SCIENCE AND ME—THE EXCITEMENT OF DOING SCIENCE

—Dr. Jayant Narlikar

At a time when purely commercial attitude prevails in education it has become necessary to state the obvious: that pure science, motivated as it is by the thirst for knowledge, forms the foundation of the superstructure of science and technology that has be-come the mainstay of our present civilization. But even more than that it needs to be emphasized that pure science today is a natu-ral extension of the age old and continuing efforts of intellectuals to understand the mysteries of nature. The ancient sages searching for enlightenment went through extended periods of agony which only made the attainment of goal a matter of great ecstasy.

The scientists have experienced similar moments of agony and ecstasy in their search for truth. Agony that you go through when you are searching for the elusive solution to a problem—a solution that you feel it in your bones, must exist. Ecstasy that you experience when you find it.

Indeed/history of science is full of inspiring names of scientists who have gone through such cycles of agony and ecstasy. It may be worth of our going through a few examples. When I made my selection for recounting them here I discovered that, inadvertently, all of them belong to my alma mater, the University of Cambridge! I may not be exaggerating when I say that it is hard to think of any other institution with such a long tradition of scientific discoveries.

Isaac Newton

Now more than 350 years have passed since the birth of Isaac Newton. Imagine celebrating 'the three and a half centenary' of a scientist when in India we will shortly be celebrating the centenaries of Megh Nad Saha and Satyendra Nath Bose.

Newton was a rare combination of genius, hard work whimsicality. It is often stated in scientific folklore that he thought of the inverse square law of gravitation when a falling apple hit him on the head as he was relaxing in his home orchard. Nothing can be more unfair to Newton's abilities, to the work of his predecessors like Kepler and Galileo and to the history of astronomy. It would be hard, if not impossible, even for the most sophisticated instruments of today to deduce the inverse square law by accu-rately measuring the acceleration of a falling apple. The inverse square law was deduced not from the fall of an apple but by at-tempts to understand the motions of planets and the moon. Newton had Kepler's laws to explain. He invented a new branch of mathematics to calculate planetary trajectories—a branch now known as calculus.

The Nobel laureate astrophysicist Professor S. Chandrasekhar has remarked that he had solved the propositions in Newton's Principia and found, on almost every occasion, the Newton's origi-nal solutions three centuries earlier were more elegant than his own modern attempts! But the final product Principia does not reveal the painstaking efforts

that went into it. Newton's biographies have given us glimpses into the agonies of scientific discovery that he must have gone through.

The following accounts illustrate how his contemporaries saw in Newton:

As when he has been in the hall at dinner he has quite neglected to help himself, and the doth has been taken away before he has eaten anything. When on surplice days, he would go toward S. Mary's church, instead of college chapel, or perhaps has gone in his surplice to dinner in the hall. That when he had friends to entertain at his chamber, if he stepped in to his study for a bottle of wine, and a thought came into his head, he would sit down to paper and forget his friends.

<div align="right">P. Stukeley</div>

He always kept close to his studies, very rarely went a visiting and had a few visitors, excepting two or three persons, Mr. Ellis of Keys, Mr. Lougham (called Laughton in his other letter) of Trinity, and Mr. Vigani, a Chemist in whose company he took much delight and pleasure at an evening, when he came to wait upon him. I never knew him take any recreation or pastime, ei-ther in riding out to take air, walking, bowling, or any other ex-ercise whatever. Thinking all hours lost, that was not spent in his studies, to which he kept so close, yet he seldom left his Cham-ber, unless at term time, when he read in schools, as being Lucasianus Professor... He very rarely went to dine in the hall unless upon some public days, and then, if he has not been minded, would go very carelessly, with shoes down at heels, stockings unty'd, surplice on, and his head scarcely comb'd.

<div align="right">Humphrey Newon</div>

This was my first example. Let me now jump across two centuries to look at two other great scientists.

Kelvin and Maxwell

In his early life Lord Kelvin was known by his family name Thomson. This story refers to Thomson and another young man Parkinson when both were competing for the top rank in their Cambridge examination. In the end Parkinson topped the list and Thomson was the next one with the rest of the pack far behind.

There was one particularly difficult question, which only the two had answered correctly. What struck the examiner most was the similarity of their answers so much so that he suspected malpractice. Did one boy copy the other's answer? He called Parkinson for an interview.

"Tell me, how did you manage to solve such a difficult question?" he asked Parkinson.

"Sir, I occasionally read research journals. I came across a paper wherein the author had solved this problem." He gave the reference to the paper.

The examiner who himself had taken the problem from that paper was impressed. He complimented the boy for going out of the teaching syllabus and reading new articles. Dismissing him with a pat on the back he called Thomson and asked him somewhat

aggressively, "I would like to know how you solved this problem. Parkinson who solved it saw the solution in a research paper. Don't tell me that you also saw it there."

"No Sir!" replied the future Lord Kelvin. "I wrote that pa-per."

And that about sums up the intellectual calibre of the student.

James Clerk Maxwell was another aspirant for the top rank in his batch. Indeed so confident was he that he did not bother to attend the result declaration ceremony at the Senate House. Instead he sent his valet with the instruction, "Find out who is second." For, he was curious to know who amongst his rivals would be second.

The valet came back in due course; "Well! Who was second?" asked Maxwell.

"You, Sir!" said the valet!

Maybe, Maxwell was disappointed at not making it to the top of the exams as, probably did Thomson. But both made it to the top of scientific research making outstanding contributions to electricity, magnetism, thermodynamics, etc. In a scientific career what in the last analysis matters most is originality. So not all is lost if you failed to secure the top rank in your examination! I can also name persons who topped the merit list by sheer hard work and rote learning but failed to make the grade in scientific research.

After all, what did Parkinson do in later life? Or the man who surpassed Maxwell in the finals? We do not know!

Brian Josephson

Coming to the present century, I will now tell the story of a genius who was a fellow student with me at Cambridge.

We all came to know of Josephson when his name began to appear in the list put out by the mathematician Besicovitch. The list was of those students who solved the problems, announced by Besicovitch from time to time on the Faculty Notice Board. So we thought that Josephson would become a pure mathematician.

However, in his final year as an undergraduate he wrote a research paper pointing out a serious error in an experiment claiming to have proved an assertion of Einstein's general theory of relativity.

As a result of Josephson's paper the experiment had to be repeated with greater controls to make the claim stick. But that was in physics—and the beginning of Josephson's transition from a mathematician to a physicist. And today all physicists working in low temperature physics know of him for his discovery of the so-called 'Josephson Junctions—the discovery that brought him a Nobel Prize. He made that discovery as a research student in the Cavendish Labs.

Having given these examples of great scientists let me come down to earth and share with you my own experiences that led me to opt for a career in science. These are experiences of my formative years, which school children can very well appreciate.

Seeding

One of my early childhood memories goes back to when I was in Std III. Our class teacher asked all the students, "What does your father do?" As the school was in the campus of Banaras Hindu University (BHU), most of us were children of university staff members. I recall replying that my father was a professor. "Professor of what?" the teacher asked. I did not know. So the teacher told me: "Your father is a professor of mathematics". My feeling of inadequacy at not knowing the full answer was instantly replaced by one of elation. So my father did the same subject that I like best.

I narrate this incident to underscore the fact that my early liking for mathematics was not dictated by my father, or by others telling me that I should grow up to be a mathematician just like my father. I know of cases where children are consciously or unconsciously pressured to emulate the achievements of their parents.

That I liked maths and science was noticed by my father who made me acquainted with the recreational aspects of mathematics, with its wealth of anecdotes, puzzles and paradoxes. He did this either directly or by giving me books of this nature. He also encouraged me and my brother to do experiments. Our house in the BHU campus was spacious enough for him to provide a chemistry lab for myself and my brother to play with.

In those days it was customary for visiting faulty from other universities to stay with their local host and so we had mathematicians like N.R. Ram Behari, A.C, Banerjee or Vaidyanathaswamy staying with us on such visits. Even if I did into understand what they were talking about the overall ambience did help in creating an aura about mathematics.

Growing

However, a crucial development, which helped foster a competitive spirit in me took place when I was in the VIII standard. My maternal uncle Moreswar Huzurbazar, or Morumama as I used to address him, came to live with us in order to do an M.Sc. in mathematics at the BHU. He was a brilliant scholar, having done very well at the B.Sc. exam of Bombay University. (Later in his life he was a Professor and then Director of the Institute of Science, Bombay.)

Morumama discovered that I enjoyed doing mathematics. He also noticed that my father had two blackboards built into the walls for myself and my brother to write or draw as we wished. He found a new use for the boards. Once in a while he would write a mathematical problem or puzzle, under the title "Challenge Problem for JVN". The problem would remain on the board till either I solved it or gave in and asked for the answer (which, I am glad to say happened rather rarely).

Morumama's problems were certainly outside my school syllabus; they called for analytical reasoning and 'trick solutions' which would light up for me some hidden aspect of mathematics. My lasting regret has been that no record has been kept of those problems. But so far as I was concerned, I developed an attitude of taking on the challenge posed by a difficult question.

I should mention too that some teachers I encountered at school were also inspiring. Occasionally I would take Morumama's problems to school. Mr. Pande, my maths teacher would have time for discussing it, even though he himself could not solve it. How

many teachers, overburdened as they are with a large student population and an overstaffed syllabus, can today find time for such excursions into the byways of mathematics? I recall taking up a whole period discussing the proof of the so-called difficult converse: "If the angle bisectors of the base angles of a triangle are equal, then the triangle is isosceles." (Perhaps, readers of Resonance unfamiliar with the proof may try to find one! It is easy to show that the base angle bisectors of an isosceles triangle are equal; but try proving this converse)

Perhaps I should also mention that books like 'Men of Mathematics', "The World of Mathematics', 'Living Biographies of Great Scientists', etc., played a key role in bringing to my impressionable mind the excitement and frustrations of creative geniuses. The anecdotes given in the beginning of this article tell us that science is not a drab subject to be memorised, but an arena of adventures. It is revealing to know about the pride and prejudices of great scientists, and to learn that they too occasionally made mistakes. But science has a self-correcting mode that leads ultimately to the right answer. This was one motivating influence in my opting for a career in science.

Decision Making

I have stressed my liking for mathematics, but I should add that I liked physics too. Here, however, my school syllabus was not very exciting and apart from an occasional puzzle, I did not get to share the excitement of learning and experiencing how nature's laws work. So Physics was my second favourite and close on its heels came Sanskrit.

So far as my liking for Sanskrit goes, I owe a lot to my late mother and to Morumama. My mother inducted me into Kalidasa and Bhavabhuti... identifying the power and beauty of the language, which one can appreciate only through the works of literary geniuses like these. And Morumama inducted me into the literary gymnastics and puzzles that this language seems uniquely fit to describe.

I wish our university system were flexible enough to allow a science student to do a course in Sanskrit too. But alas, no! After my matriculation I had to make the choice; and I could have Sanskrit only if I opted for arts.

But the point of decision making came at the end of the intermediate science examination; the stage now identified with the higher secondary or standard XII. The BHU had an engineering college with a national reputation (now part of the Institute of Technology). It was difficult to get into, and much sought after. I was expected to do well in the ISc Examination, and one of the options before me was to go for the engineering degree.

I recall visiting the BHU Engineering College at the time of the annual exhibition which was put up by students for the general public. In fact I used to visit the exhibition every year and enjoy the clever way machines were used to do work. On this particular occasion, some college faculty members greeted me and said that they hoped to see me as a student there next year.

However, for me the decision was already made. I had developed sufficient attachment to mathematical sciences so that the alternative of opting for engineering did not even enter my mind.

The thrill of solving problems whose solutions one did not know, must be even greater, I felt, than solving Morumama's problems whose solutions were known, at least to him. I had seen my father working on such problems with long calculations spread over several pages all lying on the floor all around where he sat.

Indeed my future projections at this stage took me to the Mathematical Tripos at Cambridge, where I felt, one's mettle is really tested. I had decided to try for it after completing my B.Sc. at the BHU. My father, who had a very successful career at Cambridge was all for it.

Passage to Cambridge

There were two hurdles, however. Getting into Cambridge was difficult. Simply doing well at the B.Sc. was not sufficient... for the external assessment of the standards of education at Indian Universities was rather low even in the 1950s. And, even if one got admission, the finances would pose another problem.

Fortunately, several plus points in my case helped. The achievements of my father helped in establishing a basic credibil-ity level of my own first rank at the B.Sc. examination. Even then, the Cambridge University refused to give me an affiliated status, which would have allowed me to get the degree in two rather than three years. The reason? The B.Sc. degree of Bombay University was recognized for this status, but not the B.Sc. of Banaras Hindu University. So I was given admission but for the full three year course.

The problem of funds was solved by my getting the prestigious J.N. Tata Endowment scholarship. Here again my antecedents helped: for my father had been a successful J.N. Tata Scholar himself. Nevertheless I had to go through a tough interview con-ducted alone by the Chairman of the Endowment, the redoubtable Mrs. Piroja J.Vesugar. Although she passed me, she did not fail to issue a warning. She mentioned a few names of recent Tata Scholars, who were sons of distinguished Tata Scholars, but who had done not so well at Oxbridge. So don't be complacent, she said. I have greatly valued that advice.

I should close this account with a brief discussion of another career option which was open to me at the time. When I called on Mr. R. P. Paranjpye, Senior Wrangler at Cambridge of the 1899 vintage, he asked me: "After doing the Mathematical Tripos, will you go for the IAS?" For he was voicing a view common in those days, that a Cambridge degree was a good stepping stone for the Indian Administrative Service. When the great RPP himself distinguished himself at Cambridge he was expected to join the Indian Civil Service. But he opted for a teaching career.

My answer to Mr. Paranjpye was likewise quite definitive: "No Sir, I wish to enter a career of teaching and research."