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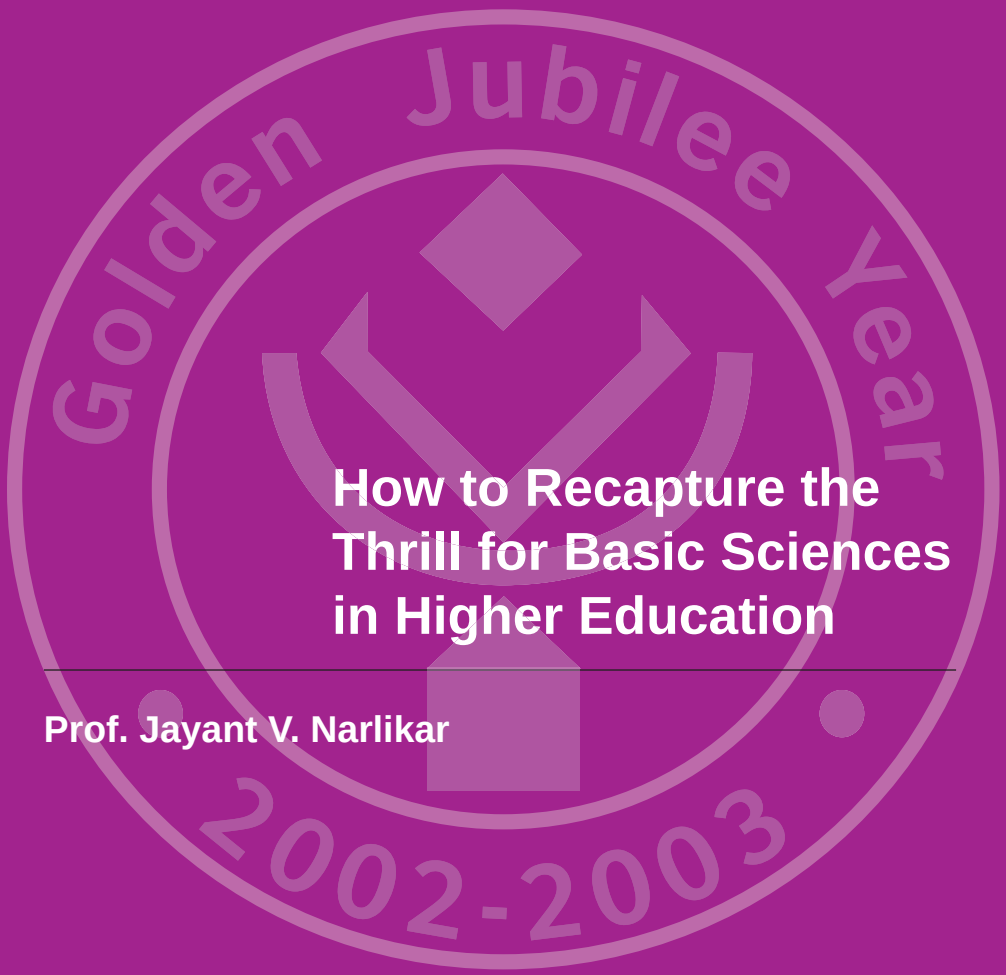
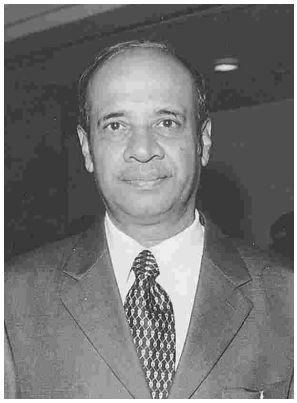


How to Recapture the Thrill for Basic Sciences in Higher Education

Prof. Jayant V. Narlikar

UGC Golden Jubilee Lecture Series

Chairman's Foreword



The University Grants Commission, an apex body of higher education responsible for the coordination, determination and maintenance of standards of university education in India, is celebrating its Golden Jubilee Year during 2002-2003. As part of the academic activities the UGC has conducted the '*Golden Jubilee Lecture Series*' throughout the country by eminent individuals who have excelled in their respective fields and made a mark not only in India but abroad too. These Lectures have mostly been organized in Universities located in remote areas. The basic concept behind organizing these Lecture Series was to bring UGC closer to students, teachers and intelligentsia in that region. It is hoped that these luminaries including academicians, scientists, social scientists and others, with their rich and varied experiences have motivated and enabled the youth of the country to understand things in better perspective.

To reach out to a wider audience, the UGC is presenting these lectures in the form of Golden Jubilee Lecture Series Booklets. I hope students, teachers, educational administrators and the general public at large, will benefit from the vast repository of knowledge of these achievers.

Arun Nigavekar

Introduction

This lecture was delivered by Dr. J.V. Narlikar at Maharastra University of Health Science, Nasik on 25th April, 2003 as part of the UGC's Golden Jubilee Lecture Series.

I shall begin by narrating two episodes in Indian history. The first one is from the life of astronomer Guillaume Le Gentil who came to India from Paris in 1761, on deputation by the King of France. He had been recommended to the King by the Academie Royale des Sciences, to observe the transit of Venus across the solar disc which was to be visible in Pondicherry in 1761.

Le Gentil, however, met several misfortunes in his ventures. He left France on this deputation but because of the seven year war between England and his country, he had to take several detours to avoid the war zones. So when he reached Pondicherry the date of 6 June 1761 for observing the transit was already past. Like time and tide, astronomical events do not wait for anyone.

Nevertheless Le Gentil decided to remain in India to observe another transit due eight years later on 3 June 1769. He stayed in India this period and did important work on the oceans and also carried out the determination of the longitude of Pondicherry. He published his results in Paris in 1779 under the title *Voyages dans les Mers de l'Inde*. However, his patience was not to be rewarded, since when the prescribed date for the transit came, the sky was overcast and no observations could be made. (If it was any consolation, the British astronomers deputed by the Royal Society were similarly thwarted at Madras in their rival attempt.)

When Le Gentil sailed back to France, his tale of woes continued. He was twice shipwrecked en-route and arrived much later than expected. He arrived back in Paris after 11 years of absence only to discover that he had been declared 'legally dead' and his property given away to his relatives.

Scientists from European countries were willing to travel great distances braving adventures, in order to observe astronomically significant events like eclipses and transits, so that our knowledge of the cosmos shall improve.

Apart from a saga of misfortunes this story conveys a message. Scientists from European countries were willing to travel great distances braving adventures, in order to observe astronomically significant events like eclipses and transits, so that our knowledge of the cosmos shall improve. In India religious taboo on foreign travel forbade such adventures. Even so, we do not know of any local Indian astronomer

stepping out of his doors to view the transit of Venus for which Le Gentil came all the way from France. Why do we find no records of scientific observations being taken at solar and lunar eclipses? So far as the eclipses are concerned, one can see the reason in the age old superstitions relating to the mythical monsters Rahu and Ketu. That the situation has not changed substantially was demonstrated at the time of the eclipses of 1980 and 1994…when foreigners had thronged from thousands of miles to watch the spectacle while denizens of even the most advanced city in India, Bombay, had shut themselves within their abodes.

Since I am speaking under the auspices of a medical university, my second episode is drawn from the annals of Indian medicine. The endemic fever of malaria had been a perpetual bane to the inhabitants of India since time immemorial. However, in the 19th century it was Ronald Ross, a British ex-patriot who tackled the mystery of its origin and transmission and hence cure. Ross began the study of medicine at St. Bartholomew's Hospital in London in 1875; entered the Indian Medical Service in 1881. He commenced the study of malaria in 1892. In 1894 he determined to make an experimental investigation in India of the hypothesis of Laveran and Manson that mosquitoes are connected with the propagation of the disease.

After two and a half years' failure, Ross finally succeeded in demonstrating the life-cycle of the parasites of malaria in mosquitoes, thus establishing the hypothesis of Laveran and Manson. Why should it have taken an ‘outsider’ to come and solve our problems? Why did no one in India, seeing the havoc caused by the disease, feel the urge to investigate its origin and find ways to combat its effect?

Both these examples, drawn from two widely different areas, share a feature that is common to all basic sciences, namely the urge to know. It is this urge to know the why, how, and when about the natural events taking place around him that drove man from primeval times to become a scientist. In basic science, one is driven by curiosity as the prime motive…even in Ronald Ross's case it was the desire to know for sure the basic cause for malaria that made him launch his research. In any society, this curiosity is an energizing and refreshing trait that keeps it on an intellectually upward path. It prompts creativity that is on the same high level enjoyed by the creativity of the artist, the musician or the literateur. Indeed a society needs to carry out serious introspection if this creativity seems to be dying out. My two examples drawn from the colonial era illustrate how in terms of scientific creativity, the Indian subcontinent was in a decadent state.

A Nobel laureate from the subcontinent, the late Abdus Salam has drawn an interesting parallel between the development of India and Europe in the seventeenth century. He mentions that the Taj Mahal in Agra and St Paul's Cathedral in London are contemporary masterpieces of architecture showing that creativity in this field was running high in both countries. However, in a few years, England and the rest of Europe enjoyed the first important revolution in science, initiated by Isaac Newton's work. There was to be no parallel development in the Indian subcontinent. The urge of scientific creativity simply did not seem to exist. Or if it existed in a latent form, the social ambience certainly did not seem to encourage it. While the arts, architecture and music enjoyed royal patronage, science had no foothold amongst the creative intellectuals or their patrons.

That India did have such an urge a few centuries earlier is seen by the golden age of science starting from Aryabhata in the 5th century and extending to Bhaskara in the 11th century. It was the period, when Europe was nowhere on the intellectual scene. The Arabs who had earlier acted as conduit for transfer of knowledge from the ancient Greece to Asia,

were now looking to India for new ideas. Thus it was that Al'Biruni translated Sanskrit works by Brahmagupta and others on astronomy and mathematics. This was when the Hindu system of writing and manipulating numbers became popular, to say nothing of the important concept of the number Zero!

A resurgence of the old spirit of scientific enquiry took place in the beginning of the twentieth century, when even under the colonial rule Indians began to assert their intellectual potential in science. Names like Srinivasa Ramanujan, Jagadish Chandra Bose, Meghnad Saha, Satyendra Nath Bose, Chandrasekhar Venkat Raman are examples of this new resurgence. Alongside these names from mathematics, physics, chemistry and botany I may also mention the gynaecological genious the late Dr V.N. Shirodkar, now very often remembered by the 'stitch' named after him.

These people were all distinguished as teachers who inspired younger generations of students with their examples. So succeeding generations of students in the 1930s, 1940s and 1950s were motivated by them to take up research and teaching in basic sciences. I give a few examples.

Subrahmanyan Chandrasekhar, as an undergraduate was inspired by the work of Ralph Fowler in Cambridge to work on the state of matter at very high density in the white dwarf stars. He wrote a paper on this work and after some correspondence with Fowler, it was accepted for publication in the Proceedings of the Royal Society of London. Later Chandrasekhar met Meghnad Saha, the doyen of astrophysicists in India. Here is a brief account of how his meeting with Saha proceeded, as narrated by Kameshwar Wali in his biography called Chandra.

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A few months later, 2-8 January 1930, Chandra attended the Indian Science Congress Association meeting held in Allahabad. The host and the president of the physics section of the Congress was Meghnad Saha, the eminent Indian astrophysicist, whose theory of ionization a decade earlier had unlocked the door to the interpretation of stellar spectra in terms of laboratory spectra of atoms of terrestrial elements, providing information about the state of stellar atmospheres, their chemical composition, the density distribution of various

elements, and then about the most important physical parameter – the temperature.

Chandra had learned all of this from Eddington's book "The Internal Constitution of Stars" and was aware of the high esteem Eddington had accorded to Saha and of Saha's election to the Royal Society in 1927. But Chandra was not aware that Saha was acquainted with his own work; so when he met Saha at the Congress and introduced himself, he was pleasantly surprised by Saha's compliment on his paper in the Proceedings of the Royal Society. Saha said that it was very suggestive and that one of his students was working on extending Chandra's ideas. He introduced Chandra to this students, who also seemed to know about his work, and he invited Chandra to his home for lunch with a small group of research workers all older than Chandra. The small lunch turned later into a dinner invitation withuch distinguished senior Indian scientists as J.C. Ghosh, D.M. Bose, and J.N. Mukherjee. Saha persuaded Chandra to extend his stay in Allahabad so that he and his students could discuss more with him. Chandra, so young, did not expect to be treated almost as an equal by an internationally renowned scientist of Saha's stature.

The account is illustrative of how even a senior and well experienced teacher can learn from a talented student! Not surprising that with such responsive Gurus new Shishyas felt inspired to proceed further with their researches.

My father (Vishnu Vasudeva Narlikar) was similarly motivated to take up higher mathematics at Cambridge in preference to the lucrative Indian Civil Service. Hearing of his achievements, Mahamana Madan Mohan Malaviyaji, the founder of Banaras Hindu University, while on a visit to the UK for the Round Table Conference personally contacted him in Cambridge and invited him to join the BHU after completion of his studies. And he followed it up with the offer of professorship and the headship of the Mathematics department at the time my father called on him on his return to India. My father accepted the offer in preference to visiting Caltech under an international fellowship, and he stayed in this capacity at the BHU for twenty eight years during which his teaching inspired countless students. Can a Vice Chancellor today exercise the same

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initiative in attracting a highly talented young man to a senior post in his university?

These examples suffice to demonstrate the kind of atmosphere prevailing in the Indian universities in the pre-Independence era. I caught the tail end of this era in the 1950s, when after my standing first in the Intermediate Science Examination at the BHU, I was motivated to opt for the B.Sc. stream in preference to engineering, despite the existence of a nationally famous college of engineering on the BHU campus.

I should say, however, that the trend for preference for engineering amongst the bright boys had already begun and my decision was seen as against the trend. Nevertheless, the trend had not yet developed into an avalanche that it is today. Today it will take far more commitment and will power for a bright student in the merit-list of the Higher Secondary Examination to resist parental and peer pressure to take to science in preference to engineering or medicine.

What has brought about this change of perception? First I will hazard a few suggestions and then come to discuss the possibility of reversing the trend.

The Decline of Interest in Basic Sciences

In 1962, at the time of inauguration of the new buildings of the Tata Institute of Fundamental Research in Mumbai, its founder scientist Homi Bhabha had this to say in defence of basic sciences:

"…By fundamental research I mean basic investigations into the behaviour and structure of the physical world without any consideration regarding their utility whether the knowledge so acquired would ever be of any practical use. Nevertheless, the support of such research and of an institution where such research can be carried out effectively is of great importance to society for two reasons. First of all, and paradoxically, it has an immediate use in that it helps to train and develop, in a manner in which no other mental discipline can, young men of the highest intellectual calibre in a society into people who can think about and analyse problems with a freshness of outlook and originality which is not generally found. Such men are of the greatest value to society, as experience in the last war showed, for many of the applications of science which were crucial to the outcome of war were developed by men who, before the war, were devoting their time to the pursuit of scientific knowledge for its own sake. Radar and atomic energy are two examples of two fields in which a vast body of known basic knowledge was developed into technology of immense practical importance, largely through the application in war time of the efforts of those who might be called 'pure' scientists.

Secondly, the history of science has shown that "there is no genuine knowledge of the universe that is not potentially useful for man, not merely in the sense that action may one day be taken on it, but also in the fact that every new knowledge necessarily affects the way in which we hold all the rest of our stock".

Firmer advocacy of basic sciences than this cannot be found. Ironically in retrospect, the manner of establishment of institutions like the TIFR (the TIFR was established in 1946, during the twilight of the british Raj) has been largely responsible for the present decline in the following of basic

sciences amongst the students of today. This statement may sound paradoxical, so I will try to elucidate it further.

Following TIFR, soon after independence, the trend to establish specialized autonomous research institutes or laboratories started. Different agencies of the Government of India like the CSIR, DST, DAE, DRDO, DOS, DBT, etc have set up their own autonomous research institutions in specified areas. These institutions enjoy a measure of autonomy and are generally well endowed both in cash and in facilities. Moreover, in order to make the life of a typical research scientist 'hassle-free' these institutions were decoupled from universities so that teaching undergraduate or postgraduate students should not come 'in the way' of the researcher.

While this may sound something like the utopia for a scientist, it had a catch. While the researcher was decoupled from university or college teaching, he also got decoupled from students. At the same time, the universities through their acts and statutes progressively moved to a state where the typical faculty member was required to do more and more teaching and less and less research. So while research got progressively to the back seat in universities, teaching became noticeably absent from the research institutions.

Now, I have had the opportunity of attending lecture courses delivered by the best scientists in top institutions in the world. At Cambridge, I have had Dirac lecturing on quantum mechanics, Hoyle on cosmology, Davenport on number theory while at Caltech I have heard Feynman lecture on his path integral approach. These were Nobel laureates or of comparable class. Yet they never thought that teaching was below dignity, or that it came in the way of their research. Rather, they expected that their interaction with students would improve their own perception of their subject. Students like us on the other hand felt inspired that these teachers who had shaped contemporary science had come down to our level to share their excitement and understanding of the subject.

That a similar atmosphere existed in the best departments of our universities in the 1920s and 1930s was shown by the extract I read out of Chandrasekhar's interaction with Meghnad

Saha. A few years ago I was invited to deliver the Meghnad Saha Lecture at the same Allahabad University and I was very disappointed to see a lethargic atmosphere in the department with hardly any students at all. The change is regrettable but understandable also. On the one hand we have separated the students from a research ambience, where they could meet and listen to those who 'create' new science, for these people are located in the ivory towers of research institutions. On the other hand we have also made it difficult for a university faculty member to carry out meaningful research by (a) depriving him of suitable facilities and (b) overloading him with teaching. I have come across vice-chancellors who openly denigrate research on their campus saying that the teacher must teach and teach only. If the evaluation process of a university teacher is to assign very low weightage to research, why should he be so motivated?

Lest it appears that I am making these remarks only for the commonly known basic sciences, let me extend these comments to the fields of medicine and engineering also. Exactly how much research is done in a typical medical school in India? Well known hospitals may declare themselves as 'Research Centres' for income tax purposes, but how many of their doctors actively pursue research? More specifically do the medical students in their career as students in a medical college ever come across any research being done on their campuses? One may likewise ask, do they perceive their careers as medical practitioners or surgeons, or do they rather see themselves being part of a team that is attempting to discover new treatment, or a new medicine or a new technique of surgery? Imagine that you have malaria rampant today in India and that no cure is known for it. Would you feel motivated to find a cure or prevention or would you rather wait for a Ronald Ross to arrive and find the answer for you?

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What I have said does not mean that no medical research is being done in India. We have examples of the Jaipur Foot invented by Dr Pramod Karan Sethi or Dr Durga Dutt Gaur's work on laparoscopic operative retroperitonescopy with a balloon. We have surgeons like Dr V.N. Shrikhande who in terms of innovations are fitting successors to Dr Shirodkar.

But such examples are relatively rare and hardly reach the ambit of a typical medical student.

The feedback of such experiences has been that the typical student, howsoever bright, does not *see* interesting research being done around him, something that would excite him/her through the challenges it poses. So he does not see much scope for a career in research. Those few who still feel the urge to do so, take a look at the scientific establishment in the country. As I mentioned before, that lies remote and inaccessible to him. What little gets to him is a picture of bureaucracy-ridden hierarchy conscious community that does not attract him. *Ergo*, he opts for a career abroad where he sees science practised more as an intellectual exercise than as a chore to be done during office hours. Or back home he goes for a professional career that is monetarily more rewarding although not intellectually so.

It is not surprising therefore that the autonomous research institutions are finding it increasingly difficult to attract young talent, with the problem that a vacuum is slowly but steadily being created at the younger age of the spectrum. Since it is this young age-group that eventually grows to take up higher responsibilities, scientific projects which proceed in a mission mode, like atomic energy, space, industry-oriented research, defence research, etc., are experiencing serious humanpower shortage.

Recall that scientists like Homi Bhabha and Shanti Swarup Bhatnagar had created the institutional structure to boost basic sciences, but at a cost to the universities. There was no parallel growth in universities; rather what existed was slowly allowed to wither away. Consequently the very lifeline of science graduates from universities that fed young scientists to these institutions began to get more and more tenuous and is now close to becoming extinct.

How to Rejuvenate Basic Sciences?

The difficulties perceived above tell us that conditions have to be improved on the basic sciences front not only in the interest of higher education, but also in the interest of future development of science and technology in the country. There are several possibilities that need to be explored in real earnest if the situation is to be retrieved in time. The internet has already shown us how information transfer can proceed fast, painlessly and at relatively low cost. Keeping such developments in mind the following scenarios emerge for the future of higher education. Here are some suggestions.

1. In an extension of the open university system one can have an interactive classroom where pupils singly or in groups scattered in different places listen to lectures, lecture demonstrations and panel discussions *while interacting with the resource persons*. The resource persons may be distinguished scientists who can convey their excitement of doing science to their audience.

2. In the era of shrinking library budgets and escalating prices of books and journals, the networking of resource libraries with electronic transfer of information can supply the needed browsing facility to the student and the teacher as well as the facility to access the book or journal remotely. If science courses and questions are so designed that the student feels the urge to search for information that would provide the answers, these datamining systems can be very effective in motivating him/her.

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3. The electronic mail will gradually replace the conventional "hard copy" mail, often called snell-mail for its comparatively slow speed. It also allows two or more persons to "converse" on their computers, to access databases in different parts of the world, to operate telescopes remotely, etc. By saving physical travel and money it can make a future educational system much more efficient and cost effective. Through such e-mail dialogues, students from different colleges, in different

cities even, may exchange views.

Recall the episode of Lord Ganesha drinking milk, which was reported a few years ago. Although the 'miracle' was soon enough debunked, it brought home to us the remarkable swiftness with which information (or, in this case, misinformation) can travel across the world. Indeed the miracle was not in the Ganesha idol sucking in milk from a spoon, it was in the way the news spread across the world! If misinformation can propagate so fast, why not real information? Indeed the whole sphere of higher education has to adjust itself to such rapid information transfer. No country planning for the future of its education can afford to ignore this potential. For a country like India with its far flung and difficult - to - access areas this will be a boon. It will indeed be a tragedy if our planners fail to cash in on this mode.

4. Technology provides new instruments in different scientific disciplines. The astronomers have their telescopes, the nuclear and particle physicists have accelerators, for example. In each discipline there are sophisticated facilities. Unfortunately they cost a lot and providing an expensive facility to each and every university becomes economically unfeasible. Even where some instruments have been provided, the experience to date has not been very encouraging either: with the expensive equipment lying under-utilized or even inside the unopened crate. How do you solve this problem?

Even in advanced countries with greater prosperity, the shrinkage of available funds in relation to the cost of the required research facility and the low utilization factor of such facility, have forced universities into a sharing mode. Thus expensive facilities like telescopes or accelerators are shared by many institutions. For example, the National Optical Astronomy Observatory in the United States is run by the Association of Universities for Research in Astronomy. A similar culture needs to be popularized in India. A beginning has been made by introducing *inter-university centres* in areas inadequately covered by universities. A typical IUC

would act as a nodal point providing access to advanced and expensive facilities to all universities interested in that field.

This mode has to address and circumvent a resistance from the universities themselves for whom it is intended. They would tend to see it as a diversion of funds, which would otherwise have come to them. Actual demonstration of its success would be more effective than any verbal argument put forward in favour of such a mode. As such it very much depends on the few IUCs created so far to show how effective the "shared mode" can be.

5. It is still not too late for bringing the autonomous research institutions closer to universities. In a typical case there may be a university and such an institution (or several of them) in the same city. A memorandum of understanding between the university and such an institution should allow usage of the laboratory facility of the institution to the university and it should be made mandatory by the institution that each of its scientist staff member will give at least one course in the university. Although with their present mindset, most staff members may initially think lecturing a burden, they will come to appreciate it when they begin to get good students wishing to do research in the field of the institution. Let me recall one episode in the University of Cambridge which I had observed personally.

While the proposal for setting up the Institute of Theoretical Astronomy (IOTA – hereafter) was being discussed in the University in a public debate of its academics, a view was expressed that the research scientists at IOTA should not be allowed to teach the mathematics undergraduates at the University. As a young post-doctoral fellow who aspired to be one of the staff members of the proposed institute, I thought that this was a great blessing, since those who do research at IOTA would then be spared the burden of teaching and examining.

Fred Hoyle, who had been the prime mover of the proposal to establish IOTA, however, interpreted this view negatively. He mentioned to me that if you lecture to students, you can

motivate them to do research and with luck attract the bright ones to the Institute. If you are prevented from lecturing, you may find talented students being diverted elsewhere. Indeed, in the early years it did become hard for IOTA to attract good graduates coming from Cambridge's prestigious Mathematical Tripos Examination. Later the situation improved when more of the IOTA staff began to teach in the university. Perhaps I should record here that I myself had been motivated towards opting for my career as an astrophysicist because of Hoyle's inspiring lectures when I was a Tripos student. Indeed, what Hoyle foresaw in 1965, has come to pass in the Indian context today.

6. The UGC may try an experiment of its own on setting up a centre for science and technology wherein students are admitted after the XII Std on the basis of their performance in an entrance test and interviews, with the aim of studying for a 5-year programme leading to the master's degree. I believe that three such centres are being set up and I hope that it they will be run without compromising the criteria of strict merit and achievement. Such centres can be within a university, although they should enjoy functional and financial autonomy.

7. Finally let me return to the medical field. It is not enough to study medicine and surgery up to the degree level and then acquire experience followed by established practice. Like all other scientific fields, those of medicine and surgery are rapidly evolving and it will reflect badly on a practising doctor if he does not move with time. While frequent reading of literature and attending workshops on special developments help, it is like being given a ride in a motor car, with yourself having no control as to where you are going. A real sense of being in the driving seat comes only when you participate in research and are an active member of the forward moving juggernaut of science. With genetic mapping a reality and the prospects of understanding the complex but marvellous machinery that we call the human body that much closer, medical science is on the threshold of revolutionary changes. Micro and now

nano-technology are likewise bound to revolutionize surgical techniques and non-invasive methods of correcting body-defects will become increasingly available. It is more fun to be part of this ongoing urge to 'understand and improve' than to simply watch as a spectator what it delivers.

Research is possible not only in futuristic applications of technology or the basic genome-project type studies of the human body, but also into our past. Ayurveda, the ancient Indian science of medicine and surgery, which had doyens like Charaka and Sushruta, is expected to contain valuable and as yet untested information on drugs and treatments. As the episodes of turmeric and 'neem' have shown, the information can command intellectual property rights for whosoever finds it. Is it not time that our own medical scientists find this information through their researches, rather than have another Ronald Ross come from the West to find it?

Concluding Remarks

I end with one more example from my old university, Cambridge. When I went there as an undergraduate, during the first few days, I attended what was called a *societies' fair*. The fair provided a series of stalls in which the new student was presented with information on the functioning of the many societies, with a varied range of interests. There were societies of sportsmen, fishermen, roof-climbers, cyclists on the one hand and societies for those who liked mathematics, physics, biology, etc.; I recall their total number exceeding hundred. I became member of societies relating to mathematics and astronomy and through their lecture programmes was able to listen to many eminent persons from within and outside the university.

I feel that the above hobby-based society-culture needs to be encouraged in our universities and colleges so that the vision of the student can be broadened and opportunities become available to him/her to exercise surplus energy constructively. Some societies in basic sciences will go a long way towards supplementing formal education. An odd lecture heard in a society's informal setting can sometimes be more motivating than hours of formal training.

I hope I have not stretched your patience too far, while getting carried away by what I see as the gathering of real danger clouds on the horizons of our higher education scene. The growing apathy towards basic sciences in our student community needs to be recognized as a symptom calling for speedy treatment. For on the younger shoulders of today shall rest the façade of science and technology of tomorrow.

Thank You!

Profile
Jayant Vishnu Narlikar

Biographical

Jayant Vishnu Narlikar was born in Kolhapur, in the state of Maharashtra, India on July 19, 1938. His father, Vishnu Vasudeva Narlikar was an eminent mathematician and Professor and Head of the Department of Mathematics at the Banaras Hindu University, Varanasi. His mother, Sumati Vishnu Narlikar (nee' Krishna Shankar Huzurbazar) was a Sanskrit scholar. Jayant grew up in an academic and scholarly environment at home with a liking for both mathematics and Sanskrit. He went to the University Children's School in the B.H.U. campus where he was consistently on top of the class in all examinations including the matriculation one. His good academic performance continued till the Bachelor of Science degree examination at B.H.U. in 1957.

After graduation he went to Cambridge University, U.K. for higher studies in mathematics. He joined the Fitzwilliam House, Cambridge in 1957 and obtained his Cambridge degrees B.A., in 1960, M.A., in 1964 and Ph.D. in 1963. While at Cambridge, he became Wrangler (in 1959) and achieved distinction at the Part III of the Mathematical Tripos along with the Tyson medal in astronomy in the following year. As a research student he was the W.A. Meak Research Scholar of the University of Cambridge and won the coveted Smith's Prize in 1962. Later, he went on to win the prestigious Adams Prize at Cambridge in 1967. In 1976 he received the Sc.D. degree of Cambridge University.

In 1966, Jayant Narlikar married Mangala Sadashiv Rajwade who has a Ph.D. in mathematics from Mumbai University. They have three daughters, Geeta, Girija and Leelavati.

Academic Career

Narlikar did his Ph.D. under the inspiring guidance of Fred Hoyle. In 1963, he went to King's College, Cambridge as Berry Ramsey Fellow (1963-69), later to become a Senior Research Fellow (1969-72). He was also the founder staff member of the Institute of Theoretical Astronomy which was

established in Cambridge in 1966 by Fred Hoyle. He held this position till his return to India in 1972 to take up Professorship at the Tata Institute of Fundamental Research (TIFR), Mumbai. At the TIFR he was in charge of the Theoretical Astrophysics Group, which he developed into a strong centre for astrophysics. He became Senior Professor in 1983, and upon leaving the TIFR in 1989, he held the position of an Honorary Professor there for three years.

In 1988 the University Grants Commission decided to set up the *Inter-University Centre for Astronomy and Astrophysics* (IUCAA) at Pune. At the invitation of the U.G.C. Chairman, Professor Yash Pal, Narlikar became the Founder-Director of IUCAA in 1988, first in an honorary capacity and then as a full-time Director since 1989. Through his efforts, aided by many colleagues he has been able to bring to IUCAA international stature as a centre for research as well as pedagogical activities.

Research Contributions

Narlikar has made important contributions to theoretical physics, astrophysics and cosmology. He has been a strong critic of the more popular big bang cosmology and has worked on alternative approaches to the problem of origin and evolution of the universe. 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. This work is known as the Hoyle-Narlikar theory of gravitation.

He had worked with Fred Hoyle in the early sixties in a mathematically rigorous description of matter creation in cosmology, which provided a sound theoretical framework to the steady state cosmology, arrival to the big bang cosmology. Lately, in collaboration with Fred Hoyle and Geoffrey Burbidge, he has been associated in the modification of the steady state cosmology as the Quasi-Steady State Cosmology (QSSC), which is based on the Hoyle-Narlikar theory of gravitation.

There are several other areas including quasars, high-energy astrophysics, quantum cosmology, action at a distance electrodynamics, in which Narlikar has made major contributions. He was the team leader of an international

effort which successfully collected air samples from the troposphere and analysed them to establish the existence of micro-organisms at heights as great as 41 km. This discovery may have great significance in the field of exo-biology.

Honours and Awards

Jayant Narlikar 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), the Yashwantrao Chavan National Award (2003), 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 doctorate from his *Alma Mater*, the Banaras Hindu University as well as from four other universities. He was decorated Padmabhushan by the President of India in 1965.

Science Popularization

Apart from his research work, Jayant Narlikar 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. For his contributions to science popularization efforts he has received the Indira Gandhi Award of the Indian National Science Academy (1990) and the Kalinga Award of UNESCO (1996).