

RECOLLECTIONS AND PROJECTIONS

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School days

One of my early school recollections takes me back to standard III when I was seven. The class teacher was asking each of us : What does your father do for a living ? When my turn came I replied that he was a professor. Professor of what ? asked the teacher. My friend sharing the desk had just answered smartly that his father was a physics professor, although I doubt that at the time he knew what 'physics' was. Nevertheless I felt ashamed that I did not know what my father taught as a professor.

The teacher himself enlightened me : 'Don't you know that your father is a professor of mathematics ?' Mathematics ? Suddenly I felt elated. This happened to be *my* favourite subject and I was glad to learn that it was also the subject my father was expert in. The father is naturally a hero to every child, but that day my respect for my father went up two notches.

A doctor wants his son to be a doctor, a businessman wants his son to succeed him in business, a politician... well, I think I have made the point. But I was never pressured to like maths.... never told that I must get to like the subject because my father was a star wrangler and prize winner from Cambridge. Which is why my discovery of my father's profession came as a delightful surprise.

But having wrangler for a father certainly helps, especially if he is willing to stoop to the school level to encourage and develop your taste for the subject. My father bought me several books on recreational maths and opened a wide vista of the beauty and power of the subject that a school syllabus succeeds in hiding. Although I never attended his classes as a student, those who did spoke very highly of him as a teacher. There were several occasions in my life when I unexpectedly came across his students in so many different walks of life all over the country... students who would fondly remember him as a teacher. These tributes stand out all the more in today's sadly deteriorating academic ethics and standards.

I also recall my father as an excellent administrator who went by the rules but at the same time interpreted them in a human way. As the Principal of Central Hindu College, Banaras Hindu University and as the Pro-Vice-Chancellor of BHU, he had already established his reputation in this difficult field. This was further enhanced when he went to Ajmer as the Chairman of Rajasthan Public Service Commission. All those who came in contact with him recall his integrity and how he went by the rules of selection, despite pressures from high quarters. Furthermore, he himself was a voracious reader of books and he developed the RPSC library considerably on the grounds that the RPSC selectors interviewed candidates for various different jobs and as such they should read and inform themselves well about the fields

of these candidates. Again, these scholastic attributes are becoming more and more rare in today's public life.

Another inspiring personality in my school days was my uncle Morumama... who later became better known as Professor M.S Huzurbazar at the Institute of Science, Bombay. At the time I was in secondary school, he was staying with us in order to do his M.Sc. in mathematics, which he got with flying colours and the Chancellor's Gold Medal. But as a student he was a constant source of mathematical problems and puzzles for me. On the blackboard on the wall (-a specialty of the Narlikar house was that my father had provided two wall-mounted blackboards for me and my brother to use-) he would write a *challenge problem for JVN* and would remain there till either I solved it or acknowledged defeat. It was great fun and through such victories and defeats I learnt maths well beyond my school level.

I cannot bid good-bye to my BHU days without acknowledging the salutary influence of my mother, an influence that extended well beyond the scholastic aspects. I think, in general, the father's influence is more direct and visible while the mother's tends to be subtle and intrinsic. Perhaps her greatest impact in my way of life has been in self organization. She was extremely meticulous (sometimes to a fault !) in organizing her daily routine. In Marathi there is a saying that a disorganized person starts digging a well when he is thirsty. My mother would not have been comfortable until she had three good wells at her disposal at all times, just in case !

A Sanskrit scholar in her own right, my mother got me interested in several Sanskrit classics, besides getting my brother and me to memorize by heart several stotras and shlokas. And, whereas my father brought in books, it was she who read them to us right from our primary school days, until we got into the habit of reading them ourselves.

Transit to Cambridge

Seeing my progress with maths, my father felt that I should follow in his footsteps and go to Cambridge for doing the mathematical tripos examination. Admission to Cambridge was difficult but fortunately my father's old college, Fitzwilliam House (now known as Fitzwilliam College) admitted me. So at the age of nineteen I moved to Cambridge as an undergraduate. Till then I had never lived away from home and now I was to stay abroad in the first instance for *three years* at a stretch. A scholarship from the J. N. Tata Trust and my father's own support enabled me to make this transition.

The mathematical tripos course, unlike other subject-triposes, normally takes four rather than three years to complete. Since I had monetary provision only for three years at Cambridge, the choice before me was either to do the first two years' or the last two years' courses in one year. Although I was new to the Cambridge method of teaching, and had not sorted out all the problems of settling down in a new place, I opted for the former course of action. This meant doing double the work of an ordinary undergraduate : that is, lectures all through the morning and three tutorials per week. It meant a lot of work in my first year, but it turned out to be a wise decision. For, the tripos course gets progressively more difficult and it would have bee much more difficult to manage both Part II and Part III in one year.

But working in Cambridge was an inspiration in itself. It is rare to see so much of tradition and so much of academic excellence concentrated in one place, hardly more than a square mile. Noble prize winners could be seen cycling down the street or walking down the towpath of the river, people whose names you

read in textbooks were there to teach you and then there were equally distinguished visitors on the college campuses and departments drawn by the aura of Cambridge. The ambience was awe-inspiring to begin with.

Coping with the tripos turned out to be manageable, thanks to my tutorial supervisors, Dr. R. A. Lyttleton and Mr. Murphy both of St. John's College. At the end of the first year I did not do badly, getting a good first in both my exams. Due to obvious reasons of economy, I drafted the cable informing my parents, with the one word message 'doublefirst'. But the man at the telegraph office noticed it and congratulated me. By coincidence, he was there on each of the two succeeding years when I had occasion to send home cables of my further successes. Each time he would greet me with the comment : "Now what have you won ?"

Fitzwilliam was 'non-collegiate' in those days and I was missing the camaraderie of college life. With reserved Englishmen all around me, it was not easy to make friends. However, it took a traumatic experience to bring home to me the latent goodness of the institution. This happened on 9 February 1959 when, crossing a small lane, I was knocked off by a scooter.

I was admitted to the Addenbrookes Hospital where it was discovered that I had a broken leg. An operation was duly performed to fit a plate to the broken bone and I had to spend four weeks in a nursing home followed by three months in plaster. My tutor R.N. Walters and several others were a great help; but I found a new friend in this adversity, in the College Chaplain the Rev. Peter Schneider. Peter took great pains to ensure that I was not bored by this enforced inactivity. He even brought curry and rice from a local Indian restaurant. The chessboard I have with me even today was presented by him. And, he arranged for me to go for a one week vacation to Lynton in North Devon along with a college group.

Going to the Lee Abbey at Lynton was no problem thanks to the special coach that took us door to door. The students were to spend three weeks, and given normal circumstances, I would have liked to do the same. But I had to return ahead of others to make up for my lost days of study. How was I to make the return journey in the 'plastered' state with crutches ? This is where I found another friend : Dr. W. W. Grave, the newly appointed Censor of Fitzwilliam, offered to drive over with his wife and fetch me. I was deeply touched with this kind offer which solved my transport problem.

When the Graves arrived to fetch me I was waiting at the doorstep with my suitcase. They made me comfortable on the back seat of the car but in their anxiety to settle me properly, they forgot to load the suitcase. After half an hour's drive they discovered the lapse and had to turn round. To my great relief, the suitcase was still thee on the footpath !

Thanks to the morale boosting I received from so many quarters, I decided to go ahead with my attempt for the second part of the Tripos that year. For me it had a special significance: if I got a first, I would be called a 'wrangler' like my father. I had dreamed of appearing in this examination for so many years.... but not with plaster and crutches which now were unavoidable.

The real ordeal, however, lay not in the exams themselves but in the ceremony where the results are announced. Mathematical Tripos being the oldest of all Tripos examinations enjoyed a special status in Cambridge and the results of Parts II and III were not simply posted on the notice board but announced by the Chairman of the Examiners from the inner balcony of the Senate House. He started reading the results at

the stroke of nine from the clock of the University Church across the King's Parade. Only the hardy souls confident of success could listen to the names being read out this way. For they were read out alphabetically in each class and I waited with baited breath as the initial 'N' appeared. Will he skip my name from the 'Wranglers' list ? The relief was immense as I heard it, despite my confidence in my performance. I had to undergo a similar suspense the following year till I heard that I had scored the coveted distinction (star) in Part III and qualified for the Tyson Medal in astronomy like father thirty years earlier.

Early Research

The tripos was only the beginning of my long association with Cambridge. The natural follow-up was research for a Ph.D. and here one of my dreams was realized when I was informed that Professor Fred Hoyle had agreed to accept me as his research student. For, although I had gone to Cambridge with open mind regarding the branch of mathematics I would do research in, by my thired year I had narrowed my options to astronomy and that too under Fred Hoyle whose lectures I had immensely enjoyed as an undergraduate. A great many things were happening in astronomy around 1960 and I could see that a research career therein would be full of excitement.

One of my earliest research efforts arose in the context of the famous Hoyle-Ryle controversy. Martin Ryle, the Director of the Mullard Radioastronomy Centre at Cambridge had long been a staunch opponent of the steady state theory. Twice earlier he had claimed to have found obsevational evidence from radio surveys of the universe disproving that theory. On both occasions he had underestimated the observational errors thus rendering the claims groundless. In January 1961 he came up with fresh and improved data, with which he claimed once again to have disporved the steady state theory. He was planning to present his results at a meeting of the Royal Astronomial Society in London.

This was a personal challenge to Hoyle who felt that, unlike the previous occasions, Ryle's present data deserved to be taken seriously even if his conclusions might be prejudiced. He asked me if I would like to work with him on an alternative interpretation of Ryle's data, to show that they were not inconsistent with the steady state theory.

We had a meeting with Ryle and his colleagues who were very unwilling to part with their data. After some persuasion we had their main diagram to look at, and a crude copy of a hand-drawn figure with some numbers scribbled on it, was given to us. 'Explain this curve within the framework of the steady state theory if you can !' was their challenge to us. And we had barely two weeks to do it.

So, working more details into Hoyle's nebulous idea, we did some crucial calculations, tried out a few parameters to match Ryle's curve. And, to our surprise, we succeeded. Armed with this work, Hoyle asked the Secretary of the RAS to allow us to present our reply to Ryle's claim after his talk. The Secretary agreed.

However, there was a snag. On the very day of the RAS meeting (held traditionally on the second Friday of every month) Hoyle had another previous lecture engagement in London which he could not change. So how would he present his reply ? There was only one way. 'Jayant, why don't you do it ?' he asked. I reeled at this suggestion. I was a research student with not even six month's experience; how could I reply to such an important challenge and before such an august gathering as the Fellows of the Royal Astronomical Society ? But Hoyle reassured me. If I had confidence in the

correctness of our approach then nothing else mattered in a scientific debate. The only danger to avoid was that of running out of time while presenting our model. To take care of it we carefully rehearsed what I would say (and, more importantly, what I would avoid saying) within eight minutes, leaving a buffer of two minutes.

In the end it went off well and several persons in the audience told me afterwards that I had put forward our point of view clearly and calmly. Thus, although to begin with I had felt that Hoyle was putting too much of responsibility on my inexperienced shoulders, I found that I had immeasurably benefited from the experience. Indeed, the self-confidence I acquired that day helped me stand up to even grater challenges in the future. I think a research supervisor should encourage his students to take initiatives at an early stage.... a practice I have followed with my own students where possible.

My interaction with Hoyle became closer as a result of the Ryle episode. I will not go into details of our long research collaboration covering several fields which lasted till I left Cambridge in 1972, and continued intermittently till 2001 when he was no more. I will content myself with one highlight.

Much has been made of our work on the new theory of gravity based on Mach's Principle which we presented at the Royal Society in June 1964. This work gave me great intellectual satisfaction as it provided a direct link between Einstein's general relativity and Mach's ideas on inertia. Einstein, who had been an admirer of Earnest Mach, had tried to find such a link but had not succeeded. For, Mach had argued that there should exist a long range effect which gives the property of inertia to any particle of matter. Thus a lump of matter has a mass and requires a force to change its state of rest or uniform motion (Newton's first law of motion) because it exists in a universe filled with matter. This ideas of Mach had never been explicitly and quantitatively stated. Einstein had felt difficulty with it because it seemed to involve action at a distance, a concept whichwas introduced by Newton in his law of gravitation and had been used by Coulomb to describe electric and magnetic forces but which had fallen into disrepute by the end of the 19th century.

As it happened, by 1963 Hoyle and I had made considerable progress with the revival of the concept of action at a distance so far as electromagnetism was concerned. We had managed to resolve most of the lacunae that had prevented its being taken seriously by physicists and had found that the concept worked as well as if not better than the prevalent field theory. Our next hurdle was to find a way of describing gravity through action at a distance. The breakthrough came in late 1963 when we found that it was not the property of gravitational attraction that held the key to the solution but the property of inertia. Once this fundamental issue was clear, it was like working on the final stages of a jigsaw puzzle, when the remaining pieces readily fell into their appropriate places.

I still recall the excitement both of us felt when after starting from the *Mach* end by defining inertia, our equations led us to a theory of gravity, to the so-called *Einstein* end ! The gravitational equations turned out to be more general than those of Einstein's relativity, but we could see how the latter followed as a special case. This was the work we presented at the Royal Society.

This was not, however, an end in itself. We had further to go. During 1967-72 we were concerned with the quantum aspects of action at a distance and it was only very recently (in 1992) that we were able to show that the role of the large-scale structure of the universe can be very vital to our understanding of the microscopic quantum phenomena. I also suspect that our

gravity theory may be able to throw light on some of the mysterious results on the redshifts of the quasars and galaxies... results that do not seem to fit into the framework of general relativity.

The Influence of Fred Hoyle

My interaction with Fred Hoyle was not confined to discussions in his house or office. It carried over to the hikes and trips both of us went on. Hoyle, or Fred as I came to address him, was fond of mountains and had made extensive trips of the Lake district and the Scottish mountains. I went with him on some occasions and have very rewarding memories of those trips. For, these were occasions when he would freely speculate on physics, astronomy on the one hand and sports, world affairs etc. on the other. Often, the change of gears would be quite drastic ! Camping, trekking, caravaning in the unpredictable weather of the region had their own excitement, like doing research in uncharted territory.

Fred Hoyle has influenced astronomy profoundly and in so many different ways. Yet he is often called an iconoclast, because in several important scientific issues he took a stand contrary to the conventional majority view. His argument was that if the conventional approach were correct, then with so much brainpower applied along it a breakthrough would have been made long before; the fact that this has not happened means that the majority view must be wrong. It is a bold position to take and requires considerable strength of mind to sustain it. Also, being regarded anti-establishment has its own drawbacks in denials of recognitions and awards (in Hoyle's case the Nobel Prize). Having followed Fred's example in a more modest way, I have similar experiences. Nevertheless, working in uncharted territory instead of along the beaten track has its own creative satisfaction.

The foundation of the Institute of Theoretical Astronomy (now Institute of Astronomy) at Cambridge was another lasting and seminal impact of Fred Hoyle on contemporary astronomy. In the early sixties, foreseeing the revival of astronomy, Hoyle had pressed for a new institute devoted to the subject to be created at Cambridge. When the UK Government was not forthcoming, he went to private foundations and largely because of his personal prestige and charisma the IOTA came to be established in Cambridge. Later its demonstrated success brought Government support, and the institute went a long way towards reasserting the preeminence of Britain in theoretical astronomy. I consider myself fortunate that as a founder staff member I was able to participate in the first six heady years (1966-1972) of the new institute under the dynamic leadership of Fred Hoyle. This experience was to help me in a similar exercise of setting up the Inter-University Centre for Astronomy and Astrophysics at Pune in 1988.

TIFR and IUCAA

I have dwelt at length on my distant memories. I will be brief with those relating to more recent events. Since 1972, I have been working in India, having spent the first 16-17 years at the Tata Institute of Fundamental Research (TIFR) and the next 14 years in Pune as the Founder Director of the Inter-University Centre for Astronomy and Astrophysics (IUCAA). Both these tenures have given me considerable information on Indian science. In a small way, I have been able to contribute to the many developments going on in Indian Science. The TIFR experience showed me that good fundamental research can be carried out with manpower and equipment available in India. The IUCAA experience has shown that expensive facilities can be optimally utilized when shared with many institutions. As I retire from the director's post this year I feel that the

experiment of creating Inter-University Centre is worth extending to other fields and I hope that in the future the University Grants Commission (UGC) will open Inter-University Centres in other subjects.

While in TIFR I began in a small way an experiment of communicating science to the masses, both in English and in Marathi, In fact while at Cambridge I had started writing popular science articles and also giving popular lectures to lay audiences. In India I realized that science communication can be more effective in the mother tongue of the target group. So in Maharashtra, I used Marathi quite often for this purpose with great impact and audience-appreciation. Whenever I had the opportunity I found that the use of Hindi in the northern belt is likewise very effective. In 1986 the support received from the then Prime Minister Rajiv Gandhi enabled me to make a 17-part TV serial called *Brahmand* in Hindi with the help of the Films Division. This has been televised several times on Doordarshan. I was very gratified when I was selected for the prestigious Kalinga Award for science popularization instituted by UNESCO in 1986, an award previously received by such doyens as Bertrand Russell, Margaret Mead and Fred Hoyle. Likewise I was honoured to have got the Desharatna award. At IUCAA I have built in science popularization as one of the declared activities of the centre. This also has been very warmly welcomed by the general public.

Looking to the Future

On the future front I see certain dangers lurking on the horizon of Indian Science. There is less and less interest and motivation amongst the young for a scientific career. This is already showing its effect in the growing lack of trained manpower in Indian science and technology. To address this question, many steps will need to be undertaken, the most important of these being the following two :

1. The universities need to be revitalized with access to good teaching and good research for the faculty and students. Unless the students see good research being done on the campus and are taught by excellent scientists, they will not capture the excitement of doing science.

2. The research institutes need to be brought into closer contact with the undergraduates especially the science students. At present there is absolutely no way that the typical undergraduate can learn about what is going on at the research front in Indian Science.

I hope that steps will be taken soon to address these issues on an undergraduate level. Even though I retire from official chores I will be only too happy to lend my own modest support to any activities aimed at revitalizing higher education.

