Connect

WITH THE INDIAN INSTITUTE OF SCIENCE

Volume 5 | Issue 2 | June 2018

SECOND INNINGS
G Padmanaban on science in India

MEET VIOLET BAJAJ
A 101-year-old alumnus on what IISc was like

SCIENCE ARCHIVES
How Bangalore preserves its history

ISSN 2454-6232

IN THIS ISSUE

EDITORIAL

On the occasion of IISc's centenary in 2009, the Institute published *Down Memory Lane* and *Reminiscences*, both collections of memoirs by former faculty and students. These included recollections by some of the early women students of the Institute and a glimpse of what life was like for them at the time.

In this issue of *Connect*, we are republishing edited versions of memoirs of five of these pioneering women. *Connect* also travelled to New Delhi to meet Violet Bajaj (née D'Souza), who studied fermentation technology in the 1940s. The 101-year-old, sharp and witty, spoke about the regressive customs she saw at the time in the Institute, and reminisced about the firm friends she made for life among her fellow women students.

IISc was host to many distinguished visitors these last few months, and *Connect* spoke to one of them, the evolutionary geneticist Jennifer Graves, about her work on sex chromosomes. We also interviewed G Padmanaban, former Director of IISc, whose memoir *Doing Science in India*: *My Second Innings* was recently published by IIScPress.

The Archives and Publications Cell – which is home to *Connect* – and the Centre for Contemporary Studies, working with the Kalakriti Archives, recently held a month-long exhibition showcasing a rare collection of different kinds of maps of India from different time periods. We find out more about this unique collection and its place in IISc's undergraduate curriculum.

Bangalore is home to many research institutions that have archival collections; *Connect* visited some of them to learn more. And, as in previous issues, we dug into the archives for interesting stories from IISc's past: the time when the Institute was evacuated for a few days in the summer of 1937, when rats infected by the dreaded plague started dying on campus; a look at the brochures for some of the Indian Science Congresses held in Bangalore over the years which give us a glimpse of how IISc saw itself and presented its research to the delegates of the Congress; and a story, from 1936, about an eventful meeting at the Gymkhana starring CV Raman.

Published by the Archives and Publications Cell (APC) at the Indian Institute of Science (IISc), *Connect* is a quarterly magazine that seeks to bring together the IISc community and engage with the outside world – through stories about life in the Institute, its research, and rich heritage.

Team Connect

Deepika S | Karthik Ramaswamy | Kaushal Verma | Manu Rajan | Megha Prakash | Nithyanand Rao | Rohini Krishnamurthy

Contact

Email: connect.apc@iisc.ac.in

Phone: 91-080- 2293 2066

Address: Archives and Publications Cell,
Indian Institute of Science,
Bangalore 560 012

http://connect.iisc.ac.in

Design: Magnetyz

Printer: Sri Sudhindra Offset Process

Students outside the first women's hostel, c. 1945. (L-R) Rajeswari Chatterjee, Roshan Irani, Prema, Miriam George and Violet D'Souza (Photos courtesy: APC, IISc)

Women and the Institute

- Deepika S

On the day IISc first opened its doors to students, as the Institute's Annual Report for 1911 tells us, one hostel block was ready for occupation. What the Annual Report doesn't mention, however, is that the "students' hostel" was only meant for men. In 1909, plans had been made for staff quarters, two blocks of student quarters, quarters for "servants, sweepers and maistries", and even quarters for police. But it would take around three more decades for a women's hostel to feature in the Institute's plans.

While there are no records specifically identifying the first woman to ever have enrolled at IISc, records from 1920 mention a "Miss M. M. Mehta", and those from 1922 a "Miss R. K. Christie". After a long spell, the next woman to be admitted to the Institute appears to be "Miss K. Bhagvat", who joined in 1933.

Kamala Bhagvat (also spelled Bhagwat), later Kamala Sohonie, had just graduated with a first-class degree from Bombay University when she sought admission to IISc as a research student in biochemistry. CV Raman, who was Director at the time, infamously denied Sohonie entry because of her gender. It was only after great persistence from Sohonie and her family that he agreed to admit her, with humiliating restrictions. It was a slight that Sohonie never forgot.

Years later, at a function organised by the Indian Women Scientists' Association (IWSA), she is reported to have said: "Though Raman was a great scientist, he was very narrow-minded. I can never forget the way he treated me just because I was a woman. This was a great insult to me. The bias against women was so bad at that time. What can one expect if even a Nobel laureate behaves in such a manner?"

Sohonie would leave IISc in 1936, and in 1939, she would go on to earn a PhD at Cambridge. She is often referred to as the first Indian woman to receive a doctorate in science, but it was Janaki Ammal, a botanist, who earned a DSc (equivalent to a PhD) from the University of Michigan in 1931. Sohonie is also sometimes referred to as the first woman student to ever be admitted to IISc, but records of MM Mehta and RK Christie show that this isn't true.

Raman, who in public championed women's education, didn't make life easy for the women who studied under him. He would eventually admit three women into his lab at IISc, but was strict about not allowing them to mix with their fellow men students, as his former student Anna Mani's account in *Dispersed Radiance: Caste, Gender, and Modern Science in India* by Abha Sur, shows.

The late 1930s and the 1940s saw the entry of a few more

This photo of the Department of Physics in 1975 with 78 people in it has only three women, all seated in the front row: "Miss S. S. Kulkarni" on the extreme left, "Dr. Mrs. Kumari Santosh" towards the right, and "Mrs. C. R. Varalakshmi" on the extreme right

women to IISc, which slowly drove the need to have more infrastructure for women – including accommodation and women's toilets. The first mention of the Ladies' Hostel in annual reports is in 1942, listed under expenses. M Visvesvaraya, President of IISc's Court at the time, mentions the hostel in his address to the Court the same year.

The first female faculty member at IISc appears to have been Dorothy Norris, appointed Reader in Applied Chemistry in 1917, and made Assistant Professor of Biochemistry the following year (she would go on to be Founder-Director of the Indian Lac Research Institute). Two other women, Dr H Kale and G Clairon, taught European languages. The first Indian woman member of faculty appears to have been Rajeswari Chatterjee, who was made Lecturer in the Department of Electrical Communication Engineering (ECE) in 1953. She was also the first woman to chair a department at the Institute, heading ECE from 1979 to 1981. It is only after 2000 that more women were appointed department heads, although their numbers remain low.

Some departments have always attracted more women – such as those in the Division of Biological Sciences. Some, as in the engineering stream, have very few. The departments of Aerospace Engineering and Mechanical Engineering, set up in the 1940s, both hired their first female member of faculty in the last decade. The Department of Mathematics currently has only one female member of faculty, and the Materials Engineering (previously, Metallurgy) Department is one of a few on campus that have never had women faculty members at all. Even today, the number of women in decision-making bodies such as IISc's Court and Council remains low. IISc has had very few women Deans, and has never had a woman as its Director. The latest issue of Kernel shows that out of 42 faculty members hired in 2017-2018, only 4 are women.

Ahead of the Institute's centenary celebrations, IISc put together two documents – one in 2009 called "Down the Memory Lane: Recollections of IISc Alumni" published by the Alumni Association, and one in 2008 called "Reminiscences" published by APC. In these collections, we get glimpses of what it was like for women on campus. GV Kamala, who was at the Department of Management Studies from 1965 to 1975, describes the women's hostel as a "small house-like building" with a common room stocked with fruits and flowers sent over from Raman Research Institute by Mrs Raman (whose portrait hung in the hostel), with a note attached, saying, "Help yourself".

DK Padma, who was at the Department of Inorganic and Physical Chemistry from 1967 to 1994, talks about her initial encounter with MRA Rao, the head of the department, who asked to meet her along with her husband and said she would be admitted on the condition that she completed the course of 5-6 years and did not have a child during that period, "as in giving me admission he was curtailing a boy's career". Revathi Narayan, who studied at the Molecular Biophysics Unit from 1974-79, initially sought admission to the Department of Biochemistry, where she was asked, "So, you are married, will you leave half way to start a family?" She continues, "No doubt the learned Professor had decided that principles of 'equal opportunity' were best left in legal tomes like the Constitution of India and were not seriously meant to be put into practice!"

Kalyani Vijayan, who was at the Department of Physics in the 1960s, wrote that there were so few women at the time (around 30) that Nalini Dhawan, the Director's wife, knew most of them individually. She also talks about "dear old Ganga", who did all of the housekeeping and even washed the students' clothes in the hostel. Ganga serves as a reminder of all the other working women on campus – in housekeeping, in landscaping, in administration, in finance, in the library and other non-science tasks – whose work has kept the Institute running, but whose names are rarely recorded.

In the pieces that follow, we include the accounts of six women who studied at IISc at a time when women studying science at all was unusual. We were fortunate to have been able to interview Violet Bajaj, one of the women in the iconic photo taken outside the first women's hostel in 1945, in person at her home in Delhi. The stories by Rajeswari Chatterjee, Rajeswari Chattopadhyay, HK Anasuya Devi, Chanchal Uberoi, and Renuka Ravindran are taken from "Down the Memory Lane" and "Reminiscences", and in some cases have been edited for clarity and length.

The colourful life of Violet

- Deepika S

Violet Bajaj at her home in Delhi. (Photo: Deepika S)

Violet Bajaj, a contemporary of Anna Mani and Rajeswari Chatterjee, talks about her years at the Institute and beyond

Violet Bajaj is 101 years old. She sits in her room before dinner, with the Gerald Seymour thriller she is currently reading on the table before her. Reading is her favourite hobby, and a low cupboard near her desk has a few books neatly arranged on it, ranging from novels by Agatha Christie to Naguib Mahfouz. Detective novels are her favourite things to read, she says, and it comes as no surprise that she should love a good whodunit. Asking questions, as it turns out, is something of a way of life for Bajaj, whose search for knowledge even as a young woman took her from Ranchi to Lucknow, Bangalore, Pune and Delhi. Around six years of her life were spent studying biochemistry at IISc, where in her twenties she lived through incredible times – World War II and India's struggle for independence – and she was a part of one of the earliest generations of women in India to study at a modern science institution. Whether it was studying the RNA and DNA of a fungus and questioning societal conventions in her youth, or maintaining a keen interest in current affairs now, at over a century old, it is hard not to see Violet as someone with queries always at the tip of her tongue.

Today, Violet lives with her daughter Sheela Bajaj and son-in-law Sudhir Sahi, in Sheela's flat a quiet south Delhi neighbourhood. She was born on 21 January 1917, in a Goan family that lived in Agra. When Violet was three, her family moved to Jhansi, where she grew up.

Violet studied at St Francis Convent in Jhansi, where she finished her Senior Cambridge examination (the equivalent of matriculation). She says that no science subjects were taught at her all-girls' school – she had only studied English, Geography, History and Maths. But she wanted to study medicine like her older sister Blanche, and since there was no college in Jhansi, she joined Isabella Thoburn College in Lucknow for a four-year BSc. For the first time, she was studying Physics, Chemistry, and Biology, which she found tough. After completing her BSc, she joined Lucknow University for an MSc in Chemistry. By then, her parents had moved to Bangalore, where some of their relatives were, and lived in a bungalow on Rest House Crescent. "One of my professors at Lucknow said, 'If you're going to Bangalore, why not apply to the Institute?' So I did. [Until then] I had never heard of it. Initially I joined the Department of Chemistry to study Organic Chemistry, which I did not like. So I shifted to Fermentation Technology."

> *"One of my professors at Lucknow said, 'If you're going to Bangalore, why not apply to the Institute?' So I did.*

The Fermentation Technology Section, as it was known at the time, was set up in 1942 under the Department of Pure and Applied Chemistry. In 1951, it was transferred to

the Department of Biochemistry, and in 1953, it became an independent entity as the Fermentation Technology Laboratory under M Sreenivasaya, who had been Violet's teacher (as well as Kamala Sohonie's). In 1988, it became part of the Department of Microbiology and Cell Biology.

"I loved the practical aspect of science very much," Violet says, adding, "I loved the experimental side of chemistry. And biochemistry was a subject I really took to. It was a new science, just coming up." What she found most fascinating about fermentation technology was its application of chemistry to living organisms. She studied *Aspergillus niger*, a fungus that causes black mould in some vegetables and fruits for her PhD thesis. She also co-authored four papers (in the Archives of Biochemistry and Biophysics) between 1953 and 1957, while working towards a PhD under PS Krishnan at the National Chemical Laboratory, Pune.

For the few years that Violet studied at IISc, she lived with her parents. "There were students from all over India, but mainly South Indians," she says. Outside the classroom, men and women mixed freely, forming music clubs, playing bridge, and going on picnics to Nandi Hills. "At that time, there were people like Homi Bhabha and Vikram Sarabhai visiting the Institute. It was an exciting place because eminent scientists would visit and give talks. It was a momentous time. The freedom movement was in full swing, and students were keen on freedom from British rule."

> *It was a momentous time. The freedom movement was in full swing, and students were keen on freedom from British rule*

But Violet also remembers IISc of the 1940s as being a "caste-ridden" place. "There was a separate Iyer mess and a separate Iyengar mess, and never the twain would meet. Can you imagine, they wouldn't even eat together?" she asks, laughing. She almost giggles as she recounts how her teacher, Sreenivasaya – "a very orthodox Kannadiga Brahmin" – had to travel abroad and would have to purify himself through elaborate rituals on his return (according to Hindu Vedic texts, sea voyages cause one to lose one's caste, and hence was once considered taboo). "We used to have terrific arguments about it," she says, adding that they also "got on wonderfully well. In the end because I always stood up to him, he respected me." And perhaps it was her influence that brought about a softening of his stand on caste and ritual purity: "Later, he even came to stay at my house and ate my food," says Violet.

Even as a young woman, Violet had strong opinions. She describes herself as "very much a Commie" during her early days at Lucknow University, influenced by the activism of Ali Jafri and Aruna Asaf Ali, though she says she grew out of it in her late twenties. As a college student, at 18, once she was introduced to Darwin's theory of evolution, she stopped going to church and became an atheist, which she remains to this day. While studying at Lucknow, she had met a young Punjabi army officer named Vidyaprakash Bajaj through friends. He was later posted in Bangalore, and midway through her time at IISc, she married Bajaj in a simple civil wedding. Her family took the news of her relationship "very badly" at the time, she says with a grin, and none of them attended her wedding.

After she was married, her husband was posted in Ceylon (now Sri Lanka), and as her parents had moved away from Bangalore, she moved into the Ladies' hostel at IISc. She say there was "no question" of the caste divisions on campus applying inside the women's hostel, which had very few students in it – the students had to run the hostel themselves, and organise their own food. It was simple vegetarian fare, says Violet, and everyone ate together. "We were all always in and out of each other's rooms all the time," she says, adding that there were none of the restrictions that women in hostels face today. "Isn't it crazy?" she says of the curfews and unfair rules for women that have spurred protests across the country in recent years.

Violet during her IISc days

HOSTEL life helped Violet become more involved in activities at IISc, and brought her closer to her fellow students, with whom she would go on to make lasting friendships. Roshan Irani, Nagamani Kulkarni (née Rao), and Indira Bhat (née Gajjar) and Anna Mani were her friends at the time. Nagamani, who studied in the Department of Inorganic and Physical Chemistry, would marry a fellow student at IISc and move to Hyderabad, where she taught Chemistry at a women's college. Violet says that it was through Nagamani's family (she would visit them when in Bangalore) that she learned to appreciate South Indian music

and dance, and remembers that Nagamani had a sister with a beautiful voice who used to sing Carnatic music on All India Radio. And although she was never close friends with Rajeswari Chatterjee, she remembers her as being a "very nice person".

Like Nagamani, Indira, who Violet describes as her "dearest friend along with Anna," married a fellow student at IISc. She had studied biochemistry, and was Reader in Biochemistry at Maulana Azad Medical College in Delhi when Violet worked there for two years as a Research Fellow on a Lady Tata scholarship. (After IISc, Violet had spent a few years moving with her husband to wherever he was posted, including Pune, where she did her PhD before moving to Delhi to be at Maulana Azad.)

Although it was Indira who had been closer to Anna while in college, it was while Violet lived in Pune that she reconnected with Anna and two became best friends later on. Violet remembers Anna from her IISc days as being"still a conservative Malayali" who didn't socialise much with men. She also remembers that one of the reasons for it might have been the looming shadow of CV Raman, in whose lab Anna worked on the spectroscopy of diamonds and rubies. "CV Raman was inimical to all women who went around with men," says Violet, who describes him as a "deeply conservative man" who couldn't stand to see students of different genders mixing.

Violet and Anna met again when Anna was posted to the Department of Meteorology in Pune, and Violet's husband had been posted to Pune too. "I can't recall who contacted whom," she says, but describes the Anna she knew in later years as being "one of the most intelligent people she had ever met," someone who was "extremely well-read" and had friends all over the world.

> *[Anna Mani] didn't suffer fools gladly. If she didn't like your company, she made no bones about it*

Of Anna, Violet says, "She didn't suffer fools gladly. If she didn't like your company, she made no bones about it." Her daughter Sheela describes "Auntie Anna" as someone who "wasn't an easy person, socially". But Violet also talks about how Anna could be modest and unassuming, and never spoke about herself or what she did. Anna could be generous to her friends, colleagues and domestic help. "To me, she was more than generous," says Violet, "whenever she had to travel she would always invite me along." The two made several trips together, such as to Nainital and the Andaman Islands. But Violet laughs as she says the one trip on which she refused to accompany Anna was to China. "She said, 'Do you want to come?' I said, 'Are you mad? Who wants to pay that horrendous airfare?'"

Anna would retire in 1976 as Deputy Director General of the Department of Meteorology, and later set up a private company in Bangalore that made weather instruments, which Violet said she hardly spoke about to other people – Violet herself only knew about it, and Anna's other activities, much later. "All her charitable works we learned about only after she died" says Violet, who declines to mention what those charitable works were, saying that Anna herself (who died in 2001) wouldn't have wanted it known.

Violet had a career of her own – she worked at Biochemicals Unit, set up under CSIR, from the 1950s until her retirement. The company's field was medical biochemical research, and Violet was in charge of quality control of all their products: "I'm good at that," she says sardonically – "criticising people and rejecting samples."But she is strangely disingenuous when asked about what she considers her greatest

achievement. “Nothing – zero – no achievements,” she says with a shrug. “I’m quite satisfied that I was able to work through my life. And meet my old friends from the Institute through work and renew those friendships.”

> *Violet worked at Biochemicals Unit, set up under CSIR, from the 1950s until her retirement*

Violet admits she was one of few women in the small company. It’s impossible to avoid questions about “women in science”, given that women are still deeply under-represented in several science streams today. Talking about her friends from IISc and their careers, sitting at the desk in her room on the day of our last interview, I ask, did they never feel that they were pioneers, entering fields not considered common for women to be in at the time? Did it not feel like they were doing something important and wonderful, that was of historical significance? “No,” she says simply, with a shrug, uncomfortable with the idea of being seen as special. One night over dinner at her house, Violet also said there had never been any discrimination towards women at IISc, barring the example of CV Raman. But on the last day of our interviews, she had more to say about bias against women.

“Definitely there is discrimination,” she says firmly. “They think women are not capable enough to take responsibility. There’s a blatant prejudice against women. They say, the man has his family, so he is more deserving than a woman. It shouldn’t make a difference if she is married or not, if she has children or not. What if you don’t have children, but have elderly parents to look after?” she asks, echoing

Anna Mani at her farewell get-together at the Raman Research Institute in 1980 (Photo: RRI Digital Repository)

Photo: Deepika S

some of the questions that have been raised often by those protesting against the reasons that force women to drop out of science. Violet is quick to clarify that she has never been discriminated against herself (not unlike Anna Mani, who according to Abha Sur didn't seem upset that she had been denied a PhD herself after her years of work at IISc, but was angry on her friend Sunanda Bai's behalf), but that what she says refers to "a general attitude, an institutional attitude". "If you have men and a few women in a department in an institution, the man will get the preference for any job promotion, don't you think so?"

WHEN I tell Violet that IISc these days has daycares for children on campus, she says jokingly, "I'm in need of a daycare centre." Later, she says, "It's not pleasant to live to be 101 and have to depend on others. I like my independence, I like doing things my way. I'm a difficult person to please." Until two years ago, she was far more active and mobile, even checking and responding regularly to emails, until a bout of chikungunya took its toll.

Her daughter Sheela describes her a "toughie", saying, "they don't make women like that anymore." She remembers the years in her childhood when her mother couldn't work because her father was transferred often. "She would turn the kitchen into her laboratory – if she couldn't do science outside, she would do it at home, telling us about the chemicals responsible for keeping a soufflé stiff…she was an excellent cook," she says. Violet insists that she hated cooking. Sheela, a retired professor of economics, recalls that when she got married, her mother warned her to never let her in-laws know that she knew how to make chapatis, and advised her not to "clutter her life with children". When talking about society's expectations in terms of adhering to religion, caste, and gender roles, Violet says, "Imagine living your whole life being loaded with all those customs! I'm so free!"

"Interesting life I've led," Violet says that night in her room after an evening of reminiscing, both with wonder and satisfaction. Later, over dinner, when Violet asks Sheela questions about mundane household matters with the same solemnity with which she asks about current affairs, Sheela shakes her head at me, as if to say, "I told you so." "Mummy and her friends were argumentative, tough, opinionated, difficult women," she says in mock exasperation, but the admiration in her voice is clear. "They stood by their principles. And they were eccentric. Mummy, would you describe your group as eccentric?" she asks, turning to Violet.

"No," says Violet quickly, looking almost offended. "We were perfectly normal."

Chanchal Uberoi, former Professor at Department of Mathematics, with her husband and former Professor of Organic Chemistry, SN Balasubrahmanyam at their residence in Bangalore (Photo: Rajini Krishnamurthy)

Remembering my long association with the Institute

-Chanchal Uberoi

The mathematician and first woman to be dean at IISc on wearing many hats

I was exhausted after facing an interview for the PhD programme at IISc's Applied Mathematics Department [now called the Department of Mathematics], that lasted for more than three hours. Having lost hope, my father was ready to take me back home to Hyderabad. But I soon learned that I had been accepted for PhD at IISc. In August 1961, I became a student. My association with the Institute continued for the next 40 years in diverse roles, except for a few years that I spent abroad.

The department began as a "service department" to equip researchers from various disciplines with mathematical tools which could be applied to their fields of study. The teaching faculty and senior students from my department were expected to teach mathematics at all other departments, especially to those belonging to the engineering faculty.

So, in 1963, I was asked to teach mathematics to students from the departments of Metallurgy, Chemical Engineering, and Management Studies, as new course requirements for PhD and other programmes were framed. Prabhu Lal Bhatnagar, Professor at the department, said, "As you know, we are short of hands and I would like you to take up some teaching even while you are busy with your research work."

That was almost an order! No promise of money or position was made. But these questions did not occur to me then and I began preparing notes for teaching. Looking back, it was fun teaching. Most students had little or no training in mathematics beyond high school. To get them interested in mathematics, I began emulating a kind school teacher by sharing anecdotes about the lives of mathematicians!

> *To get [my students] interested in mathematics, I began emulating a kind school teacher by sharing anecdotes about the lives of mathematicians*

I am happy to say that some of these students are now holding high positions either in the industry or the government. I assume some may have retired from such positions after all these years.

In 1965, I completed writing my thesis on the propagation of waves, their characteristic instabilities in plasma media and its applications to astrophysical problems. To describe the behaviour of gases of neutral particles, I dedicated one chapter to Transport Properties of Ionized Gases, which employed what is known as the "BGK Model" (Bhatnagar-Gross-Krook Model, named after Professor Bhatnagar and the others). The results were good and

At a Parliamentary Committee Meeting (Photo: APC)

it could be shown that this famous collisional model could work equally well for ionized (or partly ionized) gases. The thirteen-moment method that was used required evaluation of thousands of integrals, which was done painstakingly by using a calculating machine. I worked late every night to make those calculations – this work was, after all, carried out about a decade before the dawn of personal computers.

After obtaining my PhD, I continued as Lecturer at IISc. Then, for two years, I was granted leave from my position to work at the University of Cardiff and then at the Harvard Observatory.

My work in these prestigious institutions was successful – the knowledge I acquired at IISc reflected in the academic work I carried out there. In the early 1960s, with the dawn of the space age, both plasma and space physics assumed great importance. So, I began to apply my expertise in mathematics and plasma physics to understand problems in the near-earth space environment.

In 1972, I established a very important physical process that is prevalent in space and astrophysical plasmas, which is described as resonant absorption of Alfvén waves in inhomogeneous magnetic fields. (In the same year, Hannes Alfvén was the recipient of the Nobel Prize in physics for the discovery of a new type of wave, later named after him, in natural plasma which constitutes the major part of ionized matter.) This work helped us understand the various physical processes in natural plasmas. I am glad to be able to say that I can trace the origin of this work back to my PhD thesis, where I wrote a small chapter on Alfvén waves. The work has also become substantially important in the study of heating of laboratory plasmas in fusion research. This led to a collaboration between me and Akira Hasegawa, who was a well-known scientist at the Bell Laboratories (now Lucent Technologies). In 1982, this collaboration resulted in a monograph The Alfvén Wave, published by the US government's Department of Energy. Considered a classic in the field of plasma physics, the book was written during the time of postal correspondence, letters and telegrams – all forgotten now, in the age of email correspondences.

In 1982, I became a founder member of the Joint Astronomy Programme (JAP), created to foster collaboration between IISc and other academic institutions, such as the Raman Research Institute, the Indian Institute of Astrophysics, the Indian Space Research Organization and the Tata Institute of Fundamental Research. During one of the space physics conferences, an astrophysicist visiting from abroad told me that he had learnt how to see generalities in mathematical problems from my questions during the JAP interview! That compliment was gratifying indeed. Some students

from the Programme, who are now faculty members in famous observatories, have told me that they have benefited immensely from the plasma physics courses I conducted at the Department.

> *In 1982, I became a founder member of the Joint Astronomy Programme (JAP), created to foster collaboration between IISc and other academic institutions*

Life on campus

It is here that I met my husband, SN Balasubrahmanyam, Professor at the Organic Chemistry Department and raised my two children, Vibhavaree and Sameehana. Living on campus, which was just a few minutes away from my workplace, was a blessing in disguise, especially when my children were little: I could comfortably juggle work and take care of my children.

In 1976, Satish Dhawan, the former Director, asked me if I would be interested in moving into the newly built quarters on campus. The offer came at the right time: our landlord was giving us a hard time. So my husband and I hurriedly went to the "DQ quarters" and chose a corner house. The watchman gave us the keys to the apartment immediately without asking for documents. This indicated an important fact about the Institute, that it was not bureaucratic. My daughter, around six then, asked me if "Mr Dhawan" was our new landlord, and further added, "He is so good compared to the earlier one, isn't he?"

In the late '60s and '70s, the Institute did not have many women students we were about ten women. The rooms in the ladies' hostel were luxurious, with a small decorated sit-out. Our warden, Kale, who was a faculty member at the Foreign Languages Section, took German and French classes at the Institute (this was required for a PhD degree then). She took great care of us. Professors' wives living on campus also made sure we were comfortable: they invited us home on most special occasions.

Presenting degree certificate as a Dean of Science (Photo: APC)

When Kale retired, Rajeswari Chatterjee, Professor at the Department of Electrical Communication, was named our Warden. As she did not reside on campus, I was asked to be the Assistant Warden to help her. We had several disagreements, but we took everything in good spirit.

In 1997, a policy decision of the government raised the retirement age of academic faculty at higher educational organisations from 60 to 62 years. So, in 1999, when I turned 60, I was offered the position of Dean of Science, which is usually open for two years. I became the first woman dean in the long history of the Institute. Every day, I interacted with students and faculty. I was successful in solving difficulties faced by them at various times and noticed that girls were comfortable opening up to me.

I was quite well-known on campus for not keeping up with time. However, innumerable meetings demanded me to stay disciplined. These efforts didn't go unnoticed by my colleagues from the administrative offices, especially DK Subramanian, Engineering Dean, who could not help but show his amusement at these efforts.

My association continues...

After my retirement, as part of the ongoing Indo-French Mathematics Programme, I continued working on evolving methods suitable for conducting classes via satellite contact between India and France. Until the end of 2004, I worked as an Emeritus Scientist at the Institute. I worked for three years, publishing a few papers. More recently, I was invited by Springer-Verlag, Berlin-Heidelberg, to contribute a chapter on space plasmas in the Handbook of the Solar Terrestrial Environment, which has now been published. I am happy that I represent India and IISc, among the other twenty-one famous scientists in the world.

Though my long association with the Institute has reached its end, I attend interesting technical or public lectures and some conferences that appeal to me. Often, while I visit the Indian Institute of Astrophysics, I drop in for a cup of tea with friends at IISc's Faculty Club.

I strongly believe that the vision of the founder, JN Tata, has largely been fulfilled. The Institute maintains a scientific environment by producing highly trained teachers, scientists, engineers, scientific administrators, which is reflected in the atmosphere of the Institute. Though I think this might change with time, I assure myself that it could only happen superficially – the quest for knowledge and learning that the Institute inculcates in its students will last for ages

Chanchal Uberoi was a professor in the Department of Mathematics

Rediscovery is a prelude to discovery

- HK Anasuya Devi

HK Anasuya Devi joined IISc in 1965. In the photo above, she is seen working with a speech synthesizer as part of her PhD. The synthesizer was later used by NIMHANS to help children with special needs decipher words (Photos courtesy: HK Anasuya Devi)

A computational linguist-turned-information theorist talks about the nature of research

I was a Sanskrit Lecturer at Maharani's College and BES College of Arts, Science and Commerce, while also carrying out research in language processing systems and information processing. This research was carried out in Maharani's College in collaboration with Bangalore University. One day, I read an article published in Nature, titled "Relative Efficiencies of Indian Languages", which claimed that Telugu was a more efficient language for communication than other Indian languages. I disagreed. Believing that Sanskrit is the mother of all Indian languages, I thought it should be considered a more efficient language. So, in 1974, I walked into IISc to make my arguments against the article, by confronting the author, BS Ramakrishna, Professor at the Department of Electrical Communication Engineering (ECE).

I met Ramakrishna who looked simple and nice. Soon, I began arguing with him on the subject. Amazed by my arguments, he asked, "You are right, but can you prove it? Do you know information theory?" I was perplexed. Eventually, he put me through a test in mathematics, which I cleared successfully. And I was glad to be told that I could be his student.

At the same time, the thought of pursuing a PhD abroad was lingering in my mind: I was selected by top universities such as Harvard University and University of California at Berkeley to work on Sanskrit in relation to Indo-European languages. However, my father was against sending me abroad – back then, in traditional families like mine, girls going abroad before marriage was taboo.

But destiny had something else in store for me. I chose a research career over the option of getting married and settling early in life. At IISc, The Foreign Languages Section (FLS) was looking for a person with a background in mathematics, sciences, computers and Sanskrit to work on translation and bilingual studies on syntactic patterns in widely divergent languages. I was the right fit, given my background in all the subjects. Ramakrishna also suggested that I join the project. Soon, I quit my job and joined IISc after passing an interview

> *I chose a research career over the option of getting married and settling early in life*

I learnt information theory from Ramakrishna. Being a wonderful teacher, he simplified complicated topics such as stochastic process, probability theory and semantic measurements.

In 1975, the project at FLS came to an end and I began looking for other jobs. Recognising my work, two people suggested that I join the Institute through a different route – clearing the Institute's entrance examination. With some guidance and luck on my side, I topped the list.

I then joined IISc as a PhD student in the interdisciplinary stream, involving two departments, FLS and ECE. It was worth pursuing interdisciplinary research, while also building an interface between the two distinct departments. I must say that I was the only candidate with this background suitable for interdisciplinary research.

PhD and postdoctoral research

Anasuya has been involved with interdisciplinary research in multiple departments across the Institute.

During my time at IISc, I extensively read anthologies of prose writings, discourses on style, expositions of communication theory, theories of perception, and so on, which in those days failed to elicit sufficient response, but one thing stuck in my mind, "Why not study literary prose style as a problem in the patterns of human communication, just as engineering people study fingerprints, handwritings or aerial surveys?" It was a fascinating analogy to be pursued further, but how would I know communication theory, pattern recognition theory and all such esoteric theories on which people were working on? I moved from one expert to another, learning from them.

> *One thing stuck in my mind, "Why not study literary prose style as a problem in the patterns of human communication, just as engineering people study fingerprints, handwritings or aerial surveys?*

My thesis answers the question, "Can art and science be married?" Moral support for this unification of science and art – the topic of my thesis – came from Rangaswamy Narasimhan, a computer and cognitive scientist.

Due to the complexity and special nature of my work, there was a delay in my thesis submission: I spent three years on coursework, both at IISc and elsewhere. Obtaining an extension proved to be difficult. To help me, G Clairon, the then Chairperson of the Foreign Languages Section, and PS Narayanan, the then Divisional Chairman of Physical and Mathematical Sciences, reviewed the issue and extended time for thesis submission. Clairon, in fact, volunteered to pay my thesis fees, since I was a unique student of both FLS and ECE!

I continued my association with the Institute as a postdoctoral fellow. In 1984, the Director, CNR Rao called to inform me about a job posting at the Electrical Engineering (EE) Department. Bagging it, I worked on natural language understanding of block world manipulation of robotics for two years with YV Venkatesh and G Krishna, professors at the Department of Electrical Engineering and School of Automation respectively. It was here that I learned about image processing, computer vision, pattern recognition and artificial intelligence. VVS Sarma, a professor at the School of Automation, guided me in these areas, while at the Institute and thereafter too.

People who influenced me

People who influenced me profoundly are Ramakrishna, Satish Dhawan, former Director of IISc, and H Narasimhaiah, a noted educationist and former Vice-Chancellor of Bangalore University.

In my initial days, I went through highs and lows: when an occasional input struck me, my spirits soared high, but this didn't last long when I realised that someone else had already claimed those ideas. After going through this a couple of times, I concluded that research was not for me, but Ramakrishna convinced me otherwise. "Such discoveries," he said, "should strengthen your conviction

that you are on the right track and that you can make the right kind of observations, never mind whether it is for the first time or not. Rediscovery is a prelude to discovery." Besides being my thesis adviser, Ramakrishna was also my spiritual guide. Dhawan, with his own interests and a degree in English literature, admired my research interests, and continued to support the area of stylistics. He was keen that I study Bernard Shaw's style of writing. Further, Dhawan and Ramakrishna urged me to develop hardware for style of writing similar to speech-recognition system (VOCODER), developed at Bell Labs. This is yet to be done at the Institute and is worth taking up even today. We had several meetings and it was suggested that I focus on literary prose style, from the view of communication theory that is different from the run-of-the-mill work in the areas of stylistics, linguistics and socio-linguistics.

Dhawan took great interest in my coursework and sent me to the Central Institute of English and Foreign Languages, Hyderabad, to study advanced courses in Transformation Grammar, and other related topics, that were important in the study of computational linguistics and also to conduct experiments on "The Perception of Style".

After completing several courses in Hyderabad, I returned to the Institute to give my comprehensive examination, which I successfully cleared. I was probably the only student whose exam was conducted in the Director's office.

Dhawan felt the need for a department where interdisciplinary research can be carried out: to use scientific methods to address social problems, which could have a direct impact on society. I am sure that was the starting point for multidisciplinary research at the Institute.

Moving on and my return to my alma mater

Deekshatulu, an alumnus of IISc, who had earlier spoken to me about my research during one of his visits, interviewed me informally for a Visiting Scientist position at the Hyderabad-based National Remote Sensing Agency (NRSA), which he was then heading. He enquired if I would be interested in working on a remote-sensing application using artificial intelligence techniques, particularly for building an expert system for soil taxonomy. I was hesitant to accept the offer as I knew my father would not allow me to leave Bangalore, but Narasimhaiah intervened and persuaded my father to send me to Hyderabad. I was, later, formally interviewed at NRSA and offered the post.

So, in 1987, I left for Hyderabad. Through training programmes and discussions with experts, I learnt a host of subjects, such as remote sensing and its applications, geology, geomorphology, soil science, and so on. Using remote sensing and ancillary data with a logic programming language, PROLOG, I built an expert system for soil taxonomy. I did this work just before the Indian Space Research Organization (ISRO) launched its first Indian Remote Sensing satellite.

> *Using remote sensing and ancillary data with a logic programming language, PROLOG, I built an expert system for soil taxonomy*

Besides teaching and research work, I have published several papers and reports, including the *IEEE Transactions* paper during my PhD programme, and thereafter while at various places in Hyderabad, such as Hyderabad University, Jawaharlal Nehru Technological University, Advanced Data Processing Research Institute, Institute of Public Enterprises, BR Ambedkar Open University, Centre for Ecological and Social Sciences, and so on.

During the Institute's Platinum Jubilee celebrations, I was fortunate enough to meet JRD Tata, who admired my work in interdisciplinary areas. He suggested that I work at the National Institute of Advanced Studies (NIAS), which he had planned to set up at the Institute, aiming to bring classical sciences, humanities, anthropology, archaeology and epigraphy to the forefront.

Anasuya at an IEEE meeting. She is a member of the IEEE SSIT Board of Governors

One day, the then Director of NIAS, Raja Ramanna, invited me to deliver a talk. Immediately after the talk, he offered me a faculty position at NIAS. I worked in an area concerning archaeology and epigraphy, which I wished to do at IISc itself. Since 2002, I have been fortunate enough to be associated with students as a faculty member at the Centre for Continuing Education, IISc.

The good old days

It is a pleasure to recall my time as a student at the Institute. I had the opportunity to work under the Students Assistance Programme at different centres, including the Library, Computer Centre, Mess, and the like. This gave me exposure to activities at the Institute. I was an active member of several groups such as the Students' Council (as its Secretary), and mess committee, and also as the hostel warden.

I recall an incident that reflected the strength of student community: a student (whose name I cannot mention) was not receiving his scholarship due to a delay in his thesis submission. He had no money to support himself. We formed a group of nine to help him. Speaking to professors, we found that the delay in his thesis submission was not due to his actions, but rather due to that of his guide. After probing further, we realised that in many cases, the delay was due to his guide going on a sabbatical abroad, working on a consultancy project, or shortage of chemicals and instruments in the lab. And students were being punished for no fault of theirs. After several rounds of negotiations with the Director and the Council, we were successful in convincing the Institute to sanction scholarships and to extend the time for thesis submission.

It was through my initiative that the Institute built a new hostel for ladies. We remember the pleasant days in our hostel which had security, healthy atmosphere and environment. The food in the mess was something to remember always – in particular the idli sambar or masala dosa on Sunday mornings at A Mess.

During my PhD, I started the Samskruta Sangha along with two others. We initiated many programmes to bring in ancient wisdom and classical sciences to the modern world and encourage cross-cultural activities. We organised lectures, discourses and other activities on a variety of topics. This created an environment where members belonging to different groups, such as the Kannada Association, Telugu Association, Bengali Association and others, mingled and freely exchanged ideas. The Gymkhana was one such place where we discussed many things, including sports and music. I was also responsible for initiating swimming classes for ladies.

I would like to add that about eight members of my family, beginning with my father, have had associations in some way or the other with IISc. One significant paper by Ramakrishna and his team attracted me to the Institute, and destiny allowed me to continue my association with it, for a long time. I was very fortunate to find the most lovable life partner in SR Anantha Krishnan, who was also an alumnus of the Institute. It is most unfortunate that he passed away recently. The loss is unbearable, but I am enduring it by pursuing some of his unfinished scientific work, which we both thought would offer solutions to future energy problems.

Anasuya Devi is Professor, Research Lead and Technical Advisor at National Design and Research Foundation, Bangalore

Anasuya with her husband, SR Ananth Krishnan, at the Jagannath temple, Puri

Indian Institute of Science and me – my story

-Rajeswari Chatterjee

Rajeswari Chatterjee (Photos: APC, IISc)

I was born on 24 January 1922, in Bangalore (when the Indian Institute of Science (IISc) was 13 years old) in a house called "Casetta" on Sankara Mutt Road in the southern part of Bangalore. Probably in 1934 or so, the children of our school, Mahila Seva Samaja, were taken in a bus to IISc (popularly known as Tata Institute) for an outing in the park-like campus. We ran around the park and finally arrived at a big double-storied bungalow where we were greeted by a middle-aged lady who took us into the house and led us to an upstairs verandah where she talked nicely to us in a mixture of Tamil and Kannada and served us some snacks like chakulis and fried avalakki (flat rice) served on banana leaves and some sweet lime juice. We were hungry and gobbled up the food, and did not even know that we had to thank her! On [the] way back to our school, our teachers told us that the lady who was so nice to us was Lady Lokasundari Raman, the wife of Sir CV Raman, who was the Director of IISc and the first Indian to be awarded the famous Nobel Prize for Physics. Of course, none of us understood what the Nobel Prize was and we hardly knew any physics those days!

I went on to high school in the London Mission Girls' School (now called Mithralaya Girls' School) on Mission Road from 1934 to 1937. After I passed my SSLC in 1937, I joined the Women's Intermediate College in Bangalore and passed the Intermediate Examination of Mysore University in 1939 with a third rank with optional subjects Physics, Mathematics and Economics. My next move was to join the Central College in the three-year BSc (Hons) course in Mathematics. After I passed the BSc (Hons) degree with a first class first in 1942, I passed the MSc examination of Mysore University in 1943 from Central College with a first class first.

World War II was raging, and nobody could predict the future. In the Far East, Japan was waging a war in China, and was conquering Indo-China, Malaysia and Burma, and was ready to enter India and was bombing Calcutta and Visakhapatnam. Our great freedom fighter Subhash Chandra Bose was pushing his Indian National Army towards the Indo-Burma border. All the young people were excited, and wished that the Indian National Army (INA) would push the British out of India.

I wished very much to go abroad to England or the USA for higher studies in Mathematics to obtain a PhD degree, but that was not possible during the war. So I decided to join IISc for research. There was no mathematics department there, though mathematics was required to understand some problems in physics. So I met Sir CV Raman and requested him to take me as a research student. After he found out that my degrees were in mathematics, he told me that he wanted only candidates who had an MSc in Physics with a high first class.

I had to find some alternative to keep myself engaged and learn something new so that I [could] be better qualified to go abroad after the end of the war. Calcutta was too far from Bangalore for me to go for a PhD degree, though I knew that there were very good mathematicians [there]

who could guide me. If I were a young man, my family might have allowed me to go to Calcutta.

> *Calcutta was too far from Bangalore for me to go for a PhD degree, though I knew that there were very good mathematicians [there] who could guide me. If I were a young man, my family might have allowed me to go*

The next best thing I could try at IISc was to apply for the three-year certificate course in the Department of Electrical Technology. So I put in an application to this department, and I was called for an interview by Professor SP Chakravarthy who was the head. When I went to see him, he told me that though I was very well qualified to do this course, I would find it very difficult to go for summer practical training in far away hot places like Calcutta and Jamshedpur, because I would be the only young woman among twenty young men. There were no industries in Bangalore at that time. The Hindustan Aeronautics had just started and would not take any student for training. However, he told me that he was willing to take me as a research student on a scholarship of Rs 40 a month so that I can learn some electronics and electrical communication engineering, and work on some research problem on electron tube circuits and publish a few papers, and that would help me to obtain a scholarship to go abroad after the end of the war for further studies in the fast-growing subject of electronics.

So I entered the Department of Electrical Technology at the Institute in July 1944. Professor Chakravarthy advised me to attend a course on Electrical Communication Engineering which he was teaching to third-year Diploma students, and also a course on vacuum tubes, a course on electro-acoustics, and a course on line communication. After one year, I was awarded a scholarship of Rs 60 [per month], which could just take care of my hostel expenses in the girls' hostel.

Chatterjee, who was Professor of Department of Electrical Communications Engineering, would go on to be its Chairperson

I did enjoy the company of my mates in the girls' hostel coming from different parts of India. They were Anna Mani from Travancore (now called Kerala) working with CV Raman in physics, Indira Gajjar from Bombay, Violet D'Souza originally from Goa, but educated in Lucknow, M Prema from Mangalore working with Sreenivasaya on fermentation technology, Roshan Irani from Madras working with PC Guha in organic chemistry, and Mariam George working with JV Bhat in microbiology.

However, World War II ended in 1945, and soon afterwards, the interim Indian Government announced scholarships for science and engineering students to go to England, USA and Canada to get better qualified and to come back to independent India to build up the country's industry and economy, which had suffered terribly during 200 years of foreign rule and World War II.

My two friends, Anna Mani and Roshan Irani, got scholarships to go to [the] UK in 1946. I was the third among the women to get a scholarship to go to USA. Several of the men students also obtained these scholarships.

> *My two friends, Anna Mani and Roshan Irani, got scholarships to go to [the] UK in 1946. I was the third among the women to get a scholarship to go to USA.*

I had two research publications with SP Chakravarthy and one with SK Chatterjee who was an MSc in Applied Physics from Calcutta University and who had joined the Institute as a lecturer in the Department of Electrical Technology in 1946. Did all this wonderful background of my Indian education and experience of a 25-year-old prepare me for an unknown higher education in USA?

After I obtained my admission in the University of Michigan at Ann Arbor, it took several months for the interim Indian Government in Delhi to arrange my travel to USA in the converted troop ship SS Marine Adder from Bombay (Mumbai) to San Francisco [which we reached in July 1947].

[From there, I travelled to Chicago and then Ann Arbor.] My friend Parvati Subramanian from Bangalore, who was doing her Master's degree in Psychology, met me at the station and took me to the rooming house which had been arranged for me by the University. The way Mrs Carol Woods, who was my house mother, treated me made me fall in love with the Americans.

After a month or so, I joined the Department of Electrical Engineering as a graduate student. I completed the requirements for a Master's degree called MSE (Master of Science in Engineering) by the end of January 1949.

I wished very much to continue my work to obtain [a] PhD degree by specialising in electronics and vacuum tubes, but the Government of India wanted me to take some practical training before returning to India after two years in USA. So I took training in radio frequency measurements at the National Bureau of Standards at Washington DC from February 1949 to middle of September 1949.

In the meantime, I had applied for the Barbour Scholarship at the University of Michigan to continue for my PhD degree. When I obtained the scholarship, I requested the Government of India to give me permission to accept it, which they did as long as I would satisfy their agreement that I would serve India for three years.

I decided to work with Prof William Gould Dow who had worked on microwave magnetrons in the Radiation Laboratories at MIT at Cambridge [Massachusetts], during the war years. I passed the final oral examination in January 1953. The PhD degree would be given only in June 1954.

How did I feel coming back to my country after five-and-a-half years? I had left India a month before Independence on a British Indian passport, when the partition riots were beginning in Punjab and also in Bengal. There were a few Indian students travelling with me on [the] SS Marine Adder to USA, who were from these regions. I remember Ram Parshad from Lahore who was very much worried about his family in Lahore, and also (Ms) Khaneez Ataulla from Lahore who went to Chicago University to do her PhD. Later on, I heard that she lost all her family in Lahore during the riots. Since I was going back to my hometown Bangalore in South India which did not suffer from these riots, I did not worry about these things very much, but was more worried about my future prospects in India.

The first thing I did was to get married to SK Chatterjee, whom I had known earlier at IISc. Soon after that, I received a letter from the Government of India that it would like to consider me as a lecturer in Electrical Communication Engineering at the Roorkee Engineering College in Roorkee, UP. At the same time, IISc advertised for a lecturer's post

Chatterjee spent over three decades working at IISc

in the Department of Electrical Communication Engineering, for which I was selected and given the letter of appointment by MS Thacker, who was the Director. My husband SK Chatterjee was made an Assistant Professor at the same time.

> *IISc advertised for a lecturer's post in the Department of Electrical Communication Engineering, for which I was selected and given the letter of appointment by MS Thacker, who was the Director*

So I joined as a lecturer in the ECE department in August 1953. I was asked to teach Electromagnetic Theory by K Sreenivasan, who was the head of the department, to the final year students of the Diploma course. The class of about 20 students had only one girl named Jaya and the rest were boys. They were from different parts of India, selected on their high ranks in their BSc or BSc (Hons) degrees in Physics, Mathematics and Chemistry. They were intelligent students who were eager to learn, though this was the first time that the subject of Electromagnetic Theory was taught in the department. After a few years, the Diploma course was called the BE degree and ME courses were started in Advanced Electronics and in Microwave Engineering.

My daughter Indira was born on 2 April 1954, and I continued my teaching and research work in my special fields of Electromagnetic Theory, Microwave Engineering and Antennas.

My husband also taught many courses on the above subjects as well as on many other subjects like satellite communications and so on, and guiding his research students on topics in these subjects. He guided 12 research students [to a] PhD and I, 20. I have about 120 research publications in Indian and foreign journals.

I had several research projects from CSIR and UGC and from the Defence R&D, while my husband had a PL-480 project from USA. I was awarded the Ram Lal Wadhwa Gold Medal by the Institution of Electronics and Telecommunication Engineers (India) [IETE] in 1978, and earlier the Meghnad Saha Award by IETE in 1975, and the JC Bose Premium of the Institution of Electronics and Radio Engineers (IERE), UK, in 1967.

One important Defence R&D project that I and my colleague Dr DN Bose of [the] ECE department completed in collaboration with Professors AR Vasudeva Murthy and Narayanan Kutty of the Inorganic and Physical Chemistry Department was on YIG-tuned microwave devices.

I have published four technical books on Microwave Engineering and three on Antennas in India and abroad. The last book, *Antennas for Information Super Skyways* published by the Research Studies Press in 2003, was written jointly with my old student PS Neelakanta of the Florida Atlantic University at Boca Raton, Florida.

A very happy day in my life at IISc happened on 1 January 1989, when the [former] students of my [late] husband celebrated his eightieth birthday by holding a research seminar in his honour at the IETE premises in Bangalore, where many research papers were presented by his [former] students on microwave engineering and antennas. My daughter, Indira Chatterjee, also presented a paper by OP Gandhi, who was her PhD research guide at the University of Utah in USA

Today when I am 86 years old, I am very happy that I worked at the 'Tata Institute' for more than thirty years.

Rajeswari Chatterjee was a professor at the Department of Electrical Communications Engineering. She passed away in 2010

Working in the microwave lab (Photo courtesy: Rajeswari Chattopadhyay)

Too restless for academia

– Rajeswari Chattopadhyay

A telecommunications entrepreneur on the lure of industry

I joined the Department of Electrical Communication as a research student in January 1965 after completing my MSc degree in Mathematics from Mysore University. During my PhD, I worked on a problem that drew heavily from a subject I loved, mathematics.

Like many, I did not know what to expect when I joined the Institute. But I was in awe of it! Familiarity definitely changes perceptions: we went through some good and some not so good experiences. People did great work at the Institute. However, I have not met many who could give a usable practical solution to a technical problem. Having said that, I believe, amongst the alumni, I have met many outstanding working engineers.

I worked towards my PhD under the guidance of the late Prof SK Chatterjee, who was a pioneer in the microwave field. What an unusual man he was! I grew up without a father; I was five when my father left us. Prof Chatterjee was virtually my father. In 1965, he taught us satellite communications – we earn our bread and butter through this field now.

> *I worked towards my PhD under the guidance of the lateProf SK Chatterjee,who was a pioneer in the microwave field*

After completing my PhD, in 1971, I took up a job as a scientist at the Microwave Antenna Systems Engineering Group of ISRO, Ahmedabad. I thoroughly enjoyed understanding and working on all aspects of satellite earth station antennas. After a year, quite reluctantly, I joined the Indian Telephone Industries (ITI) as an engineer in its Research and Development Division and continued working there for 20 years. I was reluctant to leave ISRO because I was happy there but the thought of returning

to Bangalore kept luring me. At ITI, I was soon engrossed in industrial work and did not for a minute regret quitting ISRO. Our department was called the Bell Labs of India – the department was then headed by an alumnus and a brilliant student of IISc, DK Sachdev. Taking voluntary retirement in 1993, I now work for our own company which is involved in satellite earth station installations all over the world. This is a lot of hard work, but for someone like me, it's totally enjoyable.

Many might wonder why I left IISc, because the general perception was that one could become a member of the teaching staff, if one stuck around long enough! The reason I left IISc had nothing to do with the institution. This is a fabulous place.

> *My restless nature needed constant activity. Academic life was too placid and laidback, especially for someone who wants things to be happening all the time*

Why did I not choose academia? My restless nature needed constant activity. Academic life was too placid and laidback, especially for someone who wants things to be happening all the time. Even the late Mrs Rajeswari Chatterjee, former Professor at the Department of Electrical Communication Engineering, used to get quite annoyed at the number of calls I made and received on my mobile whenever we travelled together in a car!

The other reason was that I didn't consider myself an intellectual. I was not satisfied just with ideas. I rather enjoyed seeing tangible results of my endeavour – hundreds of pieces standing in a row, to be equipped into systems that helped communication somewhere.

That I played a part, however small, in establishing networks is what has kept me going for years!

Rajeswari Chattopadhyay was a PhD student at the Department of Electrical Communication, IISc, from 1965 to 1971.

Rajeswari Chattopadhyay is at the extreme right, followed by her contemporaries from IISc: Shanta Vijayaraghavan (BE from ECE Dept IISc) Prabhavati Pyati (ME from ECE Dept IISC), Vasantha Raju (BE from ECE Dept IISc), Bharati Bhat (ME from ECE, PhD from Harvard) and her husband, Aloknath Chattopadhyay

Alpha to Omega

- Renuka Ravindran

The mathematician and former dean on her growth at IISc

Renuka Ravindran obtained her PhD in applied mathematics from IISc before going to Germany for further studies in aerodynamics. She returned to her alma mater as a faculty member, eventually becoming a full professor and Chair of the Department. She retired from IISc as the Dean of Science Faculty in 2005 (Photo courtesy: Manmohan Rao / Creative Commons Licence / Wikimedia)

Put it in any way you like – (a) from the beginning to the end, or (b) from the start to finish or (c) from alpha to omega – of my active research life was spent at the Indian Institute of Science. I entered as a meek, diffident research student in 1965 and left as a not-so-meek, not-so-diffident researcher in 2005. Certainly, these 40 years were the best years of my life. Looking back on these years is a pleasure, more so as I have erased all that I do not want to remember with one click of the "Delete" button of my memory.

What do I remember of the sixties? The figure that looms up first is that of Prof PL Bhatnagar, the founder Chairman of the then "Applied Mathematics" Department. He was formidable and overpowering – mentally, physically, and spiritually. He was a strict taskmaster, who could breeze into our "cubby hole" offices in the now extinct "Director Bhagvantam's Lab" (which was the Applied Mathematics Department) at any time he chose and demand what we have accomplished since he last reviewed our work. He was also a father figure, who took care of us with as much (if not more) attention and affection than he lavished on his own children.

Another scene that flashed in my mind is that of the Ladies Hostel – now demolished, known lastly as the J Block or affectionately as "Old Ladies Hostel". It was a sprawling building housing 20 or so female research students. It had a patch of green in the inner quadrangle, where we amused ourselves before the days of TV by jumping rope or playing badminton. The best among us could skip rope up to 1000 times without a pause. One of the constant features in the hostel was the row of soap boxes in front of the bathroom, the one with the geyser. This gave one the right to be ahead in the morning queue to take bath. Those who worked late in the laboratories were at a distinct advantage because any soapbox placed after midnight gave its owner the right to access. Along with the hostel, one remembers the messes – the vegetarian mess (later A mess) and the non-vegetarian mess (later B – NV mess). In the NV mess, Wednesday nights were special with dosa and half a grilled chicken – with the champion consuming up to 20 dosas. The servers knew each of us personally and we were all a part of one large family. There were special dinner days – where we ate a fare, which was truly royal, under the full moon outside. At a princely rate of Rs 3 a day, we had a truly well run mess with all that one could wish for. Besides, the lady students were at a distinct advantage. For the almost 1000 men students, we were around 20 women students. The ratio was certainly in our favour.

> *For the almost 1000 men students, we were around 20 women students*

As for the department, we were a small group with one Professor, one Assistant Professor, a handful of lecturers, and a whole bunch of enthusiastic research students. Since many of us had taken up research problems which involved

numerical computations, we had to spend hours cranking the hand-operated "Facit" machine. The more adventurous among us, who took up large computational work, had to make the trip to HAL, where the sole computer in Bangalore was situated. This involved a long and tedious bus journey – much like the pioneers – and sometimes carrying a bed roll to spend the night there, if required. A very precious piece of equipment carried along was rolls and rolls of paper tape carefully punched on the punching machines at IISc and which had to be protected from any kind of damage during the arduous bus journey. The more tech savvy among us could simply unscroll and read these rolls with ease and staring at the punch holes could tell us where a sign was missing or a character had been wrongly typed.

At the department there was a constant stream of foreign visitors. One of the frequent visitors was Prof Kampe de Feriet, a kindly old Professor from France. There was Prof AR Robinson from Harvard, who introduced Oceanography to the department, Prof. Collatz, the Numerical Analysis Professor from Hamburg, Germany, Prof (later Sir) M James Lighthill, the aerospace expert, who was later the Lucasian Professor at Cambridge University, to name a few. Another frequent visitor was Sir CV Raman, who was very disappointed that none of us students were colour blind. There was a very close relation with the Mathematics Department at Central College, especially with the late Prof Noronha. Prof Bhatnagar and his entire entourage of faculty and students would make trips to Central College to attend seminars, lectures, or workshops. Bhatnagar also had close links with Prof Narasimhaiah of National College. He believed that if you lived and worked in a city, you must make a difference to it.

Getting a PhD was a big affair. The entire department would gather in the lecture hall for tea and the new doctor would be given a gift. I still treasure the foldable bookstand that I got on the occasion. After the degree was given, each one was encouraged to go abroad for a postdoc. Each of the foreign visitors was requested to support a postdoc. It was almost like a world family, where you moved from one house to another in a different continent.

> *Getting a PhD was a big affair. the entire department would gather in the lecture hall for tea and the new doctor would be given a gift*

Besides the many classes and lectures we attended, the "fun" class was the foreign languages class, a pass in which was the prerequisite for taking the comprehensive examination. Three languages were offered – French, German, and Russian. The French and German classes were full, so some of us opted for Russian, where there were only about ten students. Learning the Cyrillic script was not difficult and most of us considered the class as a respite from an otherwise tough life. However, there was one among us who took the class in real earnest. Every Russian word would bring out a question – "How is it related to the following German word?" or "Is the root in the following Latin word?" One of the lessons in the Russian text was translated as "Charlie is a good student." So this particular student was affectionately called Charlie.

As the years rolled on, life changed. Some of the changes were for the better, some were not so good. Forty years is a long time in the life of an individual, and as far as IISc is concerned, it was a sizeable part of its life as well. Watching the scene change and being part of this change was a privilege for me.

"Little drops of water, little grains of sand

Make the mighty ocean and the pleasant land."

So whatever we have contributed to the image and stature of IISc, may it add in a small, but not insignificant way, to its glory.

Renuka Ravindran was a professor at the Department of Mathematics.

G Padmanaban on the Way Forward for Indian Science

- Rohini Krishnamurthy

Govindarajan Padmanaban is a celebrated biochemist and biotechnologist, known for his work on malaria. In a career spanning 50 years, he has mentored several students, helped establish start-ups and several research institutes. Recently, Padmanaban turned 80 and on 23 March 2018, the Director, Anurag Kumar, released the second volume of his memoir, titled Doing Science in India: My Second Innings*, published by IISc Press.*

In this memoir, Padmanaban dwells on his life and research post-retirement. While a part of the book is dedicated to his research on malaria, he also writes about challenges in Indian science, ranging from the lack of infrastructure and inadequate funding to the importance of innovation in renewable energy, agriculture and healthcare sectors. Besides discussing Indian science, he defends genetically modified (GM) crops, which, according to him, could address issues of crop productivity.

In an interview with Connect*, Padmanaban spoke about different facets of doing science in India – the challenges, the unfair age limit for retirement imposed on public sector scientists, the perils of not engaging in public outreach, innovation in the country and his own research.*

Padmanaban at the launch of his second memoir. The Director, Anurag Kumar is seen in the background (Photo: KG Haridasan)

Do you think people aren't getting drawn to pursue research because of the long years of preparation it demands and the belief that a career in science doesn't lead to cushy well-paying jobs?

It takes, on an average, over five years to get a PhD. In India, if you have to do good science in a good institution it does take that many years!

Most researchers I know have done well after a PhD: they go abroad, make some money, and then, a few settle down in India. One can lead a decent life. Secondly, this profession gives a sense of satisfaction that you can address and try to solve an issue of relevance to society. In a company, we are asked to work for the company, whereas as a scientist, I can choose to work on whatever I'm interested in and I get paid for that!

How would you say one can popularise science?

Apart from all the standard measures in place, I think scientists should also get some recognition that is appreciated by the public. We have heard of Indian of the Year awards. But have you ever seen scientists on the list? It will send a signal to the community that science is recognised by the public. And when this is done, youngsters will get motivated.

In your book, you express disappointment over the difficulties faced by retired scientists who want to continue doing research. How do you think this issue can be addressed?

This issue faced by public sector scientists has been raised with the government. But I'm told that the Indian Administrative Service lobby does not like this because they have to retire at 60. What usually happens is that scientists move to private universities where they are allowed to work even up to 70. But it's difficult to start research built over the years in a new place. In India, most of the research gets done in public sector laboratories and much less in the university system. It looks unfair that while Central universities, IITs and IISc permit service at least up to 65 years of age, public sector scientists have to retire at 60. Unlike IISc, many institutions, especially universities, do not accommodate retired scientists who wish to continue with research. We are missing out on gaining from a lifetime worth of experience in science.

This can be changed without interfering with the careers of scientists in service. I feel we should have large numbers of contract appointments made for retiring scientists who choose to work. They should be allowed to continue in the same institution and lab, while also being allowed to hire research staff. But retired scientists should not have administrative positions of authority in the same institution.

In the recent past, we have had people holding responsible positions making statements with no scientific basis. In times like these, should scientists be more involved in public outreach?

Public outreach is very important. I think there is a lacuna in the Indian system. Of course, some of the government agencies have a separate wing to engage with the public. As scientists, we tend to isolate and confine ourselves within our labs. One problem, I think, is that many scientists may be good in communicating science within the scientific community but are not good at expressing this to the public, and it's even worse when it comes to communicating in a vernacular language.

One example of the lack of public outreach is the issue of GM crops, of which I am a proponent. But to my mind, if scientists had engaged with the public earlier, we could have addressed the real concerns. Now, we have a lot of imaginary and engineered concerns such as claims, from non-governmental organisations and other activists, that GM crops cause harm to the health and the environment. The Bt gene from the bacteria Bacillus thuringiensis has been in use for the last 75 years and we have had no major issues of health

or environment reported in the last two decades of GM crop (corn) consumption by millions. While genuine concerns should be addressed by scientists, we cannot handle people with vested interests.

You have written about GM crops and the controversies surrounding it. Bt cotton is said to be resistant to pests. But in India, the pink bollworm attacks Bt cotton, whereas this is not the case in countries such as the US and China. Why has this happened?

Indian farmers use hybrids, while those in other countries use varieties. Hybrids give better yields than varieties but farmers cannot reuse the seeds and so companies prefer to sell hybrids. But varieties can be packed and grown densely, unlike the hybrids, compensating for lower yields. To increase yields, Indian farmers grow hybrids for a longer period, which increases exposure of pests to the toxin, causing the pest to eventually become resistant. Our yield of Bt cotton hybrids is less than 50 percent of China's, which uses varieties. Another advantage [of using varieties] is that farmers can reuse seeds.

In 2016, a 400-page report released on GM crops by the US National Academies of Sciences, Engineering, and Medicine specifically mentions why India is the only country where pink bollworm has developed resistance to Bt cotton. The two reasons for this are: India doesn't follow the refuge strategy – the practice of using 10-15 percent non-Bt cotton in a field containing Bt cotton crops. When this method is followed, pests attack the non-Bt cotton, leading to reduced exposure to the Bt crops, thereby reducing pressure on the pathogens to grow resistant to the Bt toxin. The progeny between a pest potentially resistant to the toxin and one that is sensitive to the toxin would be sensitive to the toxin. Indian farmers don't follow this method; they want 100 percent Bt in their land.

The other thing is we need to ensure that the expression of the toxin remains high, such that it is adequate to kill the pest. The pest load can sometimes be high, moderate or less. This should be tested every season. Analysis of the expression in labs should be a part of the extension programme. I don't think farmers have any help at all. If you give them the crop and leave them on their own, what will they do? They'll end up spraying more pesticides to safeguard their plants! So farmers should be advised and mentored. Labs should analyse samples and, these days, results are available in a few hours. Agriculture needs this kind of an extension activity.

What do you think needs to be done at the moment to set things right?

I think the government itself is not very clear on this [GM crops]. Why do we still have an embargo on Bt brinjal when Bangladesh is successfully growing this? For GM mustard, all that is needed is approval for commercial trials. It [GM mustard] is a hybrid, which means farmers cannot use it after a year. If cultivated, in a season or two, we will have the results. If results are good, farmers should be allowed to go for it. There are many hybrids that the Indian Council for Agricultural Research introduces, some [hybrids] are good and some are not. We don't hear about poor-performing hybrids later. This can also be applied to GM crops. Scientific validation should be allowed. Then, compare the results with non-GM crops and make a decision. That is all that is asked for. Overnight it [GM mustard] will not become a commercial crop. I have mentioned it in my book. Activists are probably afraid that GM mustard may succeed!

Could you tell us about Biotechnology Industry Research Assistance Council (BIRAC) and your association with it?

BIRAC is a Section 8 company of the Department of Biotechnology that provides funding and mentoring for projects with industry. The whole effort started a decade ago and BIRAC became a formal entity six years ago. It is a public-private partnership and several schemes are available for industry with or without academia partnership. I chair the Technical Evaluation Committee (TEC), which reviews and shortlists all projects. We call them [applicants] for presentations. This is followed by site visits and then there is further shortlisting. Once we approve a project, the administrative team takes over. BIRAC has supported around 700 projects with 500 industries and close to 100 products have become a reality.

From your experience as the Chair of TEC, do you think there is a dearth of innovation in India?

I don't think we are not creative or innovative. For example, we have a scheme in BIRAC called Biotechnology Ignition Grant (BIG), where young people just out of their academic journey approach us to fund their start-ups. They do have bright ideas. Once we select them, we give them Rs 50 lakh for a period of 18 months. Some of the brightest projects are coming from BIG. This tells me that there is no dearth of innovative ideas among young people. I think over a period of time this innovation gets killed because the environment doesn't have the support system to foster innovation. If they [young people] didn't have the BIG project, for example, to support them, they would have gone abroad to do their postdoctoral research or work with somebody there. The reason why we don't have an environment that is conducive to innovation is that we are afraid of failure. The system, in general, doesn't allow a person to try again. There is scope for BIRAC-like support towards translation in many other fields of Research and Development.

Moving on to your research, artemisinin based derivatives [also called ART derivatives obtained from Chinese traditional medicine] is the universally approved drug for malaria. Your research suggests that when curcumin is used in combination with ART in mice, the infection doesn't relapse. And yet, clinical trials are still pending. How are you going to take this forward?

I don't know. My research shows that by using it [curcumin] as an adjuvant, it bolsters the immune activity of the host, despite its poor bioavailability. These results are all published in well-established journals.

again, antibodies and cell-mediated immunity would be in a position to recognise and kill them.

We are also working on blocking transmission of malaria. There is a big move to eradicate malaria all over the world. But in India, our focus is on controlling and not eliminating malaria. African countries focusing on elimination have decreased malaria by 50 percent. We have not done it yet. At the research level, we have shown that the heme biosynthetic pathway of the parasite is essential for its development in mosquitoes. When the parasite is prevented from making heme, it fails to develop in mosquitoes, blocking transmission to humans. This pathway is a good target for designing drugs. We can now look for heme biosynthetic inhibitors.

Curcumin is a yellow-orange pigment isolated from turmeric (Image Courtesy: Simon A Euster/Creative Commons License/Wikimedia Commons)

Clinical trials have to go through the New Delhi-based National Institute of Malaria Research (NIMR), which is my clinical trial partner. I have been communicating with them [NIMR] by sharing my ideas and answering queries from the office of the Drug Controller General of India. This has been going on for more than five years. The problem is that there is confusion as to how to treat a natural molecule like curcumin, which does not satisfy the classical parameters of medicinal chemistry, as a drug. Its mechanism of action is different and it acts through creating an immune memory to fight against the parasite long after it has disappeared from circulation.

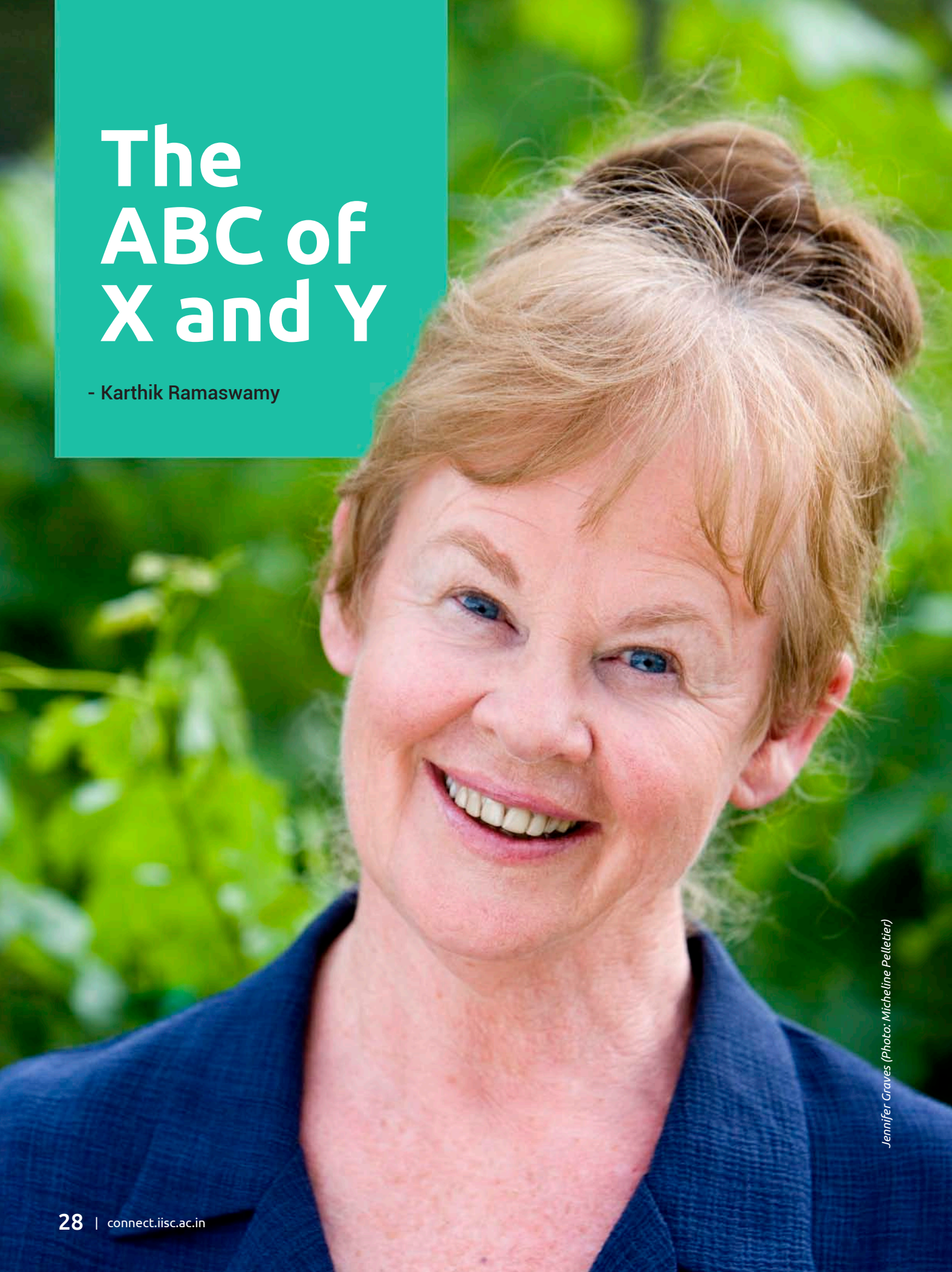
A map of malaria-endemic countries in the eastern hemisphere (Source: https://wwwnc.cdc.gov/travel/yellowbook/2018/infectious-diseases-related-to-travel/malaria)

What are you working on now?

While I stay at IISc, my group has moved to the Institute of Life Sciences, Bhubaneswar and I am part of the group. My research continues through regular Skype meetings, emails and personal visits. The aim is to prove our hypothesis that though curcumin doesn't kill the malaria parasite directly, it generates memory against those antigens [from the pathogen] by producing antibodies or working in combination with T cell memory. This is important because if pathogens strike

The ABC of X and Y

- Karthik Ramaswamy



Jennifer Graves (Photo: Micheline Pelletier)

Jennifer Graves is Distinguished Professor at La Trobe University in Melbourne, Australia. Her groundbreaking investigations into how genomes are organised in Australia's unique fauna have yielded insights into our understanding of evolutionary genetics, particularly the function and evolution of mammalian genomes. She is also well known for her influential studies on human sex chromosomes and sex-determining genes. Her work has won her several awards including the 2006 L'Oréal-UNESCO Laureate Fellowship for Women in Science and the 2017 Prime Minister's Prize for Science given by the Australian Government.

Graves was in IISc in March 2018 to give a public lecture organised by the Indian Academy of Sciences and participate in a discussion titled Women in Science *hosted by the IISc Alumni Association. During her visit, she also spoke to* Connect *about how sex is determined in humans, why the human Y chromosome that specifies males might soon go extinct, and what Australia's unusual animals can tell us about the evolution of sex chromosomes.*

There are many costs of sex not least of which is the huge investment females make in producing males. But sex seems to have evolved almost as soon as eukaryotes appeared on the planet. So, why sex?

That's a good question. An asexual female would be doing much better by cloning herself because all her genes would be passed down to her offspring instead of only half. So there must be a good reason for you to mix your genes with those of another individual. My favourite hypothesis is that the real driver for sex is genetic variation which helps you deal better with pathogens and parasites. If there is genetic variation among the members of the population, surface antigens of pathogens are going to be different in each of them. On the other hand, inbred populations with less genetic diversity are vulnerable to getting wiped out by pathogens. So that seems to be why sex, which is at least half a billion years old, is ubiquitous in plants and animals.

> *My favourite hypothesis is that the real driver for sex is genetic variation which helps you deal better with pathogens and parasites*

Sex typically requires two sexes – other than in hermaphrodites. In humans, we know that females have XX chromosomes and males have XY chromosomes, just as in most other mammals. How exactly does this work?

Before I answer the question, I want to remind your readers of some elementary genetics. Our DNA which is present within the nuclei of our cells is divided into smaller fragments, rolled up with proteins into chromosomes. All our genes are present on these chromosomes. We have two copies of each chromosome, one of which is from your mother and one from your father. We humans have 23 such pairs of what are known as homologous chromosomes. The chromosomes of males and females are similar except for one pair of chromosomes. These chromosomes are identical in females and are called X chromosomes. Males on the other hand have a single X chromosome accompanied by a teeny-weeny chromosome called the Y chromosome.

In an embryo if the undifferentiated gonad receives the Testis-determining Factor (TDF), it turns into a testis, which in turn makes hormones that trigger the development of other male characteristics. If it doesn't, it becomes an ovary. TDF is the key to making male babies. Until 1990 we didn't know which gene on the Y chromosome encodes this protein. Many people were involved in this race to identify this gene in the 1980s. The first gene that was cloned from the Y chromosome was called the *ZFY*. It looked like a very good candidate for sex-determination.

Now this is something that I accidentally got involved in during the 1980s. It started with a phone call from David Page [the geneticist who discovered *ZFY*]. He asked me if we could map this gene in kangaroos. He said that if it is the right gene then it should be on the Y chromosome in all mammals including marsupials. I gave this job to two of my students: Jamie Foster and Andrew Sinclair. And to their shock, they found that it was not on the Y chromosome in kangaroos; it was instead on chromosome 5. In another mouse-like marsupial called the dunnart, it was on chromosome 3. So *ZFY* was in the wrong place and so must be the wrong gene. Andrew Sinclair went to London after his PhD where he eventually cloned the right gene: *SRY*. We know this is the right gene because a mutation in this gene makes the embryo female even if it has a Y chromosome. And Jamie came back a few months later to my lab where he cloned a similar gene, *SOX3*, on the X chromosome, which is the ancestor of *SRY*. Then he returned to the UK and discovered *SOX9*, which is the target of *SOX3*. But the story of sex-determination is much more complicated than we initially thought with many more steps upstream and downstream to *SRY*.

> *We know this [SRY] is the right gene [for sex-determination] because a mutation in this gene makes the embryo female even if it has a Y chromosome*

Graves with a slide of marsupial chromosomes in the background (Photo courtesy: Jennifer Graves)

You've described the sex chromosomes as an example of "dumb design" to contrast it with the idea of "intelligent design" used by creationists. Could you elaborate on what you meant?

Sex chromosomes are a lot of trouble. They don't pair very well during meiosis. They pair only at the very, very tip. That's dangerous because it can lead to infertility.

Another problem is dosage. The X chromosome has over 1500 genes and the Y chromosome only has 27 in the male-specific part [it has about 45 in all]. So females have two copies of most genes and males just one. Therefore there's a very elaborate mechanism to silence one of the X chromosomes in females to match the males. So that could go wrong as well. Another problem for males is that there's only one X chromosome; if a gene on it mutates, there's no backup. So men get many sex-linked conditions like haemophilia and colour blindness.

And finally, the gene that promotes sex is right at the top of the Y chromosome. And sometimes it gets accidentally recombined with the wrong chromosome and that doesn't work very well either.

So are sex chromosomes the way they are because there's no better way to make them? My answer is no. Organisms are stuck with the genes they receive from their ancestors and they make the best of this bad situation by evolving mechanisms like making genes on the X more active to match the other chromosomes, then silencing one in females. So I think it's a wonderful example of dumb design. You see many such examples of poor design in the human body itself. There is a tendency is to look at nature and say that there must be some good evolutionary reason for this. But sometimes it's just a hangover from our evolutionary past.

You just said that the Y chromosome is a degraded genetic landscape. In the past you've referred to it as the "wimpy Y". Why is it degenerating?

There are two things about the Y chromosome that are bad. One is that it is always in the testis by definition. It's never in an ovary. And the testis is a very dangerous place to be because there's a lot of cell division to make sperm. Every cell division is an opportunity for mutations. So you get a much higher rate of mutation in the genes that come from the sperm than you do with the genes that come from the eggs. And that's true for all the father's genes, not just sex genes.

Besides, Y can't repair itself very well unlike the other chromosomes. For instance, if you have a mutation at the top of one X and one at the bottom of the other X, when they pair, they undergo a process called recombination. So you can combine the good bits of the two X chromosomes and get a good X in the egg. The Y is all alone in the world – it doesn't have the opportunity to recombine and get rid of the mistakes. So the lack of meiotic crossing over of genetic material and the high mutation rate mean that its genes are very vulnerable and the chromosome degenerates very fast.

You've also predicted that the human Y chromosome could go extinct in a few million years. Given the rate of loss of genes in the Y in the past few million years, what is the prognosis for this chromosome?

All placental mammals and marsupials have Y chromosomes. But they are all a little different. The mouse Y has lost almost everything. There are only about two genes that you need to make sperm. And in fact in some rodents the Y has completely gone, and has been replaced with something else. The primate Y has been stable for some time. But that doesn't mean it's going to be stable forever. It could degenerate very rapidly. It's full of repetitive sequences; so deletions are quite common. Many of these cause infertility.

If you assume that degradation is linear, you can easily work it out. We know from studying the genomes of other mammals that our XY pair started to differentiate about 166 million years ago. Originally there were 1669 genes on it, and today there are only about 45. So you can work out that about 9.8 genes disappear every one million years. At that rate, the rest of the Y chromosome is going to be gone in 4.6 million years. But of course this process is probably not linear. So it could be gone sometime between next week and in the next several million years.

> *At that rate, the rest of the Y chromosome is going to be gone in 4.6 million years*

When that does happen, males, and therefore the human species, could go extinct. Or a new sex-determination system could evolve...

Yes, it's interesting to think about it. One possibility that people love to champion is that we'll become a species with just females who reproduce by parthenogenesis. There are lizards that do it. But that wouldn't work with humans or other mammals because of genomic imprinting. We know that there are about 30 genes that become active only if they come through the sperm. They're very important genes for development. So we do need men, we do need sperm, and without them, we're all going to go extinct. Unless, as you say, a new sex-determining system arises. And that's actually happened much more frequently, and more recently, than you might think. It's quite easy to make new sex-determining genes. There are rodent lineages which have already lost

their Y chromosomes, and a new sex-determining gene has evolved very recently. If you came back in 4.6 million years, you may find that another chromosome will have become the sex chromosome in humans.

In one of your talks you seemed to suggest a speciation angle to this story.

When you look at the big picture, at every major rearrangement of mammal sex chromosomes, you see divergence of major groups of mammals. So I did begin to wonder if sex chromosome evolution drove these major separations. And I think there's quite a bit of evidence that sometimes speciation is driven by a chromosome change, particularly a sex chromosome change. Because when it changes, you really mess up sex. And that serves as an effective barrier between two divergent populations. So I'm suggesting that once you have a sex chromosome change or if you have the evolution of a novel sex-determining gene, that's going to drive speciation. And I think that's what's happened in these rodents that have lost their Y.

> *Once you have a sex chromosome change or if you have the evolution of a novel sex-determining gene, that's going to drive speciation*

Tell us more about these rodents.

It's a group of rodents called Japanese spiny rats...I love them. There are actually three species. One of them still has a Y chromosome; it's a bit of a strange Y, with 100 copies of a mutated *SRY* that doesn't work well. But the other two species have lost their Y and I'm suggesting that it's the evolution of a new system that drove speciation there. And exactly the same thing seems to have happened with the mole voles in eastern Europe. Again they have one species with a Y chromosome, one species with a single X chromosome in both sexes, and one species with two X chromosomes in both sexes. So again you see these species which diverged very recently have different sex-determination systems.

Let's talk about the X chromosome now. You have used the term "brains and balls genes" to describe the genes on X. What do you mean by that?

The X and Y chromosomes are similar only at the very top – that's how they stick together during meiosis when the sperm is made. The rest of the X chromosome is very different, even when compared to other chromosomes. There's been an accumulation of way too many genes that have to do with both reproduction and brain function on the X chromosome. And many of same genes are active in the brain and the testis, and code for both reproductive and cognitive traits. So when there's a mutation in them, it leads to sex-linked intellectual disabilities which are also accompanied by abnormalities in the gonads or infertility. And this is seen mostly in males because they have only one X. These are what I call the "brains and balls" genes; the term was actually coined by my German collaborator Horst Hameister.

But why has this happened? The brain and the gonads are of course very different organs. The best explanation I can think of is that different types of selection have acted upon the same large multifunctional proteins, giving them functions related to intelligence and reproduction. If a mutation confers an advantage to males, it'll be immediately selected because, as I just mentioned, males have only one copy of genes on the X chromosome. And I like the theory that intelligence in males is selected by females who are looking for smart partners! I'm waiting for somebody to look at what these proteins actually do and how they bind in the testes and the brain – they could have different binding partners.

> *There's been an accumulation of way too many genes that have to do with both reproduction and brain function on the X chromosome*

Your main research is in the field of comparative genomics. What do the genomes of marsupial and egg-laying mammals, which are native to Australia, tell us about the evolution of sex chromosomes in mammals?

What we see in marsupials is the same kind of sex-determination system with an X and a Y. Again, the *SRY* on the Y looks like the sex-determining gene. And it turns out that they are the original X and Y of therian mammals [marsupials and placentals]. In early placental mammals, a bit of an autosome [non-sex chromosome] got stuck on to it. The human Y is practically all derived from this recently added bit. We know that in the elephant X, for instance, the bottom part is old and the top part is new. And it's almost the same as in humans. The only difference between human and elephant chromosomes is the centromere [place where chromosomes attach during cell division] has moved slightly. So what we can tell by studying marsupial and other mammals is that mammal sex chromosomes evolved rather recently.

The koala is one of Australia's many marsupials (Photo courtesy: Jennifer Graves)

Graves' lab has also studied sex-determination in the Australian dragon lizards (Photo: Wildbear Entertainment)

But the real key to understanding the origin of sex chromosomes in mammals is the platypus. These are bizarre egg-laying animals. Platypuses and all other mammals had a common ancestor about 165 mya [million years ago]. They are mammals of course – they have fur and feed their young with milk, but retain many reptilian characteristics – but their skeleton is more like that of a lizard and the male makes venom much like snake's venom. They also lay leathery eggs like those of snakes. And their chromosomes too are very different compared to those of other mammals. They do have the old X and the bit that was added later on, but these are on autosomes. So they have completely different sex chromosomes with no homology to human or even kangaroo sex chromosomes. Remarkably, they have a lot of homology to bird sex chromosomes! We think what they have is probably what the first mammals had, but then it changed into the new XY sex-determination system just before the evolution of the marsupials about 150 mya.

> *The real key to understanding the origin of sex chromosomes in mammals is the platypus*

So how is sex determined in platypuses?

It is really weird because they have ten sex chromosomes. They have five Xs – with two copies of each in females and one in males. And there are five Y chromosomes that are male specific. We used a technique called chromosome painting to mark the Xs and Ys and showed that each sperm has only Xs, or only Ys. During meiosis we see these ten chromosomes all lined up and we think all the Xs go to one pole and the Ys to another. So you get two kinds of sperm: one having five Xs and the other having five Ys. It's a crazy way to do sex. But it works quite well. And there's no *SRY* gene. We think another gene, *AMH* – the anti-Mullerian hormone gene – which we find on one of the Y chromosomes, is the sex-determining gene.

Reptiles are also fascinating because in some species sex is determined by the temperature of incubation of the eggs. But you have found something even cooler in the Australian dragon lizards...

The Australian dragon lizard – a beautiful little creature – has genetic sex-determination, but a number of its closely related species have temperature sex-determination. We identified sex chromosomes and got the sequence from them. In fact, we sequenced the entire genome of this particular species a few years ago and we think we know the sex-determining gene. While studying this lizard, we found something really strange. At its usual range of temperatures, sex is determined by their chromosomes. Boys have ZZ chromosomes and girls have ZW chromosomes. But when we incubated the eggs at a higher temperature, they were all girls. We already

had molecular markers for their sex chromosomes by then. We were able to show that we had both normal ZW females and also sex-reversed females with two Z chromosomes like males. What's more is that they were viable and fertile; in fact ZZ females do better than the normal ZW females – they lay more eggs and their hatch rate is better.

The nice thing is that we could mate ZZ females with ZZ males. All of their hatchlings were ZZ, and their sex is completely temperature-dependent. So we were able to switch a sex-determining system from genetic to environmental in just one generation. The scary thing is that this is actually happening in the wild because of increasing temperatures due to climate change. We've been sampling for ten years and during that period, there's been a big increase in the numbers of sex-reversed females. So at this rate they'll all be females in next few decades. So you have to worry about climate change not just for species with temperature-dependent sex, but also those with this over-ride system like this dragon lizard. It might be more common than we think – there's a skink in which cold temperatures induce sex-reversal in males. So obviously a lot of things can happen with extremes of temperatures even when you've got sex chromosomes.

I'd also like to add one thing here. We've been able to use the dragon lizard to understand how TSD [temperature sex-determination] works. We looked at the transcriptome (the RNA made from active genes) of the ZZ sex-reversed females and found some really spectacular changes. We found that the stress genes were elevated; so it looked like high temperatures were inducing the stress pathway. That's not such a surprise because we think stress is involved in sex-reversal in fish as well. But we also found that two genes had a really unique transcript that could not code for the normal protein. These genes are big players in epigenetic silencing. So we now have the first clues of how the environment affects the genome.

> *The scary thing is that this is actually happening in the wild because of increasing temperatures due to climate change*

In the next few years what are the big-ticket questions in this field of sex-determination that you would like to see answered?

I would love to understand how the sex-determination systems change. We have many examples where they have very recently changed and turned over. Even better, in an experimental system, we actually might be able to build a sex chromosome, and see what happens in real time in the lab. And that's not an impossible dream.

As I mentioned already, the sex-determining pathway is very complex. We thought it would be simple. We now know of at least 30 genes in this pathway – some promote testes and some ovaries, some antagonise testes and some ovaries. This is again an example of dumb design because these pathways get built up and changed all the time – sex is so diverse. Mapping this process is going to be important.

I would also like to see how the environment interacts with these pathways. We have the genomes of many species sequenced. We don't lack the data anymore; we have to know where to look.

You study a subject that can be controversial to some people. Have you received any pushback, either from the extreme right or left, especially given how politically charged our world is right now?

It's never been an issue in Australia. It's been an issue for some other people in the same field. And they tend to be men. I think that's worked in my favour for once. Not many things work in favour of a female scientist, but I think I have been able to say things that would be hard for a man to say.

But a few years ago, I started to get strange invitations from some feminist magazines with words like "hermeneutics", the meaning of which I didn't even know. And I realised that they were using my work to further a political agenda. I thought that was rather unfortunate. It is not political in the traditional sense, but it does feed into all sorts of social tensions of gender and gender politics. In some quarters I am unpopular because I cannot pretend that women are genetically identical to men (see my article "Not just about sex: throughout our bodies, thousands of genes act differently in men and women" in *The Conversation*).

> *In some quarters I am unpopular because I cannot pretend that women are genetically identical to men*

An Evening with Raman at the Gymkhana

CV Raman was the Director of IISc from 1933 to 1937. It was in this period, in November 1935, that Kenneth Aston arrived as the professor and head of the Department of Electrical Technology. Uma Parameswaran, in her biography of Raman, writes that Aston was not Raman's choice for the post and became "one of Raman's bitterest foes".

The following is an account, from the IISc archives and by an unknown author, of an eventful Gymkhana meeting in 1936 that featured Raman, Aston, K Sreenivasan (Assistant Professor of Electrical Communication Engineering) and disgruntled students who took matters into their own hands.

A business half-yearly meeting of the Gymkhana was held in 1936, to elect office bearers, etc, for the ensuing half-year. There was a fairly large gathering of the members of the Gymkhana, consisting mainly of students of the Institute. Among the staff members other than the Director, Prof K Aston and Mr K Sreenivasan were present. They were sitting in the middle of the hall along with Prof Aston's research students like Mr Annaswamy Iyengar, BN Narayana Iyengar, etc.

CV Raman (Courtesy: RRI Digital Repository)

The Director who is the present President of the Gymkhana arrived just before the time of commencement of the meeting. He saw on the verandah Mr Chakradeo, a student of the Institute, who had some days previously been suspended by order of Council [of IISc]. The Director went to Mr Chakradeo and privately told him not to come to the Gymkhana and also not to attend the meeting and cause trouble. Mr Chakradeo said he was eligible to attend the meeting and if he should not be present at the meeting, he should be given an order to that effect by the Director in writing. The Director called the General Secretary and was writing the required order.

Meanwhile, Mr Narayandas (II year ET [Electrical Technology]) who was sitting inside the hall went out and talked to Mr Chakradeo. Immediately, Mr Chakradeo went and sat inside the hall, apparently determined to attend the meeting. The Director sent word through the General Secretary to Mr Chakradeo that the required letter was ready. But, Mr Chakradeo replied that he was going to attend the meeting ignoring the Director's advice. The Director then came into the Hall and occupied the Chair. Most of the members had already from the morning been expecting some trouble, because there was a rumour that Chakradeo backed up by some of his friends and some members of the staff was thinking of attending the evening Gymkhana meeting and creating trouble. Hence, everyone present was expecting with excitement some trouble or disturbance.

> *Everyone present was expecting with excitement some trouble or disturbance*

Mr Oke, General Secretary, before proceeding with the business of the meeting, raised a point of order and said that Mr Chakradeo, who had been suspended from the Institute by order of Council, was present at the meeting. He wanted a ruling from the Chair whether Mr Chakradeo could be present at the meeting and participate in discussing the business of the Gymkhana. The Chairman rose up and said that he was present there in two capacities, namely, as Director of the Institute and as President of the Gymkhana. He said he had given some thought to this problem as he had been informed earlier in the day that Mr Chakradeo was thinking of attending the meeting. He said that as Mr Chakradeo had been suspended from the Institute by order of Council, he was convinced that Mr Chakradeo was not eligible to take part in the Gymkhana activities, and hence, he asked Mr Chakradeo to leave the meeting.

SCIENTISTS ENTERTAINED

SIR C. V. RAMAN'S "AT HOME"

(FROM OUR CORRESPONDENT)

BANGALORE, Nov. 18.

To meet Prof. Max Bourne, well-known scientist and Prof. Kenneth Aston, who have come to the Indian Institute of Science, the first as Reader in Physics and the latter as Professor of Electro-Technology. Sir C. V. and Lady Raman gave a delightful "At Home" last evening at their bungalow.

Pleasant weather prevailed and there was a distinguished gathering present on the occasion.

The guests, on arrival, were received by Lady and Sir C Venkata Raman and conducted to the hall. After tea and music, the guests spent a pleasant hour in conversation.

Among those present on the occasion were the Hon'ble Mr. L. G. L. Evans, British Resident in Mysore, Sir M. O. Forster, Lt.-Col. J. B. Hance, Rajamantrapravina S. P. Rajagopalachari, Mr. V. N. Chandavarkar, Mr. Bava Kartar Singh, Mr. N. Madhava Rao, Dr. B. N. Aiyangar, Dr. C. V. Natarajan, Dr. V. K. Badami, Rao Bahadur B. Venkatesachar, Prof. C. R. Narayana Rao and Dr. P. Krishnamurthi.

A news report about the "At Home" reception that CV Raman hosted for Max Born and Kenneth Aston, after Aston's arrival in Bangalore in November 1935 (Courtesy: APC, IISc)

Mr Patwardhan (I year ET) (recent convert from Physics to ET) immediately rose up and questioned the ruling of the Chair. Immediately, he was followed by Mr K Sreenivasan, who rose up and questioned the ruling of the Chair and said that the matter should be discussed before Mr Chakradeo should be asked to leave the hall. At once, there were shouts of "Sit down" and "Do not question the ruling of the Chair".

Immediately, Mr Sreenivasan turned round and said to the students, "Gentlemen, I am not talking to you. I am addressing the Chair." He was applauded heartily by the ET research students and some of the regular course ET students who were sitting by him. Mr K Sreenivasan then turned to the Chair and spoke further. The President asked him not to question the ruling of the Chair and asked him to sit down.

At once, Prof K Aston rose up and shouted (at the President) "I want to know whether such iron despotism has ever been known in any part of the world."

Mr K Sreenivasan said that no one with self-respect could remain a member of the Gymkhana and that he would be the first one to leave the Gymkhana in that case. Prof Aston at once followed and slapping his hand on his chest, said "I too". Meanwhile, the behaviour of Mr Sreenivasan and Prof Aston was very much applauded by their followers (Mr Chakradeo and his friends), and disorderly scenes were witnessed. Mr Narayandas (II year ET) rose up and asked Sir CV Raman whether he could legally establish his ruling. The President asked him to sit down and maintain order. At once Messrs K Aston and Sreenivasan rose up, protested, and followed by about 15 students walked out of the hall.

Indian Institute Gymkhana

MEMORANDA TO GOVERNING COUNCIL

(From Our Own Correspondent)

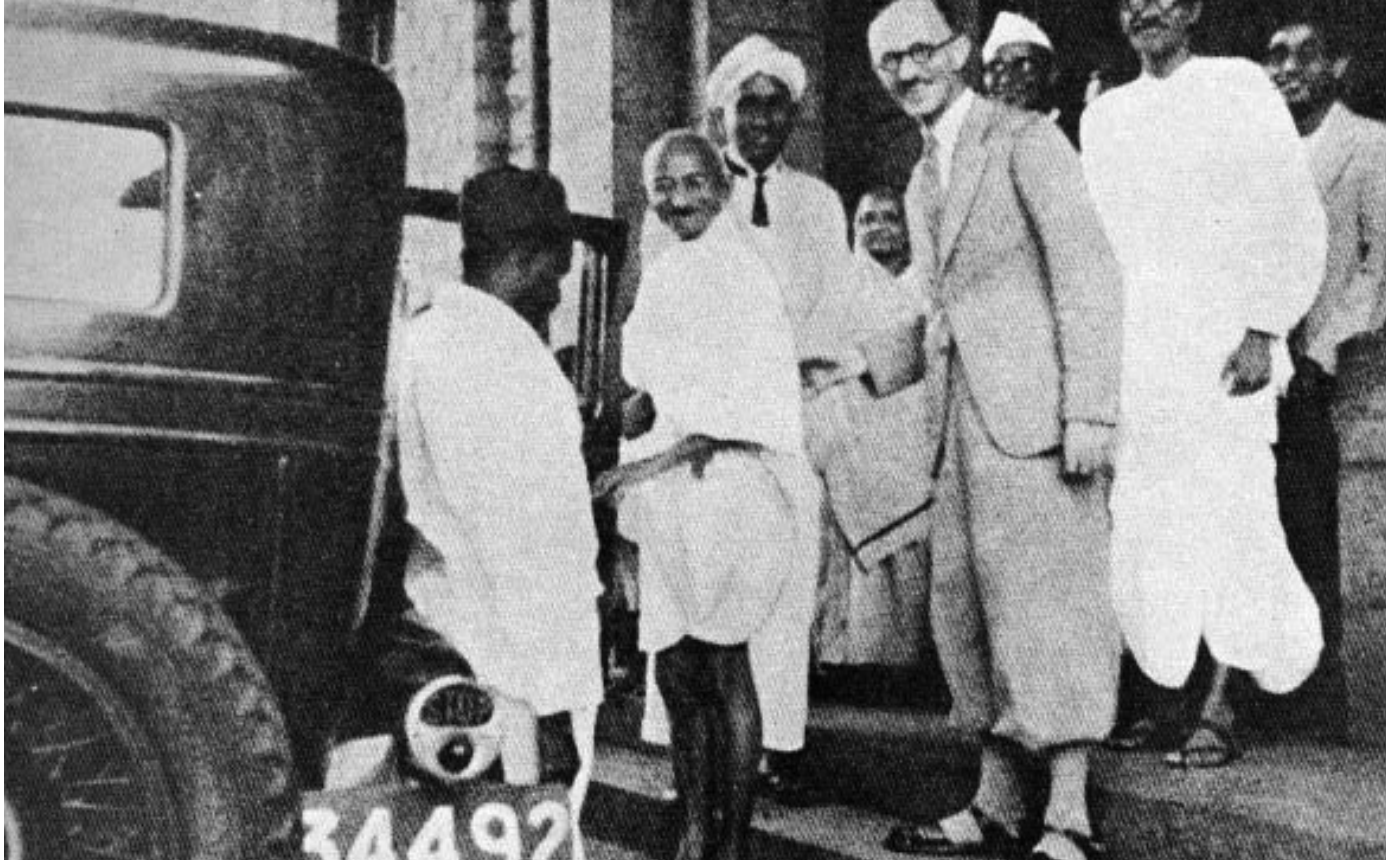
BANGALORE, Dec. 25.

It is learnt that Prof. Aston and Prof. K. Srinivasan, who recently staged a walk out at the Annual Meeting of the Indian Institute Gymkhana questioning the ruling of Sir C. V. Raman, submitted a memorandum to Governing Council complaining against the alleged autocratic ruling of Sir C. V. Raman at the Gymkhana Meeting and suggesting that Gymkhana should be made independent of the Director of the Institute and should be controlled entirely by students. It is understood that some of the students have also signed this memorandum.

The other members of the Gymkhana who resented the alleged behaviour of Prof. K. Srinivasan and Prof. Aston have also submitted another memorandum to the Governing Council putting forth what had happened at the meeting

A report in the Indian Express, dated 25 December 1936, about the Gymkhana meeting (Courtesy: RRI Digital Repository)

> *Messrs K Aston and Sreenivasan rose up, protested, and followed by about 15 students walked out of the hall*



Aston with Raman, and Gandhi, at a less contentious occasion (Courtesy: APC, IISc)

Mr Chakradeo just before leaving the hall, turned to the President and shouted: "This is not going to be the end. You will see more of this." Standing outside the door, were the people who had just then walked out. Prof Aston and Mr Sreenivasan were also there staring at the people who were inside. There were some students of the Electrical Technology and Electrical Communication Engineering departments who were sitting right before the door and though they would not have liked to walk out, out of fear, they also one by one slowly walked out. In all about 20 to 25 students walked out. There was shouting and jeering from outside.

The Director then continued with the business of the meeting. After about 5 minutes or so, two or three students were seen going to the switch board in the verandah. Immediately, the lights were off. On examining with a torch, it was found that the fuse block had been removed and placed in an adjacent socket. Some of the students set it right and again there was light. The Gymkhana peon was posted near the switch board. Meanwhile, expecting further trouble, some hurricane lanterns and petromax lights were sent for. Just as expected, in about 10 minutes the lights went off, but this time the electric wires leading from the Hostel to the Gymkhana were cut off as they were easy of reach. The Director requested everyone present in the meeting to preserve order and not be excited and assured the house that though he could fill the Institute with police in no time, he was confident of maintaining order and discipline single-handed.

> *"The agenda of the meeting was gone through with the help of hurricane lanterns, in partial darkness"*

The agenda of the meeting was gone through with the help of hurricane lanterns, in partial darkness. During the meeting, the people who had walked out, went about in a batch outside the Gymkhana shouting. Soon, stones were falling on the roof of the building. Some of the students, fearing that stones may be aimed at Sir CV Raman from outside, remained at the doorway and verandah and were keeping watch while the meeting was proceeding inside. The full agenda was gone through, and at about the close of the meeting, Prof V Subrahmanyan and Mr SKK Jatkar entered the hall and were standing at the end of the hall. Before closing, the President paid a tribute to the students present for having upheld the dignity of the Chair and concluded by saying that no institution can exist without the members caring for order and discipline and exhorted the students not to swerve from the right path.

At the conclusion of the meeting, the Director wanted to walk to his house. But, the students surrounded him and strongly advised to go home in his car. As Sir Raman left the Gymkhana, he was continually cheered by the students. The disturbers were standing at a distance on the verandah of the Hostel, and were calling the students, who were coming from the meeting as "rats" and went on making fun at them.

India on the Minds of IISc's Undergraduate Students

Photo: KG Haridasan

- Rohini Krishnamurthy

What do maps of India have to do with an undergrad course at the Institute?

If you attended the closing ceremony of 'India on Our Mind' – the exhibition on Indian maps held at IISc from 18 March to 20 April – you might have spotted a bunch of students being given certificates that day by Raghavendra Gadagkar, Chair of the Centre for Contemporary Studies and Professor at the Centre for Ecological Sciences. These undergraduate students from the sixth-semester Bachelor of Science (Research) programme had been active volunteers, manning the exhibits and guiding visitors through the large hall lined with maps belonging to different time periods, each item retelling a story from the past. But their engagement with the subject of the exhibition went far beyond just the one-month display.

The exhibition itself was meant to supplement the course 'Introduction to Governance', as part of the humanities undergraduate programme, which is designed to acquaint students with the functioning of the Indian government.

> *The exhibition itself was meant to supplement the course 'Introduction to Governance', as part of the humanities undergraduate programme*

The maps were sourced from the Hyderabad-based Kalakriti Archives. Uday Balakrishnan, Visiting Faculty at CCS, and the instructor for the course on governance, traces his association with Kalakriti Archives to the 2014 Kochi Biennale, India's biggest art exhibition, organised every two years. Talking about the idea behind this exhibition and its relevance, he says, "Prshant Lahoti, who runs the archives, has the largest collections of South Asian maps. The theme that year [at the Kochi Biennale] was *Whorled Explorations*." Balakrishnan recalls that the Kochi exhibition drew a huge crowd. He wanted to bring this to IISc for his students, while also keeping it open to the public. Balakrishnan adds, "This exhibition would not have been possible without the support of Kaushal Verma, Chair, APC, Gadagkar, and the Deans of the UG programme."

The exhibition at IISc, which drew close to 2,000 school children, including students from other districts such as Mandya and Hassan, was split into four sections. The first section housed maps from the 15th century, which paint a picture of how people viewed the universe, comprising gods, men and demons. As time progressed, people began representing pilgrimage landscapes. For instance, a pilgrim from the 18th century documents his journey from Haridwar to Badrinath through a colourful painting. Being conceptual visions, these maps were not drawn to scale, and mainly served as guides. The second section showed how European colonisers viewed India, and the growth of India's towns and cities – this was the time that scientific tools were employed to measure the length and breadth of the country. And, after Independence, as the country began marching towards development, India built its own satellites. The third section captured this transformation: Balakrishnan included ISRO satellite images to show how India sees itself and the world. All the maps, put together, take you through a journey from the 15th century to the modern era, representing how India came together as a country and evolved over the years. But the fourth section was different from the rest – it was a series of audio-visual presentations.

The exhibition India on Our Mind, held at IISc's main building (Photos: KG Haridasan)

> *All the maps, put together, take you through a journey from the 15th century to the modern era, representing how India came together as a country and evolved over the years*

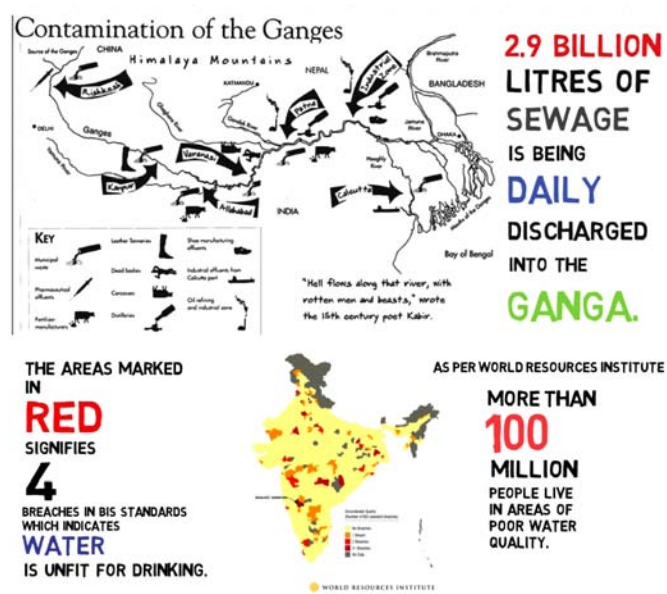
The Three-Month Project

In a span of three months, the sixth-semester students were tasked with representing different aspects of India through maps in the audio-visual presentations. Armed with creativity, analytical and interpretation skills, the students worked on a range of topics from tracing India's states since independence, and the country's borders disputes, to India's energy scenario and environmental challenges. The students brought alive these aspects of India by collecting data and overlaying them on maps. A few students lent their voice to make their presentations more effective.

Chandrakant Harjpal, a sixth-semester student and a mathematics major, who worked on a project mapping the country's environmental challenges alongside a few of his other classmates says, "We assigned topics on air pollution, water pollution, deforestation, and so on, amongst ourselves. And then we combined all the maps and graphs in a sequential form using a video editor."

The students worked on a range of topics from tracing India's states since independence, and the country's borders disputes, to India's energy scenario and environmental challenges

According to Balakrishnan, the idea was to get students to work together as a group, to get them to think about India. "I don't think this project has been done before by students at schools or colleges. I am proud of it. IISc is proud that the students could take some time off from their demanding



Snapshots of a student project on India's environmental challenges

Students at the exhibition (Photo: KG Haridasan)

schedule and come up with something like this, something as grand as this – 12 projects that mixed cartography and data to show India in all its dimensions," he says.

As part of the course, Balakrishnan invites policymakers such as Members of Parliament, Supreme Court judges, former chief secretaries, former ambassadors, and the like, to interact with his students. Justice J Chelameswar of the Indian Supreme court, Hormis Tharakan, former Head of Research and Analysis Wing, Vinay Lal of the University of California, Los Angeles, and Sir Mark Tully, former Bureau Chief of the BBC, have been some of the noted visitors.

"I wanted students to understand that Parliament is just not about people abusing each other. There are a lot of committees which examines issues. Every aspect of government is overseen by the Parliament. Parliamentarians go through a process of vetting. All this is new to the students," he explains.

On the relevance of humanities for science students, Balakrishnan says, "We try our best to interest them as citizens of our country, to give more meaning to the science they do. The course helps them understand what is happening in the country and how science can be used to connect to people."

> *We try our best to interest them as citizens of our country, to give more meaning to the science they do*

Balakrishnan brings in another perspective: as science students are honed in logical thinking, they approach concepts in humanities differently. For example, in an earlier project, he had asked his students to analyse the circumstances of India's Partition and the possibility of such a scenario occurring in the future. And they looked at it in detail, examined it and then came up with their interpretations. "I was impressed with how my students approached the question. They made their presentations on how likely or unlikely it is for such an event to happen. They were bringing a scientific vigour to the thinking. Science is a fantastic basis to do humanities." The goal, according to him, is to help students understand and appreciate how India has survived over the years despite setbacks, which will help them broaden their understanding of the country and the world.

Studying humanities

According to Harjpal, "Humanities is the bridge between education and society. I learnt that there is large number of environmental problems that we have to address both on a short- and long-term basis. Solutions need both scientific methods and an understanding of society and the needs of its people."

Deepak Arya, a Materials Science major, seconds Harjpal's opinion and adds, "I think humanities is important for science students because it tries to answer this question – why are we studying science? The course was very good, we enjoyed it a lot."

> *I think humanities is important for science students because it tries to answer this question – why are we studying science?*

Having worked on a project on the evolution of Indian borders over the years with its neighbours (excluding China), Divyansh Khurana, who is majoring in Physics, finds himself better informed. In an email, he writes, "I wasn't aware of India having an enclave [an Indian territory] inside Bangladesh, which in turn has one of its territories in India; the existence of a region in the Bay of Bengal where India and Myanmar share the waters equally, while Bangladesh has the sole rights to excavate the seabed beneath; India sharing a direct maritime boundary with Indonesia, which I thought to be a very distant nation, and many more such facts." He thinks the knowledge gained from conventional courses that IISc offers is important but abstract and doesn't directly address the problems that need to be resolved. He adds, "Through different modules in humanities such as anthropology, economics, law, or governance, we are brought face-to-face with these important concepts. Many, who may have been unaware initially, are forced to think in the direction of solving issues and our role in directly serving the nation."

When Plague Brought IISc to a Standstill

- Karthik Ramaswamy

The spotting of dead rats found to be infected led to the Institute closing in 1937 so that swift action could be taken

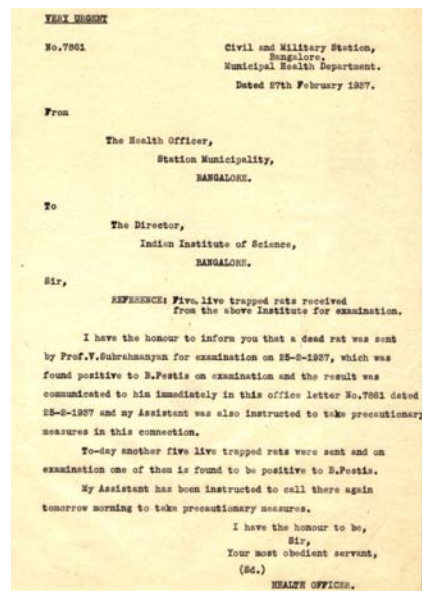
The first plague pandemic, the Plague of Justinian, ravaged the Eastern Roman Empire killing between 25 and 50 million people in the sixth century. The second, the infamous Black Death, obliterated between 100 and 200 million people in Eurasia in the 1300s. And the third, which had its epicentre in the Yunan province of China, began in the mid-1800s and remained active for over a hundred years. This pandemic killed 10 million in China alone. It spread via Hong Kong to India, where the death toll was at least 12 million even by conservative estimates. Most of these deaths occurred in the late 1890s.

In 1898, the dreaded disease struck Bangalore. This public health crisis prompted the Governments of Mysore and India to take a slew of remedial measures: scores of people were quarantined and inoculated, sanitation and health facilities were revamped, new well-planned extensions like Malleswaram, Basavanagudi, and Frazer Town were developed, Bangalore was divided into wards for better coordination, the Victoria hospital was built, and a health officer was appointed for the city. Some people in the affected neighbourhoods even took it upon themselves to build temples to ward off the disease. One of these, the Shri Plague Maheshwari Temple, still exists in Ulsoor, not far from Blackpalli (now known as Shivajinagar), an area that was particularly badly hit.

In the years that followed, the incidence of plague reduced considerably; outbreaks were more localised and infrequent. One such outbreak occurred in and around IISc in 1937. The presence of plague was suspected when dead rats were found on campus and in surrounding villages.

> **The presence of plague was suspected when dead rats were found on campus and in surrounding villages**

Rats have a bad reputation for spreading bubonic plague, the more common version of the disease. But it is in fact transmitted by fleas (pneumonic plague, on the other hand, typically spreads when air-borne plague bacteria are inhaled). However, rats do serve as reservoirs for *Yersinia pestis*, the bacterium which causes the disease. So rats dropping dead on the streets can send public health officials into a tizzy.



VERY URGENT

No.7861 Civil and Military Station, Bangalore. Municipal Health Department. Dated 27th February 1937.

From

The Health Officer, Station Municipality, BANGALORE.

To

The Director, Indian Institute of Science, BANGALORE.

Sir,

REFERENCE: Five live trapped rats received from the above Institute for examination.

I have the honour to inform you that a dead rat was sent by Prof.V.Subrahmanyam for examination on 25-2-1937, which was found positive to B.Pestis on examination and the result was communicated to him immediately in this office letter No.7861 dated 25-2-1937 and my Assistant was also instructed to take precautionary measures in this connection.

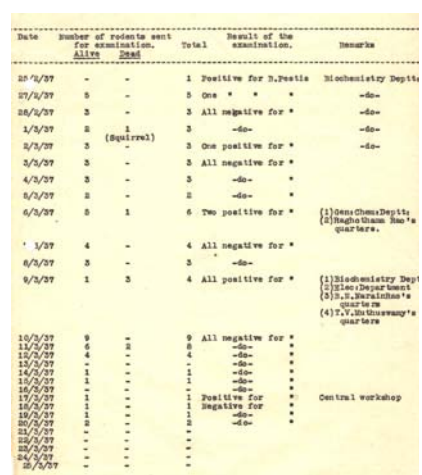
To-day another five live trapped rats were sent and on examination one of them is found to be positive to B.Pestis.

My Assistant has been instructed to call there again tomorrow morning to take precautionary measures.

I have the honour to be, Sir, Your most obedient servant, (Sd.) HEALTH OFFICER.

Letter from the Health Officer to the Director of IISc informing him of the presence of plague on campus (Image courtesy: APC, IISc)

In late February of 1937, a dead rat from IISc, sent by V Subrahmanyan, a professor in the Department of Biochemistry, to the Municipal Health Department, tested positive for *Y. pestis*. Following this, another live rat which was trapped was also found to be infected. The results were communicated by the Health Officer in a letter dated 27 February 1937 to IISc's Director CV Raman.



Date	Number of rodents sent for examination. Alive	Dead	Total	Result of the examination.	Remarks
25/2/37	-	-	1	Positive for B.Pestis	Biochemistry Deptt.
27/2/37	5	-	5	One " " "	-do-
26/2/37	3	-	3	All negative for "	-do-
1/3/37	2	1 (Squirrel)	3	-do-	-do-
2/3/37	3	-	3	One positive for "	-do-
3/3/37	3	-	3	All negative for "	
4/3/37	3	-	3	-do- "	
5/3/37	2	-	2	-do- "	
6/3/37	5	1	6	Two positive for "	(1)Gen:Chem:Deptt; (2)Raghuthama Rao's quarters.
7/3/37	4	-	4	All negative for "	
8/3/37	3	-	3	-do-	
9/3/37	1	3	4	All positive for "	(1)Biochemistry Dept (2)Elec:Department (3)S.S.Narainhan's quarters (4)T.V.Muthuswamy's quarters
10/3/37	9	-	9	All negative for "	
11/3/37	6	2	8	-do- "	
12/3/37	4	-	4	-do- "	
13/3/37	-	-	-	-do- "	
14/3/37	1	-	1	-do- "	
15/3/37	1	-	1	-do- "	
16/3/37	-	-	-	-do- "	
17/3/37	1	-	1	Positive for "	Central workshop
18/3/37	1	-	1	Negative for "	
19/3/37	1	-	1	-do- "	
20/3/37	2	-	2	-do- "	
21/3/37	-	-	-	"	
22/3/37	-	-	-	"	
23/3/37	-	-	-	"	
24/3/37	-	-	-	"	
25/3/37	-	-	-	"	

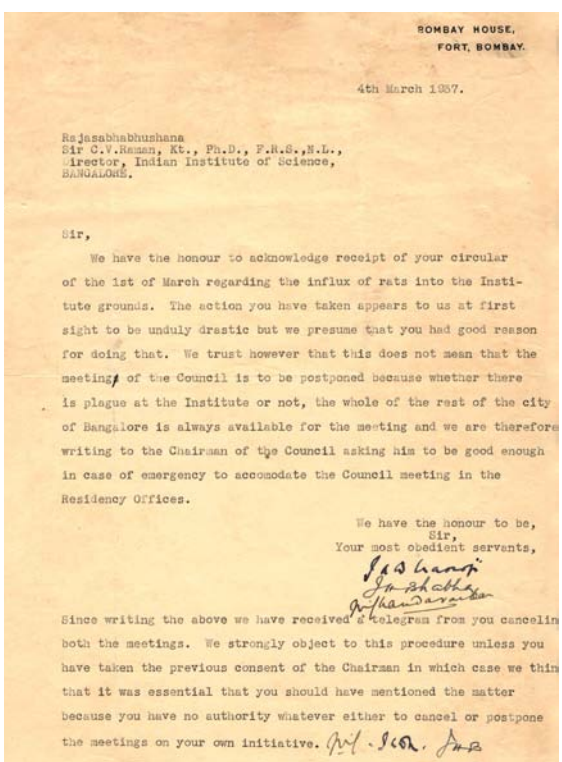
Results of tests conducted on rats for presence of plague bacteria in February and March of 1937 (Image courtesy: APC, IISc)

> **Records indicate that upon receiving the letter and following a discussion with the Health Officer, Raman acted promptly**

Records indicate that upon receiving the letter and following a discussion with the Health Officer, Raman acted promptly. He issued a directive on 1 March that IISc be evacuated right away. It reads: "The accompanying report received from the Health Officer, Civil and Military Station, Bangalore, makes it clear that the Institute has a rat population which is infected by plague. It has also been brought to the notice of the Director that there has been an influx of rats into the Institute grounds from adjacent infected villages. On discussing the matter with the Health Officer, that the safest and indeed the right course would be to immediately suspend all activities in the Institute and have it evacuated forthwith. All the students residing in the Institute hostel are hereby directed to vacate the hostel forthwith and proceed to their homes."

During the break, IISc took other steps to deal with the situation. "Our laboratories are being cleaned and disinfected from day to day. Our workers (staff and students) have all been inoculated," assures Subrahmanyan in a letter to the Director on 13 March. Meanwhile, trapping and testing of rats continued. The results were encouraging.

On 25 March, Raman sent a circular to the Institute which says that "there have been no further cases of plague-infected rats during the past few days" and asks the departments to open its doors by the end of the month.



BOMBAY HOUSE,
FORT, BOMBAY.

4th March 1937.

Rajasabhabhushana
Sir C.V.Raman, Kt., Ph.D., F.R.S.,N.L.,
Director, Indian Institute of Science,
BANGALORE.

Sir,

We have the honour to acknowledge receipt of your circular of the 1st of March regarding the influx of rats into the Institute grounds. The action you have taken appears to us at first sight to be unduly drastic but we presume that you had good reason for doing that. We trust however that this does not mean that the meeting of the Council is to be postponed because whether there is plague at the Institute or not, the whole of the rest of the city of Bangalore is always available for the meeting and we are therefore writing to the Chairman of the Council asking him to be good enough in case of emergency to accomodate the Council meeting in the Residency Offices.

We have the honour to be,
Sir,
Your most obedient servants,

Since writing the above we have received a telegram from you cancelin both the meetings. We strongly object to this procedure unless you have taken the previous consent of the Chairman in which case we thin that it was essential that you should have mentioned the matter because you have no authority whatever either to cancel or postpone the meetings on your own initiative.

Letter from members of the Council admonishing CV Raman for cancelling the Council meeting scheduled for March (Image Courtesy: APC, IISc)

A few days later, on 9 April, with the worst behind them, the Health Officer again wrote to Raman suggesting an intensive campaign against rats to keep IISc plague-free. The "Anti-Rat Campaign" note accompanying the letter recommends hiring separate staff and a supervisor "who should be able to keep a proper record of the rats caught, to keep proper account of traps and the articles and to exercise a general supervision over their work." It emphasises the importance of dividing the campus into blocks that are to be attended to systematically, one after the other. It adds: "All traps, irrespective of whether they have caught rats or not, should be washed by dipping in boiling water and fumigated every time before redistribution. The blocks should be so arranged that each will get its turn for 3 days every fortnight." The note also lists the number and cost of traps required for a period of one year, and emphasises the importance of "nice attractive baits," including coconuts, incense, onions, wheat flour and sweet oil.

While the plague episode had a happy ending, it was not without controversy. The incident only added to the simmering tensions between Raman and the Council of IISc. In a letter to the Director dated 4 March, three Council members cautiously endorse Raman's decision to evacuate the Institute: "The action you have taken appears to us at first to be unduly drastic but we presume that you have good reason for doing that." However, they go on to warn Raman not to postpone the meeting of the Council scheduled for 22 March "because whether there is plague at the Institute or not, the whole of the rest of the city is always available for the meeting." But before this letter was sent, they received a telegram from Raman saying that he was cancelling the Council meeting. The Council representatives did not take to this kindly. They added an additional paragraph to the original letter rebuking Raman for his unilateral decision. It states: "We strongly object to this procedure unless you have taken the previous consent of the Chairman in which case we think that it was essential that you should have mentioned the matter because you have no authority whatever either to cancel or postpone the meetings on your own initiative."

> **While the plague episode had a happy ending, it was not without controversy**

It is not clear how Raman responded to the strongly worded letter, but archival records suggest that the Council did not meet in March. The next meeting was held on 3 May. In the days that followed, Raman's position as Director became untenable and he eventually stepped down. His resignation was accepted at an "Extraordinary Meeting" of the Council held on 1 June.

The Indian Science Congress at IISc

- Nithyanand Rao

What the old brochures about the event tell us about its purpose, and about how IISc saw itself

The Indian Science Congress (ISC), an annual gathering of scientists, was begun in 1914 by two British chemists, JL Simonsen and PS MacMahon, who wanted to model it on the British Association for the Advancement of Science. In its early days, the ISC served as a platform for researchers across India to meet and communicate their work, and also to reflect on the growth of science in the country. The documents relating to these gatherings, therefore, serve as a mirror for the kind of research that was done at the time and also the role that was seen for institutes such as IISc.

Bangalore has been host to the ISC eight times, and brochures for three of those events – 1917, 1924 and 1951 – can be found, along with that of the 1928 event held in Madras, in the IISc archives. These serve as a window into how the Institute saw itself and its achievements in those times, snapshots of how the Institute presented itself to researchers from around the country and abroad.

1917

Sir Alfred G Bourne, the Director of IISc from 1915 to 1921, was the president of the 1917 ISC held in Bangalore. Bourne was a zoologist and botanist who first came to India as Professor of Biology at Presidency College, Madras.

In his presidential speech at the 1917 Congress, Bourne reflected on what the vision of ISC was at the time. One of the aims of the British Association was the "removal of any disadvantages of a public kind which impede" scientific progress. Bourne felt that this was now largely redundant, even in India, since the government and the public had greater appreciation of science and its importance. But research requires funds – at the time, the money spent annually on scientific work in British India, according to Bourne, was Rs 70 to 80 lakh, an amount that was supplemented by some of the "native states" such as Mysore. "Private sources," he said, "have contributed but a lamentably small extent," with rare exceptions like the Tatas. He contrasted this with the situation in England where the share of research funding from private sources was much more.

Another aim of the British Association was "to give a stronger impulse and a more systematic direction to scientific inquiry". "It seems doubtful whether much will be done in this respect," said Bourne of the ISC, "if the programme continues to be limited to an address from the President, a few public lectures; and for the rest, meetings in small sections for the reading of papers some of which, I gather from past proceedings, have been mere preliminary notes, while others, although valuable contributions to science, are of immediate interest to very few."

AG Bourne (Courtesy: APC, IISc)

He noted that because of increasing specialisation, researchers in one field must make special efforts to understand and keep up with research in other fields, and that this must be the main purpose of the ISC. "Should not some attempt be made throughout the meeting," he asked, "to deal with subjects intelligible to all students of science alike?" He said that "the isolation hitherto experienced by

many scientific workers in India has been one of the chief reasons of the comparatively disappointing results".

> *Should not some attempt be made throughout the meeting," Bourne asked, "to deal with subjects intelligible to all students of science alike?*

Bourne also reflected on the nature of research and identified three classes of research: "that carried on with the single purpose of ascertaining the truth in regard to the causes of things, that which has for its immediate object a specific utilitarian purpose but still without any expectation whatever of a pecuniarily remunerative result, and research with the avowed object of making money out of it sooner or later." "The first class alone," he went on to state," is research in pure science; second and third are applied science."

He noted that this classification of research into pure and applied can only refer to current and not past research – these distinctions are erased by time. Bourne then spent a good part of his speech in reflecting on the nature of a word he felt is used too loosely. "Research," Bourne felt, "is now alluded to as a perfectly simple operation. One even hears of men being 'taught to research'; newspapers speak of it in the lightest manner, whereas, in even my student days, it was spoken of with almost bated breath as indicating something to which only the best of us could look forward, something which few of us were ever likely to carry on with any hope of success."

He argued that applications will unexpectedly emerge from pure science research, stimulating further research. "What utilitarian research," he asked, "would have discovered the fundamental facts in regard to electricity or have led to the framing of the atomic theory?"

But this was the period of the First World War, which prompted Bourne to concede that the Institute should do work of an applied nature to help industry. He feared that "pure science may be almost submerged for a time by a wave of utilitarianism" and asked his audience to reflect upon these matters, saying "each must follow the dictates of his own conscience".

1924

Bourne's immediate successor was a chemist, Sir MO Forster, who was Director of the Institute from 1922 to 1933. Forster's essay about IISc in the handbook for the 1924 ISC listed achievements of the Institute which were all of a strikingly applied nature. Forster went into some detail in describing what he saw as important contributions to industry that had resulted from research at the Institute. He recounted how the extraction of oil from sandalwood used to take place almost exclusively in German factories. But as a result of work at IISc, sandalwood-oil factories were established in the region. "Incidentally," he noted, "the experience gained has led to marked improvement in the general methods of distilling essential oils as practised throughout the Indian peninsula."

Forster listed other contributions too, in places far away from Bangalore. For instance, IISc researchers advised the planning of civic works in Jamshedpur, working on the sewage-treatment and water supply in that city. Further, "a well-equipped laboratory for the necessary bacteriological and chemical work is conducted by former students of the Institute, whilst other former students are engaged in the scientific control of waterworks construction and operation at Delhi and at Shanghai." He also noted that many of the former students of the Department of Electrical Technology "are now to be found in active control of the numerous hydro-electric and other power-generating schemes dispersed throughout the peninsula."

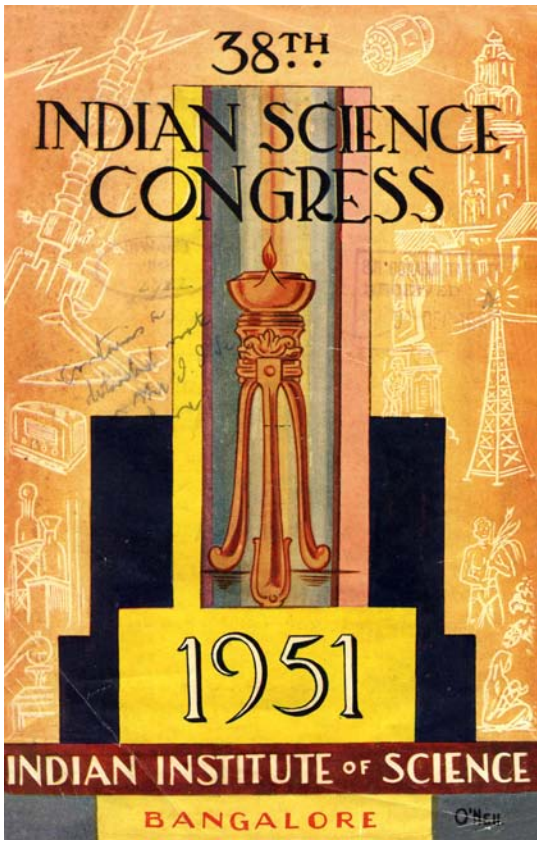
MO Forster (Courtesy: APC, IISc)

> *Forster's essay about IISc in the handbook for the 1924 ISC listed achievements of the Institute which were all of a strikingly applied nature*

Four years later, during the 1928 ISC held in Madras, Forster reflected on a more intangible contribution from IISc. "In one sense," wrote Forster, "the task of building character, of inculcating clearness of thought, habits of industry, perseverance in the face of disappointment and precision of craftsmanship, is the most important one assumed by the Institute, which has now distributed throughout the country a substantial body of men trained in the art of making and appreciating knowledge and in the techniqueof solving a problem."

1951

The push for applied research to serve the needs of the war would again be felt during and after the Second World War. There is a change of tone, and a much more strident push for



The brochure for the 1951 Indian Science Congress held at IISc (Courtesy: APC, IISc)

industrialisation visible in the brochure for the 38th ISC held at IISc in 1951 with Homi Bhabha as the President-Elect.

As the war drew to a close, a four-year programme of expansion was "inaugurated by the tireless efforts of Sir Jnan Chandra Ghosh, the then Director," according to the brochure. As part of this programme, the Departments of Metallurgy and Internal Combustion Engineering were founded in the Institute in 1945. Prime Minister Jawaharlal Nehru visited IISc in December 1948 and, among other things, laid the foundation stone for the Department of Electrical Communication Engineering. Ghosh was succeeded as Director in 1949 by MS Thacker.

At the time, IISc conferred diplomas, associateships and fellowships – not degrees as we know them today. The diplomas (known as certificates of proficiency before July 1946) were for students who completed coursework, associateships were for those who wrote a thesis, and fellowships were awarded to associates who had spent at least five years resulting in "original and valuable research work". The brochure also gives us numbers. By 1951, IISc had conferred a total of 7 fellowships, 6 honorary fellowships, 252 associateships and 705 certificates/diplomas. And we learn that "a nominal tuition fee of Rs 12 per month, payable in three instalments per year at Rs 48 per term, is charged to students admitted to post-graduate courses of instruction. No fee is levied for research."

Many important journals were published in European languages other than English during those years. Accordingly, there were French and German language classes conducted for students in the Institute, "supplemented by practice of phonetics by means of a Magnetic Wire Recorder and Linguaphone". Technical reports and articles from foreign journals in other languages were translated, and these translations were also distributed all over the country "at prescribed charges".

Incidentally, the first Pan-Indian-Ocean Science Congress was also held in 1951, concurrently with the ISC. This arose from a proposal by the Australian Council of National Research to hold a gathering of scientists from countries around the Indian Ocean to address problems of mutual interest. Jawaharlal Nehru inaugurated it "in a colorful ceremony attended by some 30 delegates from Australia, New Zealand, Burma, Malaya, Ceylon, Madagascar, the Netherlands and Portugal" and a few from the UK and France too.

> *In the decades that have followed, as in Bourne's time, the ISC has not fulfilled Bourne's aim of giving "a stronger impulse and a more systematic direction to scientific inquiry" in the country*

In the decades that have followed, as in Bourne's time, the ISC has not fulfilled Bourne's aim of giving "a stronger impulse and a more systematic direction to scientific inquiry" in the country. About a century after Bourne's speech, another Director of IISc would lament the sorry state of the annual event. "Curiously, few practising scientists of note consider the Congress as an important event," wrote P Balaram in an editorial in *Current Science* in 2012. "Pomp and ceremony take precedence over substance." Over the years, the ISC, he felt, "has been reduced to an occasion where the inaugural session appears to be the *raison de etre* for the meeting", and ceremonial speeches, including by Nobel laureates, ensure "that the Congress always acquires a degree of respectability rarely supported by the scientific program."

Bourne had felt that the ISC was not the venue for presenting highly specialised papers that would be unintelligible to researchers in other fields. He wanted the review of work in different fields, presented by the presidents of the different sections of the ISC, to not be held in parallel, so that they could be attended by interested researchers from all fields – a suggestion that remains relevant today. "But here again the object would be more fully attained," said Bourne, "were something arranged other than that the agriculturalists should shut themselves up in one room, the chemists in another, while the devotees of Natural Science segregate themselves in various ways and pay very scant attention even to one another...Should not such meetings as this be almost entirely devoted to the bringing together all the time of all the scientists present?"

HOW ARCHIVES IN BANGALORE TELL STORIES ABOUT SCIENCE

- Renuka Kulkarni

The Raman spectrograph at the Archives and Publications Cell, IISc

A look at the various ways in which scientific research and its history are preserved

September 1921. Somewhere on the Mediterranean Sea. Indian physicist CV Raman, sailing from England to Bombay, was pondering over the vivid blue of the water. Lord Rayleigh's explanation that it was so because of the blue sky above it, didn't seem convincing. He had a few simple optical instruments with him, and examined the water. The liquid molecules, like air, seemed to be scattering light too, he realised.

Raman reached India and rushed to his lab in Calcutta University, where he began to build an instrument to study scattering of light in liquids. It came to be known as the Raman spectrograph, where he obtained the first spectrum of light being scattered by liquids in 1928.

Looking at a replica of this instrument today, in Bangalore, as it lies in repose in a glass case, it's hard to imagine that this wooden contraption explained the blueness of oceans. Raman breathed his last in 1970, but his scientific pursuits rest in posterity along with the works of Johannes Kepler, CNR Rao and countless other scientists in the growing science archives of Bangalore.

Stories of people and events endure because of storytellers, and an archive is a most meticulous collector of tales. It serves both as a protector and preserver, collecting stories as assiduously as a bee collects pollen, where each grain is an archival record. A science archive is specialised: it harvests records to reconstruct scientific history.

"A science archive is a place where you can preserve not just documents about the history of the institute, but also records of past projects, scientists and processes," says Arun Mangalam, chair of the Theory group at the Indian Institute of Astrophysics (IIA) and a faculty supervisor for the archival work at the institute. "The archival space is essentially about the survival of ideas."

> *"The archival space is essentially about the survival of ideas"*

An archive collects, documents, organises and preserves anything that has something to narrate about the past, but the value of the tale is a decision of both foresight and hindsight for the archivist. The archives at the National Centre for Biological Sciences (NCBS) offers an idea about that value in its mission statement. "An archival record is a fragment of a story. The narratives of our lives give rise to these things we call collections, manuscripts, oral history interviews, each an abstract item sitting in the physical and digital shelves of an archive. We keep that in mind when we look for archival material. Every person has many stories, and every story has many people," it reads.

Venkat Srinivasan, archivist at NCBS, adds, "An archive allows us to discover these stories. And narrate them. If we know where we've come from, it can tell us where to go ahead."

So when does an archive, and its stories, begin? For the Indian Institute of Astrophysics (IIA), its archives began when the Institute was bequeathed 600 years' worth of history. "Our Institute's scientific research technically began in the Madras and Kodaikanal observatories. IIA naturally inherited their library and records, which go back to 1786," says Mangalam.

Their oldest documents include handwritten manuscripts of the Madras Observatory 1792 Annual Report, and a copy of Johannes Kepler's *Astronomia Nova*, first published in 1609. Mangalam is hard put to say which of their records are the rarest and most precious. "There are the papers about the discovery of helium by NR Pogson, a past director and an astronomer. There are documents detailing the Evershed effect (radial flow of Sunspots from the inner edge of the Sun to the outer edge). There are calculations about various eclipses. You can't really pick," he muses.

IIA acquired these priceless records and archived them in the 2000s. Around the same time, other institutes in the city were taking similar steps. While most science institutes in the city have their own repositories of past research publications, it is only in recent years that there seems to have been an archival awakening of sorts. Though their archives were set up at around the same time, their origins had different triggers.

> *While most science institutes in the city have their own repositories of past research publications, it is only in recent years that there seems to have been an archival awakening of sorts*

For the archives at the Indian Institute of Science (IISc), nostalgia reportedly beckoned on the eve of the Institute's centenary year in 2009. For Raman Research Institute (RRI), it was motivated by the availability of archival software in 2006.

When one walks into an archive for the first time, the first question that strikes us is: Is this some kind of museum of old papers? The difference between a museum and an archive lies in its storytelling method. "A museum can be interactive and it can be static: just a straightforward display of artefacts. An archive necessarily has to be interactive in nature," Sowmithri Ranganathan, who was with the IISc archives from 2011 to 2017, explains.

A museum displays, a repository collects, an archive narrates.

The archive at IISc, at first, doesn't seem to be much of a storyteller. Its 108-year-old chronicles lie sorted and protected in a small, air-conditioned room in the Archives and Publications Cell (APC) on campus. Documents, many of which are older than a century, are snug in red and white acrylic boxes, and the room is closed off from dust and heat. Many of these boxes also contain photographs of people, some identified after painstaking efforts, and others unknown still.

Raman's spectrograph is too big to fit in these boxes, and there are no documents about its story. "You won't find many people who could tell you about it," the archives' staff confesses.

But a clue to its history is illustrated on a photograph just 12 km away, in the archives of another distinguished scientist. The CNR Rao archives, run by the eponymous Foundation and housed in the campus of the Jawaharlal Nehru Centre for Advanced Scientific Research, has a collection of the scientist's numerous awards and honours. On one wall of the four-room archive is a photograph of Raman and his instrument, explaining its functioning. A small glass case near it contains a piece of the spectrograph.

Stone commemorating the CNR Rao archives (Photos: Renuka Kulkarni)

It is in the RRI that its founder looms largest of all. The institute has its history sorted: Raman's fascination with light and colour has been captured in the Rai Bahadur Bissessurlal

Motilal Halwasiya Science Museum, and a digital archive has preserved the works of RRI's other scientists.

The five-room museum, started soon after the institute was established in 1948, gleams with CV Raman's collection of various rocks and gems, one of the largest by an individual. PF Sasikumar, retired from RRI and resident storyteller, proudly leads from rock-to-rock, room-to-room, narrating anecdotes of the time when Raman was still alive. His tour of the museum, however, begins with a question. "Have you seen the plaque outside? What does it say?" he enquires. If you have managed to remember the mouthful that is the museum's name, he'll beam. If not, no matter. He tells the story anyway.

"There was a halwai who sold his sweets and even begged to collect the funds for the museum. All he asked in return was his name on the plaque," Sasikumar reveals.

As the door to the museum opens, a quaint veena in the corner meets your eye. An odd instrument in a science museum, but it's there for a reason, Sasikumar says. "It's a replica of the veena that Raman's mother used to play. When he was a child, Raman asked his father, as his mother played in the background, about why the notes from the instrument sound like a human voice. His father had no answer. But eventually, Raman discovered it himself," he says, and pauses.

A replica of the veena that Raman's mother used to play

"With help from Hermann von Helmholtz and his resonance discoveries from a guitar," Sasikumar finishes with a flourish. His memory, after 40 years at RRI, probably serves as a rich archive in itself.

> *A museum displays, a repository collects, an archive narrates*

Whether in a plaque, on a paper, or within a person, RRI is methodically preserving its history. Librarian BM Meera reveals that they are also planning to come up with an institutional archive in the next few years.

At the Indian Academy of Sciences (IASc), housed in the campus of RRI, a different kind of archival record preserves the voices of the past. Quite literally, through recorded oral history interviews of former scientists. The academy has its requisite repository of publications of IASc fellows, serving as an excellent source of research papers for students. But through their oral history interviews, they have also preserved how a scientist sounds like.

"During CV Raman's time, scientists worked a little differently than they do today. Through their lives, we have tried to capture what research and science used to be like in Bangalore in the past," says G Chandramohan, executive secretary of The Academy Trust at IASc.

An oral history interview of Roddam Narasimha, an aerospace scientist and a past president of IASc, reveals the origins of Bangalore's label as the science and engineering capital of the country. "I joined the Visvesvaraya College of Engineering (now known as Mysore University) in 1953. Even in those days, Bangalore's colleges had a national reputation. This was primarily because of people like M Visvesvaraya [and the] Tatas who had started institutes to encourage research. The seeds of Bangalore's fame as a science and engineering hub had already been sown," he explains in the interview.

Narasimha's chronicle includes another piece of crucial history. He talks about the day he visited IISc on one of the Institute's annual Open Days and saw a Supermarine Spitfire aircraft parked near the Department of Aeronautical Engineering (now Aerospace Engineering). The British single-seat aircraft, first flown in 1939, had been widely used by the Allied countries in World War II. Narasimha's Spitfire (reportedly loaned for the Open Day by the Indian Air Force) seems to have been a relic the British left behind, among other things.

IISc is one of the many institutes in the country with a past rooted in days of the British rule. Knowledge is power, and the British, through meticulous documentation, steadily built their conquest.

The origins of the IIA are proof of this.

The Rai Bahadur Bissessurlal Motilal Halwasiya Science Museum at RRI

"IIA traces its beginning to the Madras Observatory established in 1792 by the British, who promptly published an annual report. It is one of our oldest records. Their primary aim was to get information for navigation purposes, and the earliest observations date back to 1787," says Mangalam.

The message was clear, and quite literally, set in stone. A pier still stands at the observatory, bearing the inscription "Posterity may be informed a thousand years hence of the period when the mathematical sciences were first planted by British Liberality in Asia."

The pier is an example of a different kind of archival record, weathered but still standing in the full glare of the Sun, something that isn't too good for a crumbling ancient manuscript. But it preserves a two-fold story: of an 18th century scientific method to map the transit of Jupiter's satellites, among others, and of strategic psychological warfare. The inscription makes it clear: we do not acknowledge what has been there before we came. We are the pioneers and liberators.

Their methodical documentation, regardless of the intent behind it, has a definite silver lining. A large proportion of archival records in Bangalore's science archives date back to the colonial rule. Sowmithri Ranganathan experienced this while working in the IISc archives from 2011 to 2017. "There are a lot of documents and papers from the pre-Independence era when IISc's directors were British individuals. There are a lot of archival records from the last 20 years or so. But if you looked for material from the immediate post-Independence years, you won't find quite as much," she says.

Missing records is not the only problem an archive faces. Lack of a dedicated staff, limited knowledge about how to preserve of environmentally-sensitive documents and copyright issues are other hurdles. To overcome these, some archives, like those at RRI, have relied on their own staff. "We have done everything in-house. Our library staff has worked hard at collecting and organising archival records. Our technical staff helped us acquire and operate the archival software. Our self-sufficiency has fuelled every success," beams Meera.

Other archives have relied on collaborations. "The archives at NCBS has an active internship programme with students from history, the basic sciences, education, design and journalism," says Venkat Srinivasan. The reason behind this decision is explained in the archives' mission statement, which says "For the archives to be continuously relevant, it has to listen to and speak to those who will be custodians in the next generation."

The biggest challenge an archive faces, is, perhaps, the irony of its very process: the only person who can tell an archivist what each piece of old paper means is, in a lot of cases, dead. An archive lies at the crossroads of time-travel: revisiting what has been before, make sense of its relevance today, so that the resultant story will have value in the future.

Renuka Kulkarni is a biology student and an aspiring writer based in Bangalore

ABSTRACTS

IISc Photography Club

Behind State Bank of India, IISc