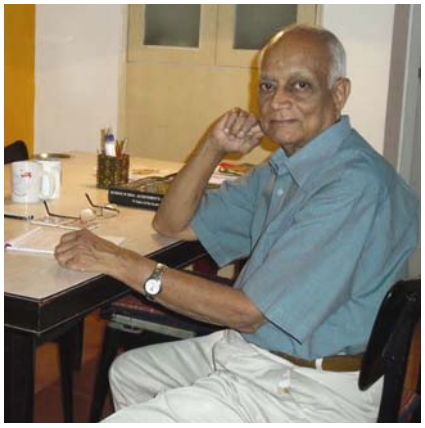
The magic of the living world

It is indeed easy to fall in love with botany – all that one needs to do is spend an hour or two with H. Y. Mohan Ram, a teacher and botanist with over five decades of experience. A scientist from one of the leading institutions of our country once described him as 'the best botanist in India – in terms of knowledge, experience, scholarship, accomplishments and above all, approachability and interest in students'. I realized the truth of this statement during conversations with Mohan Ram about his life and work, and about his specialization – 'general botany'.



H. Y. Mohan Ram at his residence in New Delhi, 13 November 2010.

On his life and work

The making of a botanist

Like any other young person, I wanted to become a doctor (laughs). But even as a student of the intermediate class, I would go for collecting plant specimens with Dr M. A. Rau, who was doing his Ph D at that time. Mysore was much more picturesque – there was more greenery, especially on the Chamundi Hills. For my B Sc, I joined St Philomena's College. There, I was influenced by B. N. N. Rao, who was fond of taking us out on trips to collect plants, and also knew a good deal about ornamental plants. Then it struck me that botany was a very nice subject to pursue.

Just after my B Sc, the Principal of my college, Mr C. J. Varkey, asked me to join as a demonstrator. He was formerly the Education Minister in Madras, was a follower of Gandhiji, and had written a book on basic education. He was a very unusual person. You might have read the reasons why I joined the Botany Department[1,2] (laughs). I was around 19 at that time, but my professor allowed me to teach some of the lecture courses also. Actually I learnt botany only when I started teaching. Our college was surrounded by lots of vegetation; we could show students how plants live, how they grow, when they flower and set fruit, and how they disperse their seeds … There was abundant opportunity for doing field work, which I liked very much.

Later, I came in contact with Dr N. K. Anant Rao, who was a Professor of Agronomy at B. R. College, Agra. The Principal, Dr R. K. Singh, had a Ph D from Harvard in education (he was a student of John Dewey), and had seen how American students used to struggle to study by taking up part-time jobs. He felt that anyone who is deeply interested to study must find some support, and offered me an assistant lecturer's post for fifty rupees a month. My eldest brother, Sharada Prasad, gave me another fifty rupees. So I managed to do my M Sc and stood first in Agra University. In 1953, I came back to Philomena's College, but after three months, I was offered lectureship in the University of Delhi, where I taught for 42 years. There, I came in close contact with one of the most outstanding botanists of the country, Panchanan Maheshwari – I think I can't tell you how much that mattered to me.

A botanist's passion for the history of science

I was always interested in history even in school. In Delhi University, P. Maheshwari and D. S. Kothari felt that all the students of science must have a course on the history of science. Maheshwari himself used to teach this course. He told me a small story about that. One day, when he was teaching history of science at Dhaka, where he worked before coming to Delhi, he found the lecture hall full. He thought, 'All right, these children are interested in history'. Suddenly, it stopped raining and half the class walked out. They had come because it was raining outside! (laughs). As the department at Delhi developed, Maheshwari couldn't find time, and so he asked me to teach history of science.

One of the topics students enjoyed greatly was germ theory of disease. Another was what determines whether a boy is going to be born, or a girl. And how does a newly hatched egg become an adult – that's also a fascinating subject to teach. I also taught history of biology to physics and mathematics students of St Stephen's College. I used to refer to Charles Singer's *A History of Biology to About the Year 1900* – a beautiful book.

This fascination with the history of science continued when I was the Editor of publications and later Secretary of the Indian National Science Academy; Prof. C. N. R. Rao was the President. Our Academy brings out Biographical Memoirs of the Fellows – when a Fellow passes away, a detailed account of his work and important publications are documented. Rao said, 'Why don't we also write about contemporary scientists and what they are doing?' So Prof. S. K. Joshi (who was also a Secretary), and I wrote letters to all the 530 Fellows, and 441 responded – quite encouraging for the first attempt. I edited articles dealing with biological sciences, and Joshi covered those dealing with physical sciences. Two volumes under the title *Profiles in Scientific Research: Contributions of the Fellows* running to a total of 1561 pages were published in 1986. These were subsequently updated in 1995. This is current history in a way.

On his ongoing work on CDs about plants

These will be mainly aimed at children, but anything that is written for children is also good for adults (laughs). There'll be pictures and some reading material. I've chosen about 50 different plants, like coconut, tomato, potato, chillies, pepper, mango, coffee, cotton, bamboos, lotus, *Cannabis* … I also want to put in the banana plant. I have worked on the banana plant – there are many fascinating things that we don't understand. It is not a tree, it has no wood, but still it can hold up a 60 pound bunch of fruits. How does it do this?

On the magic of the living world

Plant adaptations and agriculture

Some people think plants are no organisms to work on. But I think the study of plants has a lot of future. The world is already overpopulated, and yields in many crops have almost reached a plateau. I now see a new trend in countries like Australia and Israel – they are trying to understand how plants adapt as they develop in a place, and then apply those principles to agriculture. Survival strategies of plants under abiotic and biotic stresses are very important.

Plant–microbe interactions

There are many microorganisms that live inside or attached to plants. They do a lot more than what we think they are doing. For instance, in the Thar Desert in Rajasthan, there is no nitrogen in the sand. How do plants grow? They have nitrogen-fixing microbes associated with their roots! A few years ago, scientists had isolated and identified ten culturable diazotrophic bacteria from the roots of sewan grass (*Lasiurus sindicus*) from the Thar Desert[3].

We generally think all fungi are bad – they cause diseases, spoil food ... But with mycorrhiza, it is different. D. J. Bagyaraj, K. G. Mukerji, C. Manoharachary, T. N. Lakhanpal, Alok Adholeya and others have done a lot of work on mycorrhiza in India. Many workers have shown that in all the tropical forests, the soil is very poor in nutrients. So they say that tropical forests are dependent on mycorrhiza, rather than mycorrhiza being dependent on the forests (laughs). Ramesh Maheshwari has brought to light many interesting things about these fungi. [*Ramesh Maheshwari has explained in very simple terms the role of mycorrhiza in facilitating nutrient transfer into plants in his articles in Resonance, and many interesting phenomena involving them*[4,5]*. Incidentally, R. Maheshwari was a student of Mohan Ram in Delhi University*.]

Pollination – a way to increase crop yield

There are two forces in botanical research. One is your own blue sky kind of thing – you just want to do something which strikes you as a challenge. The other is driven by our needs. In fact, it is unthinkable that a country that has done so well economically still has children who are going hungry. We need inputs from various branches of botany as well as related subjects to improve the situation. I'll give you an example – there are a number of crops that *must* have bees to pollinate them. Several years ago, Deodikar was working on this in the Maharashtra Association for the Cultivation of Science (MACS), Pune. The research laboratories of MACS have now been grouped under Agharkar Research Institute. Agharkar, incidentally, was a well-known botanist, who was invited to start the Botany Department in Calcutta University by Ashutosh Mookerji (who also appointed Shama Shastry from Mysore who had translated into English a palm leaf manuscript of *Arthashastra* to teach philosophy and logic. Another scholar he picked up from Mysore was Sarvepalli Radhakrishnan, who was then a newly appointed teacher in Maharaja's College).

Most agricultural scientists believe that an appropriate dosage of nitrogen, phosphorus and potassium (NPK) is what determines crop yields. But Deodikar showed that at the normal level of these nutrients, if you had one bee colony in a sunflower field, you will get several times the yield because seed set requires pollination by honey bees. I quoted Deodikar's work in my Presidential Address of the Sectional Committee on Plant Sciences at the Indian Science Congress held at Jadavpur in 1980.

An article came in *Current Science* many years ago on the lack of pollination management of cross-pollinated, self-sterile crop plants in India, in spite of a recommendation by the National Commission of Agriculture[6]. There is a beautiful monograph on insect pollination of cultivated crop plants, a USDA publication, covering around 200 crops and their pollinators[7]. What professional bee keepers in USA do is carry bee colonies in vehicles to different orchards and charge a substantial amount from the growers. One of my main interests has been the study of pollination ecology with Shivanna and Rajesh Tandon. It's not something very difficult to do, but it can have tremendous joy as well as benefit if you are dealing with a plant that is of economic value to the community. (See Bawa *et al.*[8])

Wonders of nature called seeds

There have been many studies on the longevity of seeds. The main problem in starting such research today is that you won't be there to know the results, because you'll be dead before the seed loses its viability (laughs). But still, a scientist called W. J. Beal started an experiment in 1879. He buried 20 bottles containing 50 seeds each of 21 species of plants and left some money with the Michigan State University, USA, and wrote a will saying, 'Every five years, take out some seeds and try to germinate them, and report the results in a journal'. This period was extended to 10 years later. *The American Journal of Botany* celebrated 100 years of Beal's seed viability experiment in 1981. The 15th bottle was taken out in 2000 – a few seeds of *Verbascum* germinated. This is probably one of the longest experiments being monitored.

There's a simpler way of conducting a seed longevity experiment. You go to a well-known old herbarium, bring seeds, note down the date of collection of the plants and germinate them. This is what a French botanist Becquerel did (not the scientist who discovered radioactivity). When London was bombed during World War II, a part of the Natural History Museum caught fire. The firemen quelled the flames, and the old seeds started germinating from the water-soaked herbarium sheets! Bulbs and rhizomes also started sprouting! You can understand the tenacity of life by studying seeds.

In the sandy desert near Bikaner, the whole area becomes green after one or two showers. The sand has natural seed banks, and any seed that has not been eaten up by animals survives. Some beautiful experiments were done many years ago by F. W. Went and Sorino in USA. They had a mobile van which would serve as a lab in the day time, and in the night, as a place to sleep. These scientists travelled extensively in the Californian deserts and collected seeds by sieving the soil, sorted them out, and identified them. They saw that seeds from each species required different amounts of rain for germination. So Went called them rain gauges! This is all not modern science, but isn't it fascinating?

It is a marvellous thing for children to do experiments such as weighing a mature dry seed – it will have the same

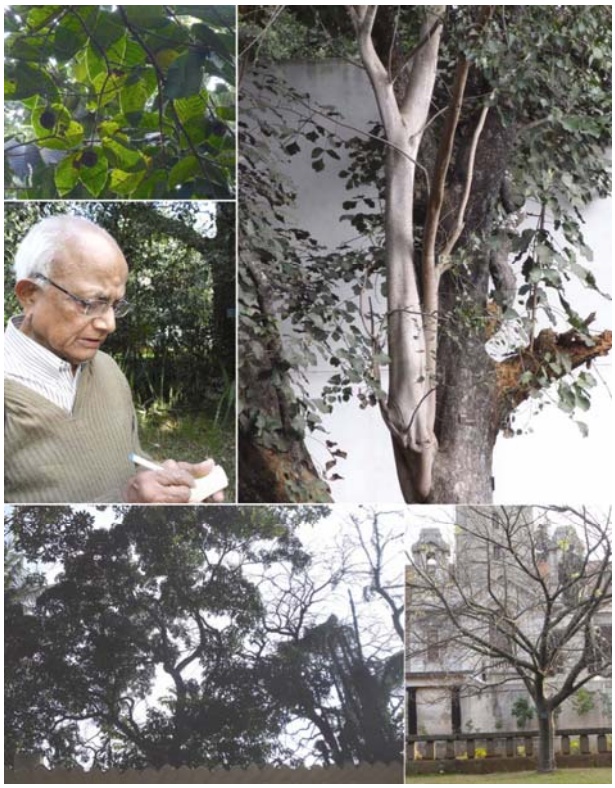
'Tree walk' in IISc

H. Y. Mohan Ram visited the Indian Institute of Science (IISc), Bangalore, in January this year. He took me on a short walk around the sprawling campus, telling me about the various trees that we saw on the way, with the familiarity and affection that one generally shows while talking about close friends or relatives. Right behind the Main Guest House where he was staying, is one of IISc's oldest trees – a flame of the forest. 'It has just one seed in each pod – that's why it is called *Butea monosperma.* I've seen drawings of this tree in *Hortus Malabaricus* that was written during 1678–1693. Even then it was one-seeded,' he explained. Unfortunately, a peepal tree that is growing on *Butea* might slowly kill the old tree, strangulating it. 'This campus is international as far as trees are concerned. K. Sankara Rao's books on the plants of IISc are fascinating,' he said as we went around the Guest House. 'Horticulturists and various Directors have planted a variety of beautiful exotics: *Calliandra* is a plant from Central America, *sapota* is from Mexico, *pannerale* is from Malaysia and Indonesia. This is a unique Australian tree, *Callistemon viminalis* – after flowering, the tip of the inflorescence becomes vegetative again, and there is a cluster of leaves at the tip. That is why it's called the "bottlebrush tree". There are two very beautiful specimens of *Cochlospermum gossypium*' he said, pointing to these trees that are native to South India and abundant in Tirupati Hills.

As we walked towards the gate of the Guest House, we saw a teak tree – an unusual specimen that has started branching very early. 'Teak looks different in different parts of India. This tree is darker leaved than those in Uttar Pradesh and Madhya Pradesh,' he remarked. We then went to the nursery, to see the two *Cassia moschata* trees that were planted by Nalini Dhawan many years ago; their flowers are of an unusual bronze hue. We could see the massive emerald green crown of one, and the bare branches of another – it was dying. Mohan Ram gave the gardener at the nursery, who was eager to preserve the trees for posterity, a few tips to make the obstinately hard *C. moschata* seeds germinate ('Treat them with dilute nitric acid, or keep them in a nylon bag under running water. The best thing would be to put them in a solution of potassium nitrate'). Mrs Dhawan also planted the two *Ceiba speciosa* trees in front of the Main Building. Her father, Nirode, was a famous horticulturist, and introduced many plants into India, including *Tabebuia impetiginosa*, which bears beautiful mauve-coloured flowers – he planted one of these just outside the IISc entrance.

As we walked towards the IISc Main Building, Mohan Ram told me about *Entada* – the impressively huge, awe-inspiring liana outside the Centre for Ecological Sciences (CES), 'It is very common in Western Ghats. The fruits are sword-like, woody and 1 m long and have many seeds in one-seeded compartments. When you shake a mature fruit, it creates a racket.' He told me that he saw young Soliga boys in the Biligiriran-gan Hills shake the fruit and drive away elephants! Right outside CES, there is a miniforest, with many species of plants from the Western Ghats. 'I like the miniforest because they haven't tried to keep it too clean. Over-cleaning is not very good for the health of the trees, because there is no replacement of minerals in the soil. Besides, the insects in the undergrowth attract birds. The man who planned Delhi, Lutyens, planted only native trees (with the exception of the sausage tree) in order to attract a wide variety of birds. Moreover, native trees have a very deep root system, and can absorb excess rain water,' he said.

Mohan Ram's favourite tree, *Neolamarckia cadamba* (Kadamba), grows near the Main Building. 'It is a member of Rubiaceae, but its leaves are not opposite decussate; they are superposed. The inflorescence is a globose head, and it has a very faint aroma. The whole flower-head becomes a fruit,' he said, pointing to the orange badminton ball-like fruits of the tree. When we came to the last tree on the walk, a *Spathodea* (African Tulip tree) that grows in front of the Main Building, he said, 'There is a liquid between the petals and the sepals of the curved flowers of this tree. I was shocked when I tested its pH – it is 10! I don't know why 10, though.' Mohan Ram has a way of making even the most common trees seem unusual.



(Clockwise from top left corner) Fruits of *Neolamarckia cadamba*; the peepal tree growing on *Butea monosperma*; *Ceiba speciosa* planted by Nalini Dhawan in front of the Main Building; the crowns of the two *Cassia moschata* trees in the Nursery; H. Y. Mohan Ram explaining the structure of the *Entada* fruit with a sketch.

weight over several days or even weeks. In fact, there is a tree called the Carob gum tree in Arabia – *Ceratonia siliqua*. It's a legume, and has a pod with 10–12 seeds. Every seed in the pod is more or less of the same weight whether it is close to the stalk of the pod or away from it. In Arabic, this seed is called *karat*. Arab traders had used these seeds for weighing precious stones, diamonds, pearls and all that. The word 'carat' has come from this word.

I used to give a course on economic botany... Some plant scientists dismissed it as mugging names and uses, but I dealt with it differently. How did a nomad who was hunting and gathering take to agriculture? How can we trace the origins of agriculture? Did it begin in one place and then spread to other regions, or did it develop in different places, if not at the same time, at different times? The other thing is, if I sow a seed and water it, it results in a plant that produces hundreds of seeds. A sunflower head will form 2000 seeds. It took a lot of time for humans to understand this secret of a seed – its ability to survive under harsh conditions and its potency to produce an enormous return from one seed, so that some seeds could be kept for sowing, and the rest could be consumed. That is the basis of agriculture, and it took so much time to recognize it, that I sometimes think people were quite stupid. [*One of the many papers that Mohan Ram gave me to read while I was interviewing him was a paper from Russia on plant dehydrins. Not only do these proteins protect a plant that is subjected to water stress, they also shield the embryo in the dehydrated environment during the maturation of the seed*[9].]

Developments in embryology

Double fertilization is a feature very unique to flowering plants; it doesn't happen in animals. But why double fertilization? Are there plants that have only single fertilization? Is the endosperm necessary? Can apomixis occur and ensure hybrid vigour? A lot of people are now interested in some of these basic things, and in that connection, the work of Imran Siddiqi (CCMB, Hyderabad) in discovering an apomeiotic gene in *Arabidopsis* is important. But how does one ensure that the embryo has the vigour of two parents sustained? And we still don't know how to manage the endosperm, because you may get a wheat seed without the endosperm, which means it is not edible (laughs)! So we have to make sure that we have not only the embryo, but also the endosperm. These appear as small problems, but they are not easy to solve. (See Mohan Ram and Shivanna[10].)

Other fascinating things about plants

A large part of Namibia in South Africa is occupied by a desert. The only water that comes is from the air that brings moisture from the Atlantic Ocean. In the night, the temperature falls and water condenses on the leaves; the leaves absorb water and send it to the roots!

I read a brilliant book on coastal redwood (*Sequoia sempervirens*). Some of these trees reach an unbelievable height of 350–365 ft and live for 2000–3000 years. There's professional training for climbing these trees using a harness and nylon ropes – there are only about 18 qualified 'arbonauts'. There's a botanist called Steve Sillett (Humboldt University, USA) who is very well known for work on redwoods, and so is his wife, Marie Antoine. These trees are conifers (draws) – and each branch is a reiteration – it looks like the main tree. Sometimes, water doesn't reach the top of the tree and the crown falls, and it forms a depression on top, which becomes a small pond. And there are salamanders, frogs, fish … all kinds of organisms on top of the tree! Sometimes the branches form bridges. There are forest fires which form dark caves in the trees, and fungi and lichens grow inside. There's a whole new subject called canopy biology. [*The book that Mohan Ram referred to is Wild Trees by Richard Preston, which has engrossing descriptions of the amazing variety of life-forms (including lichens, mosses, ferns, angiosperms and even amphibians like salamanders) found in the canopies of the Californian redwoods, and the adventures of Steve Sillett and other scientists working on these trees*[11]*. The book was preceded by an article in The New Yorker*[12]*. Recent developments in redwood research and conservation have been discussed in a cover story in the National Geographic*[13]*. Incidentally, redwoods have competition for the status of the 'largest and oldest' living organisms from a fungus, Armillaria ostoyae, found in the forests of North America*[14].]

Some work has been done about what is unique about a single tree in Costa Rica. Entomologists take a large tree, put a balloon around it, spray insecticides and then collect the total number of dead insects. They have found something like 800–820 different insects unique to each tree species. Therefore, when you cut a tree, you are not cutting just a tree. You are destroying so many other organisms that are entirely dependent on it.

On botanists and other scientists

The scientists who inspired him the most

To me, Vavilov is one of the most outstanding people in the area of plant science. He was a Russian geneticist, who put forth the concept of centres of origin of cultivated plants. There are so many ways of finding that out. For instance, soybean has two hundred names in Chinese. Likewise in India – *akki, arisi, biyam, chhawal* … so many names for rice. So there's a linguistic way of finding out the centre of origin (proposed by authors such as A. P. de Candolle). Vavilov used cytogenetics and the enormous diversity of wild relatives of crop plants as the basis. He found that certain plants originated in the New World, all the cereals (except maize) in the Mesopotamian region (modern Iraq), citrus mostly in the Indo-China region, etc. He had extensive collections of many varieties of plants from various parts of the world, and had kept them in Leningrad (St Petersburg). At that time, Lysenko, a pseudo-scientist, claimed that he was able to change the temperature and convert a winter rye plant into a summer one. This appealed to Stalin – he believed that it is the environment that can make you what you are. Stalin put Vavilov in Siberia, in a cold prison, and he died there. Not only Vavilov's work, but also the tragic end of the man who was so devoted somehow had a deep impression on me. I am also a great admirer of Charles Darwin. I went to England two years ago, and one of my missions was to go and see his house in Kent. All his works have been kept in the Natural History Museum, London.

Panchanan Maheshwari and Brij Mohan Johri

Some of the eminent scientists of India have had their training abroad; others like

C. V. Raman and G. N. Ramachandran did all their work here. Panchanan Maheshwari didn't go abroad for his Ph D; but an American missionary, Winfield Dudgeon, gave him all that he could receive from USA right in Allahabad, at the Ewing Christian College. Dudgeon also founded the Indian Botanical Society in 1920. What he taught Maheshwari basically was what Maheshwari taught us – that you have to be very focused on what you are doing, you must have perennial curiosity to know things, you have to be totally involved in what you do and must work very hard. Maheshwari imbibed all that Dudgeon could tell him – methodology, neatness, punctuality … what I call academic rigour. Maheshwari believed that you must have a very strong background to sustain a high degree of specialization in any field you choose, and that Ph D is just a license to practice botany or any other subject. I did my Ph D under him, and worked on the seed structure in some members of the family Acanthaceae. Maheshwari was more of a synthesizer of knowledge, a reviewer. He wrote a book in 1950, which became the only one available in English on the descriptive, comparative and experimental aspects of embryology. An Indian scientist writing an authoritative book from Dhaka was unusual for that time. It is still studied by graduate and postgraduate students all over the world. It was also translated into Russian.

When Maheshwari joined Agra College as a lecturer, in his first batch, he had B. M. Johri as a student. There were also V. Puri, who later became a reputed floral anatomist, Hari Raman Bhargav and many others. Johri was somebody who was like Hanuman – he had tremendous respect and faith in his teacher, and whatever the teacher told was like *vedavakya*.

Johri's original contributions to botany were many, especially on the families of Loranthaceae, Viscaceae and Santalaceae. Ovules in the first two families are not distinct and the embryo sacs develop from a structure called mamelon at the base of the ovary, they grow and even extend into the style. The endosperms of all the embryo sacs fuse together to form a composite endosperm. Johri had also observed that in a water plant, *Butomopsis umbellatus*, pollen grains were deposited directly onto the ovule, and they germinated there (unlike what happens in most other angiosperms, where the pollen grains first land on the stigma, where they first germinate, and the sperm cells enter the ovules to effect fertilization). Birbal Sahni was highly appreciative of this discovery; the mechanism was thought to be unique to gymnosperms. Johri was also superb in drawing, slide preparation, and the use of the blackboard. He'd take two pieces of chalk, and complete a drawing using both hands; he probably learnt that from Birbal Sahni. He brought out many authoritative books on embryology and edited two volumes of *Botany in India*.

The combination of Johri and Maheshwari was disrupted for some time because Maheshwari went away to Germany and then to Harvard, and Dhaka. He was teaching in Dhaka even after three years of partition, because there were very good faculty – Prof. Satyendranath Bose was there, K. S. Krishnan – a student of C. V. Raman, and R. C. Majumdar, the eminent historian.… Sir Maurice Gwyer, the then Vice-Chancellor of the Delhi University, invited Maheshwari to Delhi. At that time Johri was already in the department, so the teacher and the old student got together. And between them, Maheshwari planned and Johri executed the development of the Department. What was unique to both was they were interested in all aspects of botany – not just one narrow thing.

B. R. Seshachar

I happened to be a neighbour of Seshachar. (Draws on a sheet of paper and says) In Vishveshwarapuram (Bangalore), this was our house in the middle, this was Seshachar's house on the left and this was the house of a geology professor, B. Rama Rao on the right. So we were sandwiched between scientists. Seshachar was the eldest of twelve children. He was very handsome and an impressive person. He was fond of music. My father was a composer and singer, and a disciple of Mysore Vasudevacharya, the composer of the immortal song, *Brochevarevarura*. Every Saturday, my father used to sing for two or three hours in the evening, and Seshachar used to come to our house. My father always told me, 'If you want to become a scientist, you must become like Seshachar. He goes at 8 O' clock in the morning to Central College, and comes back at seven; and he's not just a scientist, he's also interested in literature, music and all that.'

Seshachar came to Delhi University after retirement in 1960, and transformed the Department of Zoology into a centre of teaching and research. Even before he joined, there were already two Mysore people there. One was M. R. N. Prasad, a well-known endrocrinologist, and C. M. S. Dass, a distinguished cell biologist and protozoologist. Seshachar recruited some very good colleagues, like S. Duraiswamy (biochemistry), B. I. Sundararaj (fishery biology), K. N. Saxena (avian endocrinology), V. C. Shah and S. R. V. Rao (cell biology and cytogenetics), and Vasudeva Rao from Pune, an embryologist. People for fun used to call it Mysore Zoo, probably because the Department had a lot of Mysoreans (laughs). Our Department and the Zoology Department were both elevated as Centres of Advanced Study, along with physics, chemistry, economics and later sociology. Economics because V. K. R. V. Rao, B. N. Ganguli, K. N. Raj, Amartya Sen and Sukhomoy Chakravarty were there; and M. N. Srinivas had mentored outstanding social scientists.

About some of the forgotten heroes of Indian science

When you talk about the history of botany in India, it is mostly from the British times. But *Hortus Malabaricus* was published before that period under the supervision of Van Rheede, during the Dutch occupation. K. S. Manilal, formerly Professor of Taxonomy at Calicut University, has spent 40 years translating it from old Latin to English and to Malayalam[15]. He was not elected to the Indian Academy of Sciences or INSA, maybe because these academies did not consider the value of this kind of work. He lives in Calicut and his health is not very good. Similarly, Sambhu Nath De, the man who discovered the cholera enterotoxin, was also left out. In fact, his name had been proposed for the Nobel Prize, but he didn't get it. Again, there was nobody to support him. Balaram took interest in this and brought out a whole issue on him in *Current Science* (1990, **59**, 623–716) – some amends for the things that we have not done. There were eminent scientists like B. G. L. Swamy, a plant morphologist, anatomist, artist, Tamil scholar and a Kannada writer honoured

by the Sahitya Academy, and M. S. Mani. Mani was an outstanding entomologist and linguist – he knew more than 10 European languages. His D Sc thesis (1947) submitted to the Agra University had 12 volumes of insect taxonomy. He started a School of Entomology at Agra in 1950. I was a student at Agra at that time, and I know that Mani's lab was very highly respected. He worked on Himalayan butterflies, and on plant galls. Insects feed on the bark, stem, leaf or even flowers of plants. Sometimes, insect substances can incite cell division, and can induce galls. Let's say there are two insects A and B. They are so much alike that it's very difficult to tell one from the other. But B will form a gall like this and A will form a gall like that (draws two different shapes). So they can be identified from the type of gall that they make. Mani was honoured with the E. K. Janaki Ammal Award some years ago. He wouldn't give his bio-data to anybody, and I persuaded one of his students to send it – it had to be reviewed by the Committee and approved by the Ministry of Environment and Forests. When reading up on him, I came to know of his pioneering work on the dipteran family Caecidomydae and plant galls, which is a master piece[16]. But he was not a Fellow of any Academy in our country, although he was highly valued and honoured outside India.

The path to excellence in science

A message to beginners in botany

One need not regret taking up botany (laughs). I know that at present, botany has become the last choice. Those who study botany don't get well-paid jobs. But most students never understand the thrill of doing science. And, good original work can be done without much equipment. To give an example, an Australian pathologist, J. Robin Warren, showed that *Helicobacter pylori* was invariably associated with ulcers in the autopsies that he carried out. Most experts believed that these microbes were harmless. But Barry Marshall, a young medical student, wanted to apply Koch's postulates to prove that *H. pylori* actually causes gastritis and ulcers in a healthy person. Marshall actually drank a heavily inoculated 4-day culture plate of *Helicobacter* mixed with alkaline peptone water to the utter disgust of his wife. Lo and behold, he developed gastritis after a few days. Having proved the causative organism, Marshall went on to develop new treatments for the infection. Warren and Marshall received the Nobel Prize for this. The ulcer story tells us that keen observation, perennial curiosity, perseverance and the daring to question the so called 'facts' trigger creativity and excellence in science.

The role of a teacher and mentor

Talent is pervasive, but mentoring is not so widespread. I would say that being a teacher has been my most rewarding experience in life. Some people used to ask me, 'Why do you read your students' manuscripts five times, ten times?' They felt that it would be ultimately *my* thesis. I said, 'No, it's training, because nobody just sits and writes a thesis! It's not only English.' Writing in science should be terse, accurate, it should not contain too much information and at the same time it should not be just superficial. Many times, students don't even know why they did something! I wouldn't say that of my students, because I never gave them a problem. I told them, 'You find a problem'. That always put them into some kind of awkwardness and uncertainty because thinking of a problem itself is a very difficult thing. They would rather be the second person to do something than be the first.

I feel very strongly that students don't have a passion to do things; I blame the teachers. They themselves have no passion or energy. They don't even sit in a lab with students … A subject has to be studied together. Maybe I know more than my students, but that doesn't mean that they cannot know – they may know more. It is just a question of time. There must be an understanding that the subject is bigger than all of us.

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