Professor Jayant Vishnu Narlikar is an Emeritus Professor at IUCAA, Pune. He has made important contributions to theoretical physics, astrophysics and cosmology. He is considered a leading expert and defender of the steady state cosmology against the more popular big bang cosmology. His work on conformal gravity theory with Fred Hoyle demonstrated how a synthesis could be achieved between Einstein's general theory of relativity and Mach's principle. Apart from his research work, he has established a name in the field of science popularization. He has used the print and electronic media for this purpose, with English, Hindi and Marathi as languages for communication. He has been honoured by several awards for his research, including the S.S. Bhatnagar award for physical sciences (1978), the F.I.E. Foundation's Rashtrabhushan award (1981), the B.M. Birla award (1993), etc. He is Fellow of the Indian National Science Academy, the Indian Academy of Sciences, the National Academy of Sciences of India, the Cambridge Philosophical Society and the Third World Academy of Sciences. He has honorary doctorates from the Burdwan University and the Banaras Hindu University. He was decorated Padmabhushan by the President of India in 1965.

THE EXCITEMENT OF DOING SCIENCE

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 become the mainstay of our present civilization. But even more than that it needs to be emphasized that pure science today is a natural 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 our going through a few examples. When I made my selection for recounting them here I discovered that, inadvertantly, 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.

Issac Newton

Now more than 350 years have passed since the birth of Issac 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 come 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 accurately measuring the acceleration of a falling apple. The inverse square law was deduced not from the fall of an apple but by attempts 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 original 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 Newton:

As when he has been in the hall at dinner he has quite neglected to help himself, and the cloth has been taken away before he has eaten anything. That sometime. 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 steped 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.

P. Stukeley

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, either in Riding out to take y^{e} Air, Walking, Bowling, or any other Exercise whatever, Thinking all Hours lost, y^{t} was not spent in his studies, to w^{eh} he kept so close, y^{t} he seldom left his Chamber, unless at Term Time, when he read in y^{e} schools, as being Lucasianus Professor... He very rarely went to Dine in y^{e} Hall unless upon some Public Days, and then, if he has not been minded, would go very carelessly, wth Shooes down at Heels, Stockings unty'd, surplice on, and his head scarcely comb'd.

Humphrey Newon

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 paper."

And that about sums up the intellectual caliber of the two students.

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!

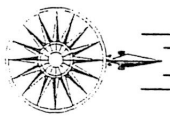
Maybe, Maxwell was disappointed at not making it to the top of the exams as, probably did Thomson. But both made it to the top of scientific research making outstanding contributions to electricity, magnetism, thermodynamics, etc. In a scientific career what in the last analysis matters most is originality. 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? 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 will 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.

A personal Experience

The great names I have cited may have given the impression that only a select few enjoy the thrills of doing science. Far from it as an ordinary scientist I can also testify to the agonies and ecstasies I have experienced in the course of a career longer than three decades.

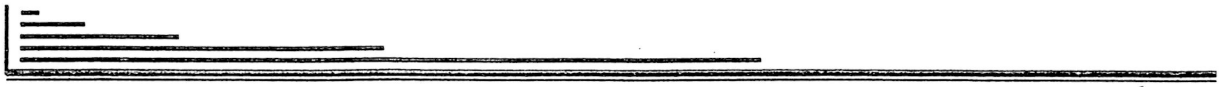
While working on the idea of action-at-a-distance I recall being stuck at a technical point. There seemed no possible solution – at least all those we tried seemed to lead to a dead end. The 'we' here stands for Fred Hoyle and myself.

It was then that I accidentally came across a paper written by two authors in the United States. The paper was written in a different context and normally I might have set it aside after reading its title and the abstract. But somehow I did probe further and found that whatever was blocking our progress could be circumvented by the techniques described in that paper.

There comes the first stage when you try a new method – a stage of optimism. Then comes apprehension : will it work when you go into details? This is the agony part. When you find that it works all the way comes the ecstasy. Yes! it does work and opens a new vista for future progress. In our case the solution to our problem not only dealt with the immediate bottleneck but led to a new theory of gravity.

To Summarize...

These examples illustrate the rewards you get if you really like doing science. First, as a professional scientist you are that fortunate person whose hobby is his (or her) profession. Second, except for the total involvement in your field, you are under no external tensions. So you may earn less money than a medical doctor but your way of life is more relaxed both physically and mentally. Finally, if you do succeed in making even a small discovery, you have the satisfaction of having added your little bit to the vast and growing storehouse of human knowledge.

My final remarks are directed at the general public who also needs to share the excitement for the quest. I should mention that all the scientists I have discussed here from Newton to Josephson, were motivated by the desire 'to know'. Their work was in the area of pure science. Yet, all of it proved to be 'useful' in some form or other. Newton's laws of motion and gravitation are essential to present space technology : they provide the framework for launching our spacecrafts and keeping them on track. Kelvin and Maxwell provided the electromagnetic theory which tell us how to generate power, how to transmit radio and television programmes, how to run so many different types of machines and so on. Josephson junctions play a useful role in low temperature technology.

So there is a great need to keep the human curiosity alive, to foster pure science.