Face to Face

This section features conversations with personalities related to science, highlighting the factors and circumstances that guided them in making the career choice to be a scientist.

Mulling Over Mathematics

M S Raghunathan talks to Sujata Varadarajan

Spring is not in the air, but the fountain in front of the Mathematics department almost belies this notion. You look around for Prof. M S Raghunathan with a mental image derived from a photograph wherein formally attired, he is signing the parchment book of the Royal Society, London, with a traditional quill. You spot a slender, sprightly figure with a jaunty step, a gleam in his eyes, overflowing with energy and enthusiasm.

Conversation with this erudite and quick-thinking professor is remarkably down to earth, enjoyable and stimulating. He is a skilled orator and writer, and has attempted to try and po-pularize mathematics amongst laypersons and students of various disciplines. For an eminent mathematician whose work has had considerable impact on one of the core areas of basic mathematics, Prof. Raghunathan is amazingly accessible and matter of fact.

Prof. Raghunathan began his career in mathematics at the Tata Institute of Fundamental Research (TIFR, in Bombay, now Mumbai) as a research assistant and remained associated with this institution as a member of the faculty and later, as a Professor of Eminence. His work has been recognized and appreciated not only through awards and honours (including the Third World Academy Prize, the S S Bhatnagar Award, the Padmashri, the Srinivasa Ramanujan Medal and fellowships of several prestigious academies), but also by various eminent scholars of Mathematics and Physics. The Nobel laureate S Chandrashekhar, while talking about the status of Indian research said in an interview, " …On the faculty of TIFR now, just to mention one name, Raghunathan – he is considered by everyone outside as one of the best mathematical intellects."

Prof. Raghunathan's potential was evident right from the early stages of his career – he solved his thesis problem (suggested by his advisor, an eminent and outstanding mathematician, Prof. Narasimhan) in a few months, but overlooked mentioning it to him for several weeks. As soon as he finished his PhD, he was appointed Associate Professor at TIFR, where he was actively involved in research as well as teaching and guiding a relatively large number of students, by choice. His emphasis on rigour and scholarship has left a mark not just on his selection and approach to mathematical problems but also on the quality of training that his students received. At an early stage in his career (in 1970), he was invited to give a talk at the International Congress of Mathematicians – a very prestigious Mathematical Congress organized once every four years. Since then, he has continued to make strides in various areas of pure mathematics (especially number theory).

While mathematics appears to many as an obscure subject dissociated with real life issues, no one can deny its pure and exacting nature. It is my feeling that mathematicians (especially those working in pure mathematics) view numbers differently from the rest of us. This difference is not determined by one's intelligence but by an inner sense of appreciation of the beauty of mathematical principles and satisfaction in striving to extend that beauty. Indeed, many who have made a mark for themselves appear to have done it out of the sheer enjoyment of doing the work. Unfortunately, this is not a field that is easy to describe in a relatively limited time frame to lay people, and though Prof. Raghunathan has a flair for communication, the scope of this interview does not allow for a technical explanation of his work. In this short space, he provides however, an insight into how he got drawn to the subject, the aspects of mathematics that he enjoys, the current status of mathematics in the country and his attempts to enthuse the youth to consider it as a career.

M S Raghunathan, visiting the Department of Mathematics, Indian Institute of Science, Bangalore, July 2008.

SV: Could you tell us about your early education and your introduction to mathematics?

MSR: I grew up in Madras (now Chennai). My grandfather had a timber business which was running very successfully. We were quite well off and were considered one of the richer people in Madras.

I went to three different schools in Madras: first, a very good, neighbourhood school run by a German lady, Ellen Sharma. At some point my parents shifted me to a more famous school in that area known as P S High School and later, they decided that I should go to an English medium school – till then I was in a Tamil medium school. They shifted me to the Madras Christian College School. I was there for two years. I completed high school in 1955 – school ended in the 11th standard in those days, and then studied in Bangalore for two years. There was an age bar for entrance to the University in Madras and I was six months short of the age bar. Bangalore colleges were under Mysore University, which didn't have this age limitation. It was a peculiar thing because you could go back and join the (Madras) University at a higher class. The age restriction was when you were entering the University, no matter at what stage you entered (laughs). So, many Madras students used to do that kind of a thing " move out just for this period of two years and then return and join the University.

And when I went back I joined the mathematics course – what was called the BA Honours in Mathematics. I joined the course not because of any particular liking for mathematics. I liked mathematics but I liked everything else as well. There's no subject which I liked any more or less – I enjoyed everything that came my way. But of course I was quite proficient in

mathematics; I was never really good at exams though. My teachers had no problem in declaring me clever but I don't know how they arrived at that conclusion because my exam marks were never great. They were lingering around 60% to 70%, which was certainly not the case at the top. The toppers were all in the 90s.

But marks were important to get admission in the right courses. I wanted to do what was called the Honours course in Physics which was a three-year course in those days, with one extra year (compared to the BSc) at the end of which you got a BA (Hons) degree but a year later you got the MA degree. They called it MA by 'efflux of time' – it's very peculiar (laughs). Actually in the degree certificate, it is written 'MA by efflux of time' – it must be an Oxford or Cambridge practice imported into this country. But it was a good course, it was a rapid course and you covered more material. In three years you covered the material you would normally cover in four years.

If I had got admission to the Physics Honours course, I would have taken it. But that was much in demand and I couldn't get admission. But I could get admission to the Mathematics Honours course. Actually, my father would have been happy if I had done engineering, for which also I had applied, but once again marks were insufficient to get me into engineering colleges. So I ended up in mathematics. Nevertheless, there's no question that I enjoyed mathematics always. However, from my school days I have a clean record – I've never scored a 100% in mathematics in an exam. Anyway, I joined this Mathematics Honours course and once again I passed the course with the minimal first class. It was a touch and go thing: the examiners were from different colleges and one of the examiners was from my college who appealed on my behalf and jacked up my marks so that I would get a first class. He told me this himself afterwards. That actually did not matter because at that point I applied to TIFR.

Once again, I applied because a number of my friends were applying; I had not made up my mind to do mathematics at that time either and still had ideas of going back to physics. I wanted to do some theoretical physics and applied for a Theoretical Physics course. I applied for all kinds of things, even for a master's degree in Politics! I got admission to everything I had applied for. I chose TIFR partly because (vanity was an important factor) I was told only 2 out of 200 who had applied were selected and I was one of them. It was in 1960.

Even after joining TIFR, it was not clear to me that I wanted to pursue mathematical research. It took me nearly two years before I finally made up my mind. I had all my options open. My father was running his business and that was an option. I could also write the IAS – that was also an attractive proposition. But at the end of two years I felt that I enjoy mathematics. Well, that's how I came to stay in mathematics.

SV: What were your experiences as a student at TIFR?

MSR: We used to stay in a hostel near the Gateway of India. It was in fact the servant's quarters of old Yacht Club which had been converted into a student's hostel. It was a terrible place – for instance, there were bed bugs, rats running around and water was a perennial problem.

I was constantly in the company of two others. I used to go fairly early, around 9 o'clock to the Institute, which is located in Colaba. The other two would turn up somewhat later. We used to spend the whole day in the Institute – eat lunch there, and sometimes dinner also, but at one point of time we used to come back for dinner in a mess near the hostel. We would eat dinner and then go back to the Institute and work there till about 1.00 or 1.30 at night, sometimes even later. Then we would go back to the hostel, stopping on the way at the Central Telegraph Office. That was one place where you could get tea at that hour. My friends Pavaman Murthy and Ramanujam would work on even after that.

I was the only student who joined the programme in 1960. There were two selected but the other did not join. So they couldn't organize any lectures for me and I learnt most of my mathematics through discussions. There were some who took a very special interest in me – some of the senior students put me at ease and gave me confidence that I was a reasonable student, because in Madras I was of course recognized as good, but there were other students who were scoring better marks and so on. I must say I did not think that they were cleverer than me, except one person (laughs), but it was a different experience at TIFR because the selection had been done so carefully. All these guys were very good as students, so to hold my own against them was not that easy, but I was not exactly competitive by nature so it didn't matter that much. Of course it probably helped because I was the only student in my batch.

My guide was Prof. Narasimhan and he set me a problem and I was lucky enough to solve it very quickly. In fact what I had done was to solve the problem in a special case but I never even told him because I thought it was not sufficiently interesting. Only a couple of months later I casually mentioned to him, "Oh, I can do it in that special case." He was surprised and asked me for an explanation. He said that it was good enough for a PhD thesis. So, I did not even know that I had a thesis when I actually had one. I didn't rate it that highly, but he knew better (laughs). It took a while for me to write it up.

In those days, in TIFR, nobody bothered to register for a degree, it was not known as a graduate school. We all joined as 'research assistants' and we thought of it as a regular job, and your job was to simply study mathematics and do research. The degree was unimportant. Those of us who registered for a degree were the ones who had already done the work for it. That was the attitude in those days. So, it was after I had done the work, in late 1963, that I registered for a

degree. My MA degree was not recognized by Bombay University – BA Honours was considered just as a BA degree. So they said I have to wait for three years instead of two (if you had an MA degree you had to wait only two years). But there was some correspondence and my guide, Prof. Narasimhan saw to it that they broke the rules in my case and by early 1966, I got the degree.

Well, apparently they thought highly enough of my work. I had done something more after the first piece of work and put it also into the thesis, and my guide and others made me an Associate Professor in 1966. Of course, it was very flattering – it was also at the same time a huge responsibility because I wasn't sure that I was good enough to be a professor at TIFR at that time. They call it Associate Professor, but that in those days it was the most important step in TIFR.

SV: What after that?

MSR: Well, the same year I also had a visiting membership at the Institute of Advanced Study in Princeton. In fact I received the formal letter telling me that I was appointed Associate Professor after I went to Princeton. I made good progress in my work. You know, mathematics research is unlike research in most other fields. It's completely individual work. There's not much collaboration that takes place. Actually, things are changing a little bit – there's a lot of collaboration coming up these days. But certainly, in the sixties, when I entered the field, the norm was for single author papers. Of course, you talked to other people but you didn't really discuss the nitty gritties of the problems which you were looking at and so on. The conversation was generally to absorb mathematics culture in a general way. Somebody explains to you something you don't understand – that kind of thing.

Princeton has always been a great place for mathematics. For the entire mathematics community, it is considered a Mecca of sorts. I enjoyed myself professionally. But you know Princeton is not a great place for socializing. The Institute is in an isolated place and I didn't have a car and mobility was severely limited. It's a quaint place – there are these permanent members – all formidable mathematicians. But during my stay I didn't interact with any permanent member, except Armand Borel who worked in an area very close to mine and it was enjoyable. In fact the permanent members were Olympians – distant people, you're always a little scared of approaching them. And on top of that, of course, coming from an Indian background you always have greater respect for older people, you expect them to initiate the conversation and those guys never did such things. In fact there was another mathematician, Selberg, whose work was also very closely related to what I was doing at the time. In fact, it's a paper of his that led to a whole series of problems, one of which I was able to solve. So, naturally, he was the person for me to talk to. But I never spoke a single word to him during my entire stay. He would come there, to a lounge sometime in the afternoon, sit in a corner, read the *The Wall Street Journal* and

go back. I was too scared to approach him. He was a big man. He was a Fields Medalist.

Another permanent member with whom I talked on and off was Harish-Chandra. To him I did not really talk mathematics, though his area was not very far from mine. It was always general things about mathematics, about Indian mathematicians and so on. Of course, I suppose because I was Indian he made some special effort to put me at ease and make me comfortable. The most interesting thing about Princeton was that you had other visitors with whom you could interact. It was a fruitful year for me.

Then I came back to India and settled down in Bombay. Well, as it happened, because of the work I had done in Princeton, I became reasonably well known and I received an invitation to visit Yale University. So I spent a year at Yale and collaborated with Howard Garland. That was also a good year for me; TIFR was quite liberal about allowing such visits. After that I spent practically all my time at TIFR. From the beginning, TIFR had this facility for having always a number of visitors. There was money available for inviting visitors for three months, four months, So though I didn't go abroad often, there were visitors in TIFR, but not too many in my area – but I didn't really feel the need for travel abroad.

In 1970, I spent a couple of months in Bonn, Germany, and just before that I gave a talk at the International Congress of Mathematicians (ICM). The ICM takes place once in four years and an invited talk at the Congress is supposed to be prestigious. It was flattering to get invited there and three of us at TIFR were invited for talks at the same time – my teacher Narasimhan, Seshadri and I. Nowadays there are about 180 invited subject talks and 20 plenary talks. In those days there were much less – 120 to 150 talks. In fact, one measure of TIFR's reputation in mathematics is the fact that practically in every Congress since 1970, we have had at least one person from TIFR giving an invited subject talk. Unfortunately, no Indian has been invited to give a plenary talk. Two people of Indian origin, Harish-Chandra and Varadhan have given a plenary talk.

And after that, what? I've always enjoyed being at TIFR – I've been most at ease there. I always liked talking to people at TIFR, students in particular. I've had a role in decision-making at TIFR right from the time I became a faculty member, from 1966 onwards. In the early days, of course, I was somewhat nervous about exercising my privileges, but at some point I picked up enough self confidence to play an important role in decision-making.

I have an attitude here – I do not know to what extent it is shared by other people. I enjoy research, I am quite happy to see that my work is recognized as interesting or good, but even if it appears good and interesting now, after twenty years what is it going to look like? It's not clear. Some work gets completely wiped out even if it's fashionable and exciting now. So my

own personal feeling is that you render a greater service to science if you pass on solid knowledge which is accepted as important and interesting, to the next generation. Your own research may or may not attain the status of that solid knowledge. So, I have a strong bias in favour of scholarship. I believe that good research will emerge only if there is a good background of scholarship, otherwise you'll probably end up doing something narrow and not so interesting – it won't last.

In fact – this is my personal opinion – one of the reasons that Indian science has not taken off as well as it should have is the result of de-emphasizing of scholarship. People want to do research right away and very often they seem to think that teaching is not something which they want to do, which I think is an incorrect attitude. Of course, an overload of teaching is bad without question, but research divested completely of teaching – I doubt if ultimately it is really the right way.

I think scholarship is important. In the early days after Independence, even during the early 20th century, people started thinking that our tradition had emphasized scholarship too much. So the emphasis was that we should do original thinking. There was some sense in it because over generations people were writing commentaries about earlier work. They were not producing their own work. So there is something in that – there had to be some emphasis on original thinking, but I think we swung too much to the other extreme.

SV: What was the scenario like when you entered the field?

MSR: In the School of Mathematics, TIFR there was considerable emphasis on mathematical scholarship, but that was not the case in many of our other institutions, and I would say that it continues to be the trend. I mean, even now people talk in terms of research, they're not really bothered about how much the person knows. Unfortunately, even at TIFR the emphasis on scholarship has declined considerably. This is partly because in the old days we didn't have a graduate school. It was not a place where people came, got their degree, and went away. People came there with a contract and they would go on. Some of them would continue and some might leave if they didn't do so well – that was the philosophy. But now we have a regular graduate school; students come in only for a degree. At the end of the day most of them don't get absorbed. That is the kind of situation now. And when you have a graduate school, the PhD becomes all important and you have to work towards a problem – it's always research that matters, the scholarship takes second place.

Originally, it's true that our tradition emphasized too much on scholarship, too little on original thinking, but we have drifted away from that because we wanted to follow USA. In USA, people specialized very quickly, they didn't really have a lot of scholarship, and they were doing very

well. But what we forgot at that point, what we didn't pay attention to is the fact that a new generation in the United States might have done that, but the people who taught them were European scholars, who were really scholars of great breadth – they had tremendous knowledge of various different fields and they could put a student into some path very quickly. We didn't have those kinds of people here in large numbers so it was not possible for us to direct people to the right streams. Even in the United States of course it's true that there are schools where people are very narrow in their expertise. But if you take the really well-known places like Harvard or Princeton, those who are permanent faculty there are usually scholars with a wide range. But of course, the tradition in Europe is much better for that kind of thing. European scholars have a much better perspective of mathematics in general.

SV: Are there any aspects of your work which can be described to a general audience?

MSR: Unfortunately my work is not something which is accessible to lay people. It's in an area which is known as Algebraic Groups, closely connected with Number Theory. It also has connections with Mathematical Physics. But my own research work has more to do with Number Theory. Ordinarily, the notion of a 'group' is a somewhat technical concept which – er – it's possible to explain to physicists and maybe some biologists because crystallography has connections with groups. But 'algebraic group' is a little more sophisticated notion, which will require more background. Unfortunately most of advanced mathematics is like that. It's something which you cannot explain to lay people. The one effort I made at passing on some advanced mathematics was a talk which appeared in *Resonance* as a 2-part article on the Poincaré conjecture [1,2]. Reading that again, I don't know to what extent I have succeeded in making it understandable to someone with a high school background.

SV: The area that you selected to work in – did you do so actively or did it just happen?

MSR: It just happened. See, my thesis was in differential geometry. That was a problem which was suggested by Prof. Narasimhan which I worked on and which led me naturally to the subject which became my biggest preoccupation. Everything I have done has something to do with algebraic groups, but I've also strayed into what maybe called algebraic geometry related to Lie groups. But I am best known for my work in what is known as discrete groups. It continues to be an important area but in 1960s and 1970's it was even more exciting and very central. In fact I was essentially in competition with few other very good mathematicians at that time. Unfortunately, I got pipped to the post by one of them – Margulis, who won the Fields Medal. He, of course, is a better mathematician than I am. But, well, at one time, I was a competitor, so I can at least boast of having been a competitor to a Fields Medalist!

My personal taste in mathematics – the kind I like most is one which inter-relates different areas

within mathematics. See, there are people who just do algebra, algebra, and algebra. They think of nothing else. That kind of mathematics doesn't excite me sufficiently.

Essentially, thinking is done in isolation. You understand things better when you talk to people, but ideas themselves originate in your mind when you're alone. Mathematics research seems to me a lonely occupation. One of the things about pure mathematics is it's not clear what kind of problems you should take up because the guidance comes from aesthetics and not from any other considerations. What are the problems you're looking at? Why do people work on such problems? Something like Fermat's last theorem – why on earth is one interested? An equation like $x^n + y^n = z^n$; it's not clear why it's interesting. The only reason it's interesting is that people find it beautiful. They think, "Oh, this looks pretty", and that's the reason. See the way mathematics develops, you can go in any direction. If you look at Euclid for instance, to begin with, triangles may have some practical considerations, you want to understand what triangles are and so on – but you look at later theorems in Euclid's books – you find there's no connection with reality. One of the theorems in Euclidean geometry (it is not in Euclid's *Elements* – it was discovered in the 18th century) says that starting with a triangle you can describe 9 points relating to it all of which lie on a circle. Now, this is absolutely of no use wherever, in whatever context. But mathematicians find it exciting. Basically, pure mathematics is very much like the pursuit of art. The main thrust is because it's beautiful, it's not because it's relevant somewhere, especially if you work in an area like number theory. Of course, these days, even number theory has applications. But say about hundred years ago, no one thought of number theory as being useful.

It's true that mathematics has had a decisive influence in the Natural Sciences. Even Newton's science became science only because of the mathematics he put into it. In some sense, unless you start quantifying, science is not science. There mathematics is used. But, of the mathematics that is used, if you look back at its origins, it may have nothing to do with the applications it is used for much later. Of course, someone like Newton very deliberately set about developing the mathematics needed for his physics, his study of planetary motion, etc.

But there are other instances when mathematicians like Riemann (the mathematician who lived in the 19th century), have pursued something for its own sake, because it was beautiful and which later became extremely important. He developed something called Riemannian geometry, and that is absolutely essential for relativity, and when Einstein stepped in, it was a ready-made tool for him to apply. Einstein's relativity, especially general relativity, could not have been developed without this background of Riemannian geometry.

I would even say that the discovery of zero and the place value system may not have evolved because of any practical needs. Of course it's a very practical tool and we use it extensively in

our daily life, but if you look at the history of mathematics, it (the zero and place value system) was discovered in India. Not in Greece or Persia and so on. You know, long before this happened in this country, the Greeks, the Persians had huge armies with thousands of people in them. It would have been very convenient for them to make the calculations they would have needed based on the place value system. But they didn't discover it, despite great minds like Archimedes and Pythagoras and so on. It was the Hindu mathematicians who discovered these. They were obsessed with large numbers. They had names for powers of ten well beyond the million-million – 10^{19} or something, is up to which they had names – for which they could have had no earthly use – simply speculating about large numbers. Why? Why speculate about large numbers? Maybe it is because they found it beautiful or fascinating or whatever you like.

SV: You have done quite some work in trying to promote mathematics in various ways.

MSR: Somewhere around the mid-eighties is when I got involved a little bit with the promotion of mathematics. In 1983, the organization called National Board of Higher Mathematics was formed. In fact, it has an interesting history. You see there's a peculiar thing in this country – higher mathematics and nuclear physics are under the charge of the Department of Atomic Energy (DAE). This is because Homi Bhabha was fond of mathematics and wanted mathematics to be under his umbrella. He spoke with Nehru and Nehru gladly let him have responsibility for higher mathematics in the country. But the only thing DAE did for higher mathematics is to create TIFR (that was a very substantial thing). They had something called the Board of Research in Nuclear Sciences, which would finance research projects in mathematics.

My association: First of all I became a member of the Mathematics Subcommittee of this Board, of which Prof. Narasimhan was Chairman. We used to receive requests for funding for projects, but 99% of the projects were totally useless. Besides, mathematics projects were never financially intensive. There was always some student who wished to do a PhD but needed support, and we often found that the guide himself was not a particularly good mathematician and he/she focused on a problem that was not interesting, and so we were rejecting most of them.

But some of these people, even though they were not particularly good mathematicians, were excellent politicians and they started a constant battle for getting the responsibility for Mathematics from DAE to either the Department of Science and Technology (DST) or Human Resources. The point is that the DAE is located in Bombay. Many of these people were Delhi-based and had considerable clout with DST or Department of Education. It all started sometime in the sixties and especially in 1982 or 1983. A professional society the Indian Mathematical Society, which was controlled by a group of people essentially from Delhi, sent off a letter to the Planning Commission saying that they wanted mathematics to be removed from the charge of DAE. But once a department has a certain charge, it's not easy to take it out. So the government

referred the matter to DAE itself which referred it to TIFR. I happened to be at that time the Chairman of the Mathematics Department or *the team* as they call it. When that letter came, we responded by saying that the thing to do is for DAE to get proactive in trying to develop mathematics in institutions other than TIFR.

So, it was basically on the basis of that recommendation that the National Board for Higher Mathematics was formed. When it came into existence, Prof Narasimhan became the Chairman and I became a member of the Board and ever since I've been somewhat involved in promoting mathematics. In 1987, I became Chairman of that Board and stayed that way till last year.

I did try to initiate activities – see it's an extremely difficult situation because the first problem is – there are not enough good mathematicians around. What you can try and do at this stage is to see that the future students are good and that good people come to mathematics in the future, and that students undergo good training under good teachers. There are barely a dozen institutions in the country where I could say that the teachers are good. Bright students do not come into mathematics because the career opportunities are essentially limited for mathematics graduates. Now things are looking up a little bit but in the old days, the only career option was academic jobs, which were not particularly attractive in terms of emoluments. That is why over the years we have been unable to recruit a good number of good teachers. Now, if a bright youngster goes to some of the university departments and spends some time there, he/she will find it very depressing. There's no excitement in the air, people don't talk mathematics. Even universities which had at one time a thriving mathematics community, you don't find a single exciting person to talk to. I don't even mean great scholars – just somebody who is excited about mathematics. You don't find such people. So, in that kind of context, it becomes difficult for students, even if they are committed to mathematics. Where will they go? – is the first question. And over the years, undergraduate education has also become terrible. When bright people don't even want a university teacher's career, nobody's going to go to a college. The situation is pretty bad in the pure sciences. Mathematics started facing these problems some twenty years before all these other subjects and the situation is worse in the case of mathematics.

So our first problem, of course, was to identify talent and to persuade them to take up mathematics by various means. In fact, at the undergraduate level itself we tried to persuade them to go into mathematics because that is the crucial stage. We began to conduct the Olympiad programme. We offered a scholarship for the selected students – if they pursued mathematics (at the undergraduate level), a scholarship which in those days was an attractive amount of money. But still there were no takers for that scholarship for five years, because people think in terms of "What after that?"

Then we changed the rules a little bit. We said, "Okay, do what you like. We don't care what subject you take in your formal undergraduate programme. But we'll have summer programmes and year-long correspondence programmes for you, and if you're willing to study mathematics (in this way), we'll give you a scholarship to do that." And in fact, many of the IIT kids made it because we chose them through the Olympiad screen. You know, they come to the Olympiad meeting – we tell them the scholarship is available – they're not interested, they all write the JEE and many of them are bright enough to make it and so join some engineering institution. But then we offer them a scholarship and they're willing to pursue mathematics (alongside their engineering studies).

Over the years we appointed a group of people as staff faculty for each batch of students who would be in correspondence with the students. Every year we had 25 to 30 students in this programme; we started the programme somewhere around 1994. This has been somewhat successful in the sense that, practically every year, there are a couple of students who switch to mathematics. They may do their degree in engineering or whatever, and during the year they get hooked onto mathematics and they do switch to mathematics, but unfortunately, they don't stay in the country. Very often after their PhD they want to go abroad and I've had the not-so-pleasant job of (laughs) having to write strong recommendation letters for them when they apply abroad. Well, I can't deny them the recommendations because I keep in touch with them and I know that they're good.

SV: It seems that there are more opportunities now if people want to do mathematics in India.

MSR: Yes, things are improving a little bit. There are opportunities in the financial world now. Financial Mathematics – things like probability have applications in the financial firms. Wall Street has been doing it for years. Some of the companies that have come to India now also do that. For instance, the Microsoft Research Group here has mathematicians. So, slowly something is happening. But it's a slow process; it won't be quick because first of all, only certain kinds of mathematics have scope in the private sector. The rest of the mathematicians have to depend on academic jobs, and the government again is highly short-sighted. First of all you need teachers at all levels, and unless you make the teachers' lives a lot pleasanter both in terms of emoluments and working conditions, they are not going to be willing to join.
Every now and again NCERT announces a syllabus change and there's a lot of fuss about whether something is in the syllabus or not. These are not things which matter most. The syllabus is something which you can copy from some foreign institutions which are working well, which is something you can do across the board. But once you do it, who is there to teach?

I'm also very sceptical about the so-called educationists. They concentrate all the time on communication skills. Okay, there's something about communication skills, I'm not denying

that there's a role. But the most important thing is that you have the material to communicate. Your teachers are often not knowledgeable enough about the subject and that is where we cut no ice.

SV: What other interests do you have?

MSR: Precious little. Well, in the recent past, I've written a few things to address to the lay public or at least to the scientific community. That's about the only thing outside mathematics and mathematics promotion that I've been interested in. For instance, I wrote an article in collaboration with Prof. Rajashekharan, a physicist. It was for a volume of a series called *Perspectives in Science Literature*, and we wrote about science in Madras University. My contribution was about mathematics and the way it has developed, not just in Madras University alone but in the South in general. I really don't have any serious interests outside of mathematics. You know, in some sense, I feel that I should do more about science policy in general, but it never translates into action.

SV: Is there anything else you would like to communicate to the readers?

MSR: I can say this – many college students who like mathematics may not opt for mathematics as a career, for various reasons. But it's a very interesting career and mathematicians, contrary to what most people think, are not uninteresting people. If you have intellectual inclinations, this profession is as good as any (though) you'll probably never make the kind of money that people make elsewhere. If you are reasonably successful, it's a good profession to be in because the excitement, the enjoyment you get out of research or even simply learning, understanding something cannot be matched by anything else.

I've had highs of a kind which I don't think the non-researcher will experience. Of course, it's also fraught with possible disappointments. It may sound like a platitude, and I suppose it is a platitude " the enjoyment lies in doing it and not expecting returns, so to speak.

Suggested Reading

[1] M S Raghunathan, Kaun Banega Crorepati – A Million Dollars For A Mathematician, Part 1. Of Mathematics and Mathematicians, *Resonance*, pp.40-50, August 2002.

[2] M S Raghunathan, Kaun Banega Crorepati-A Million Dollars For A Mathematician, Part 2. Poincaré Conjecture, *Resonance*, pp.56–68, September 2002.