % of the total wealth is in the hands of 25 % of the number in the group. I found out that Bradford's Law had a very simple mathematical formulation. The number of journals carrying x number of articles is inversely proportional to x^2 . Such functions – called Power Laws – occur frequently in Cosmic Rays. For example, the number of primary cosmic rays with energy E is inversely proportional to E^2 . This is called the energy spectrum of cosmic rays.

Fermi, the famous nuclear physicist and the 'father of nuclear reactors' had published only one paper in Cosmic Rays – a model for the energy spectrum. I cooked up a model for Bradford's Law on the lines of the Fermi model. Basically Bradford's Law is a consequence of two facts about growth of science: exponential growth in time of the number of journals in a given field of science and concurrently similar growth in the number of papers carried by an individual journal. A short paper on this model was published in Nature in 1970 and it

attracted much attention, particularly in the East European countries. This model of ‘back-to-back exponential growth’ was extended to many other statistical laws in Bibliometrics in a subsequent long paper in the Journal of Documentation in 1971. My daughter Venil told me recently that this is one of my most cited papers.

Soon after my Nature paper, I received an invitation from the President of the Hungarian Academy of Sciences to join the Editorial Board of their journal Scientometrics and also act as a referee for the journal. I politely declined the offer stating that the Nature paper was the only paper I have ever published in the field. (I could not resist comparing myself with Fermi who published only one paper in Cosmic Rays).

My first leap was from Physics to Bibliometrics and then on to Linguistics, DNA sequences, evolutionary genetics, all related to Power Laws. Meanwhile a revolutionary development occurred in 1979 in the field of cryptography, the science of secret codes. I was drawn to it by its very innovative concept based on Number Theory. This led to fascinating studies on coding and Information Theory. A former colleague from TIFR, Dr. V.K. Balasubrahmanyam also got interested and we both collaborated on applying Physics-based models and Information Theory to studies in linguistics, DNA sequences etc. We have jointly published 12 papers between 1992 and 2005.

My retirement from a professional career in 1992 was actually welcome because I could focus more on my interdisciplinary research. The time spent on this has been and continues to be rewarding. For this I am thankful to three different factors: (1) easy access to a top-class library in Matscience (Institute of Mathematical Sciences, Taramani) (2) collaboration with VKB and (3) Prof. Kohler and Prof. Altmann, two German editors of an European Journal, the Journal of Quantitative Linguistics. They wrote to us inviting our contributions to the Journal, after seeing our first two papers on linguistics published in Current

Science in 1992. They have greatly encouraged us in continuing to publish our work and sustain our interest in research in linguistics.

My latest adventure in research is about statistical analysis of failures in solving crossword puzzles. Ten years of patiently accumulated data showed a certain regularity and the statistical function that best describes the data is known as the Negative Binomial Distribution (NBD). Just like Power Laws, NBD also occurs in many areas of behavioral science, e.g. car insurance industry. It was fascinating to realize that a model similar to one in insurance industry about car accidents, will work for the failures in crossword puzzles. I have recently found that NBD has some interesting applications in linguistics too.

Every data collected in general, deserved an understanding and if possible an explanation. Trivial observations can some times lead to profound new ideas. Here the 'curiosity' to understand is the driving factor.

I will conclude by expressing my thanks to the extended ARS family members in Chennai who have been bulwarks of support to me and my wife Visalam. We are fortunate that my second daughter Venil moved to Chennai three years ago. She and her husband Sumantran have been of great help to us in many ways.

Speaking for myself, the ARS family connection is through Visalam, who has been the woman behind all my successes.

Chennai

S. Naranan

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