Connect

WITH THE INDIAN INSTITUTE OF SCIENCE

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IISc and the Wadiyars
The influence of the Mysore Royals

Berambadi School Experiment
A pilot project to treat wastewater

Venki Ramakrishnan
An interview with the Nobel Laureate

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IN THIS ISSUE

EDITORIAL

When the Maharani and the Dewan of Mysore decided to grant land and capital to help set up the science research institute that JN Tata dreamed of, it changed the landscape of higher education in India. In this issue of the magazine, we explore the long relationship that IISc had with the princely state of Mysore, and how investments, connections and support from the royal family and administrators helped expand not just scientific research in the state but industries as well. We also take a closer look at historical accounts to learn more about the Maharani, without whom the Institute may not have been located in Bangalore, and revisit a speech by her son at the Institute in 1911, in which he makes a case for having scholarships for students who are not well off.

This time, we have a tribute to the late SR Valluri, IISc alumnus and former director of the National Aerospace Laboratories. We also look at the origins of the Centre for Electronics Design and Technology (CEDT, now the Department of Electronic Systems Engineering) through the memories of two of its founders, head to a wastewater treatment plant at a school in the water-scarce region of Berambadi near Bandipur, speak to researchers at IISc to learn about their work on cryptography and how we use it in our daily lives, and interview Nobel Laureate Venki Ramakrishnan about his latest book.

Apart from a faculty member's reflections on an unusual course she teaches that combines science with folk arts, we also bring you an interview with a former security guard with a love for wildlife who switched course to help with rescue and relocation of animals on campus and aid ecology research. And from our archives, we have a special treat: a letter from three women students in 1936 – even before there was a women's hostel – to the Director, urging him among other things to publicise the fact that accommodation for women was available on campus, so that more parents would be comfortable sending their daughters to study at the Institute.

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

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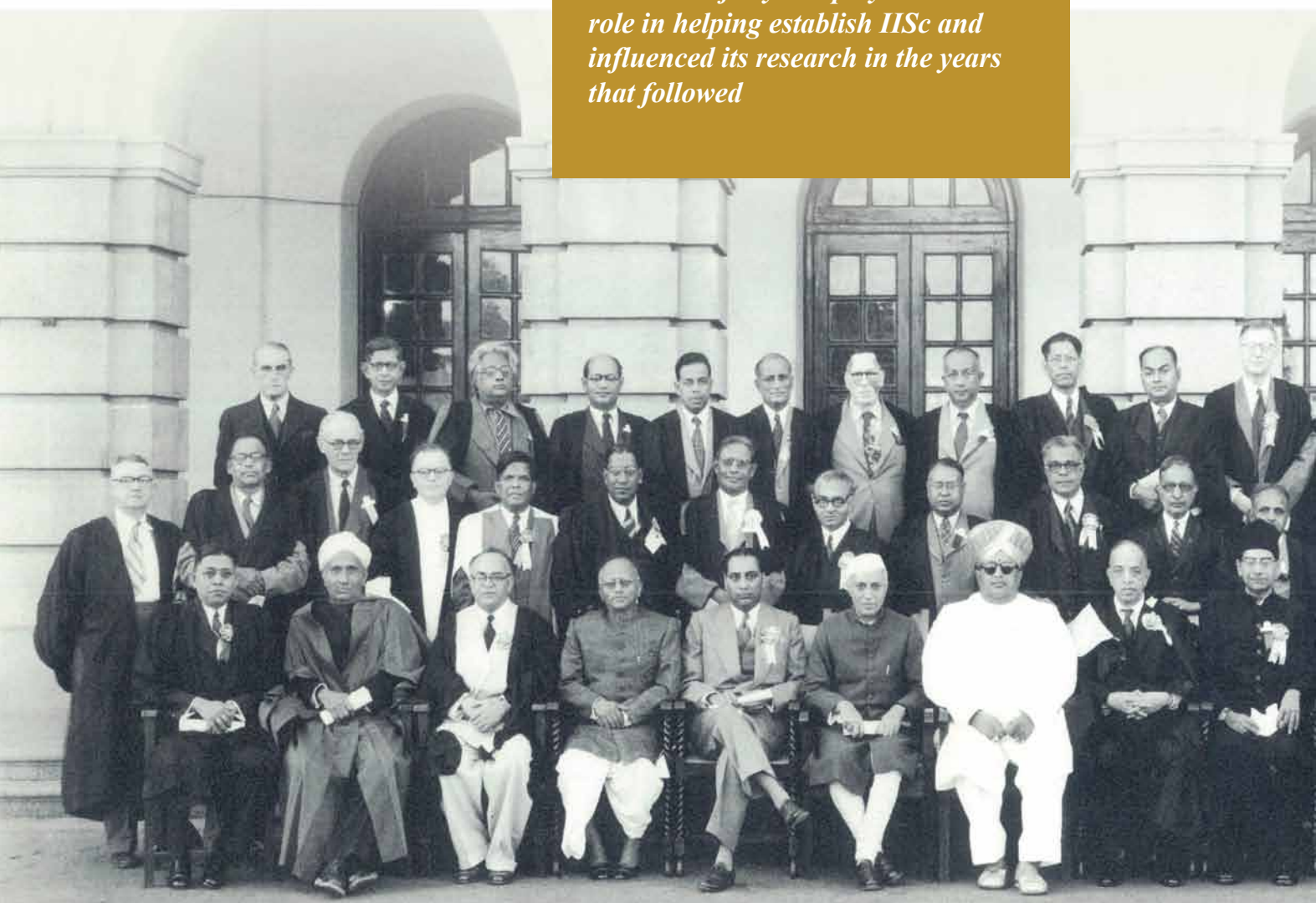
MYSORE AND THE MAKING OF A MODERN SCIENCE INSTITUTION

Karthik Ramaswamy

The State of Mysore played a crucial role in helping establish IISc and influenced its research in the years that followed



Jayachamarajendra Wadiyar (seated, in white) in IISc during the Indian Science Congress in 1951 along with other dignitaries including Prime Minister Jawaharlal Nehru, CV Raman, Homi J Bhabha, and JC Ghosh

"Mysore is the best administered state in the world," John Sankey, the Lord Chancellor of Great Britain and a human rights activist, is said to have declared during the first Round Table Conference in London in 1930, one of three peace conferences called by the British Crown to discuss constitutional reforms in India. While Sankey's claim might sound like hyperbole, Mysore did indeed make exceptional progress from 1881 to 1950, the year monarchy was abolished, thus laying the foundation for the emergence of Karnataka as an industrial, and more recently, an IT hub.

In March 1881, the Wadiyars resumed their innings – to use a cricketing analogy – as the rulers of the state after they signed the Agreement of Rendition with the British Government of India, which had ruled Mysore directly for several decades. But the royal family took over at a time when the state of affairs in Mysore was precarious.

From 1837 to 1900, India was struck by repeated famines, eight of which were considered major famines. They were brought about by droughts, plagues and the agrarian distress following the introduction of the zamindari system by Lord Cornwallis. One of these, called the Great Famine of 1876-78, is thought to have killed between six to 10 million people, mostly in southern and south-western India.

Photo courtesy: IISc Archives

Mysore was severely affected by the famine. The extent of distress was revealed in a speech that CV Rangacharlu, the Dewan of Mysore, gave to the newly constituted Representative Assembly – a quasi-democratic body – in October 1881. According to him, the state had lost nearly 20 percent of its population and a substantial proportion of its livestock to the famine. Vikram Sampath, in his book *Splendours of Royal Mysore: The Untold Story of the Wadiyars*, writes that the state's debt stood at a whopping Rs 80 lakh.

However, in the years that followed, Mysore was able to extricate itself from this perilous situation and it eventually found itself on the path to progress. The achievement is all the more remarkable considering the severe constraints imposed upon it by the Rendition Agreement, not to mention an annual "protection" fee it had to pay the British Government of India. Sampath attributes the state's development during this period to the foresight of its rulers: Chamarajendra Wadiyar X, Kempananjammani Vani Vilasa Sannidhana, Krishnaraja Wadiyar IV and Jayachamarajendra Wadiyar. But he also highlights the crucial role played by the Dewans, or Prime Ministers, of the state in bringing about this transformation through their administrative reforms. Sampath singles out the contributions of the famous quartet of Dewans: Rangacharlu (1881-83), K Seshadri Iyer (1883-1900), M Visvesvaraya (1912-1918) and Mirza Ismail (1926-1941).

During this period, Mysore's rulers believed that educating its people was indispensable for modernisation and set up several educational institutions across the state. Perhaps the most significant project they involved themselves in was Jamsetji Nusserwanji Tata's ambitious initiative to establish a world class research institute in India.

Mysore's rulers believed that educating its people was indispensable for modernisation and set up several educational institutions across the state

Mysore's initial involvement was through Seshadri Iyer, who was well-acquainted with Tata. He had helped the industrialist procure land for a silk farm in Bangalore in the early 1890s. Mysore had also provided subsidies for Tata's sericulture experiment. (Though the farm no longer exists – it was sold to the Salvation Army after Tata's death – it lent its name to Tata Silk Farm, a neighbourhood near Basavanagudi.) This successful partnership between Tata and Mysore in South Bangalore served as a precursor to a more consequential collaboration in the coming years, leading to the creation of IISc, in the north of the city.

The seeds of the plan to establish what came to be known as IISc were sown in Tata's mind at a time when there were no true institutions of higher learning in science and engineering in India. A notable exception was the Indian Association for the Cultivation of Sciences, which was founded by the enlightened medical doctor and social reformer Mahendralal Sarkar in Calcutta (now Kolkata) in 1876. But even this association – "devoted to the pursuit of fundamental research in the frontier areas of basic sciences" – was not supported by the government; it relied on public contributions.

It wasn't until 1899 that Mysore became an active player in JN Tata's plan to set up an institute of higher learning

The government was instead more interested in setting up bodies whose responsibility was merely to conduct examinations and grant degrees to students in affiliated colleges in major cities, bodies they referred to as universities. The curricula in these colleges focussed mostly on teaching English and the humanities. It was the general policy of the British Government of India not to establish technical schools devoted to science and engineering on a large scale, says BV Subbarayappa, a historian of science, in his book *In Pursuit of Excellence: A History of the Indian Institute of Science*.

It was under these circumstances that Tata decided to contribute to the growth of science in India. In his many travels to Europe and North America, Tata had seen first-hand the role of scientific research and higher education in economic and social transformation. He was also aware of the role of philanthropy in building universities. By the 1890s, Tata, who had become an enormously successful industrialist, was ready to use his personal wealth for causes that he believed would improve human welfare. He had also evolved his own philosophy of "constructive" philanthropy.

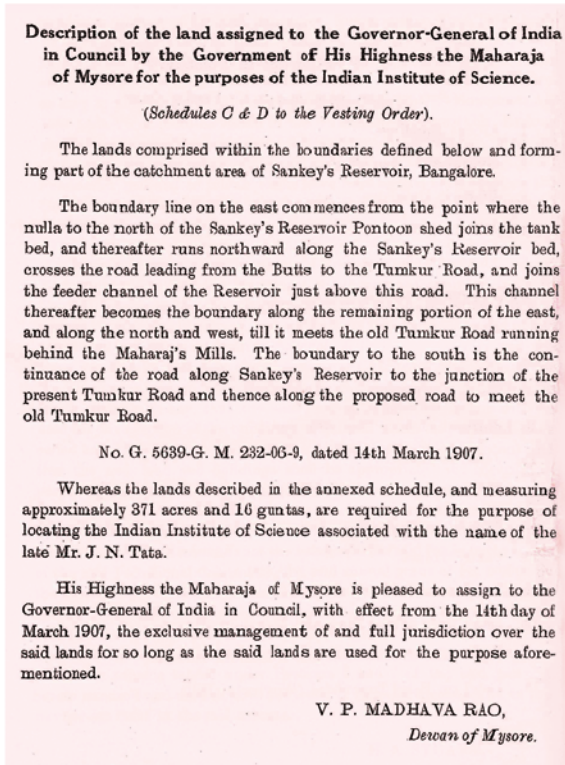
Tata elaborates on his idea of philanthropy and his motivation to contribute to higher education in India in an interview to the newspaper *West Coast Spectator*, quoted in Frank Harris' book *Jamsetji Nusserwanji Tata: A Chronicle of his Life*. He says, "What advances a nation or community is not so much to prop up its weakest and the most helpless members, as to lift the best and most gifted so as to make them of the greatest service to the country. I prefer this constructive philanthropy which seeks to educate and develop the faculties of our young men."

Though Tata conceived of his university idea in the early 1890s, it was only in 1896 that he began the groundwork on the project. And it wasn't until 1899 that Mysore became an active player. Tata, who was on a tour of South India earlier that year, paid his friend Seshadri Iyer a visit. During their discussion, he apprised the Dewan of his plan. He also expressed two major concerns he had: finding a suitable location – there were several contenders including Tata's hometown Bombay – for the "Imperial University of India", as it was then called, and the need for additional financial support. The anticipated cost of setting up and running the university was more than the expected income from Tata's endowments.

Soon after Tata's visit to Bangalore, Iyer consulted with Maharani Kempananjammani Vani Vilasa Sannidhana (her son Krishnaraja Wadiyar was a minor then) about whether and how Mysore could help Tata. The Regent Queen was easily convinced of the need to support Tata's grand idea. She also agreed to provide land and money for the project. Iyer immediately conveyed Mysore's decision to the Provisional Committee put together by Tata with the mandate of implementing his vision.

Photo courtesy: Rajachandra, Wikimedia Commons

Maharani Kempananjammani Vani Vilasa Sannidhana with her grandson Jayachamarajendra Wadiyar



Description of the land assigned to the Governor-General of India in Council by the Government of His Highness the Maharaja of Mysore for the purposes of the Indian Institute of Science.

(Schedules C & D to the Vesting Order).

The lands comprised within the boundaries defined below and forming part of the catchment area of Sankey's Reservoir, Bangalore.

The boundary line on the east commences from the point where the nulla to the north of the Sankey's Reservoir Pontoon shed joins the tank bed, and thereafter runs northward along the Sankey's Reservoir bed, crosses the road leading from the Butts to the Tumkur Road, and joins the feeder channel of the Reservoir just above this road. This channel thereafter becomes the boundary along the remaining portion of the east, and along the north and west, till it meets the old Tumkur Road running behind the Maharaj's Mills. The boundary to the south is the continuance of the road along Sankey's Reservoir to the junction of the present Tumkur Road and thence along the proposed road to meet the old Tumkur Road.

No. G. 5639-G. M. 232-06-9, dated 14th March 1907.

Whereas the lands described in the annexed schedule, and measuring approximately 371 acres and 16 guntas, are required for the purpose of locating the Indian Institute of Science associated with the name of the late Mr. J. N. Tata.

His Highness the Maharaja of Mysore is pleased to assign to the Governor-General of India in Council, with effect from the 14th day of March 1907, the exclusive management of and full jurisdiction over the said lands for so long as the said lands are used for the purpose aforementioned.

V. P. MADHAVA RAO,
Dewan of Mysore.

Image courtesy: IISc Archives

The annexe to the vesting order passed on 27 May 1909 detailing the commitment made by Mysore State on 14 March 1907 by Dewan Madhava Rao to provide land for IISc

Even though Mysore's proposition did not have any specifics at this point, it was taken seriously by the committee as well as the government. Mysore's offer of financial help, however, was conditional: the proposed university had to be in Bangalore. Mysore's insistence on Bangalore and the city's attractive climate made it the front-runner to host the university by the end of the Simla Conference held in October 1899, a meeting called for by the government to discuss Tata's proposal. Bangalore also received a fillip, when in the following year, William Ramsay, the noted British chemist, gave his thumbs-up to the southern city in a report he prepared. Ramsay had been chosen by the Provisional Committee to make specific recommendations about the proposed university or "Institute" as he called it.

Mysore, in the meanwhile, firmed up its commitment – it promised 371 acres and 16 guntas of land in Bangalore, Rs 5 lakh towards capital expenditure, and also an annual contribution of Rs 30,000 (which was increased to Rs 50,000 in 1905). Its proposal was accepted by the government, but several hurdles had to be overcome before IISc came up, including those resulting from Tata's untimely death in the summer of 1904. On 14 March 1907, VP Madhava Rao, Mysore's Dewan, officially handed over the land that was promised by the state. And on 27 May 1909, IISc finally came into existence following a vesting order and resolution passed by the British Government of India to establish the Institute.

After IISc was set up, it continued to benefit from Mysore State in many ways. The state's most direct involvement was through its Dewans, who were ex-officio members of the Governing Council of the Institute, one of the two decision making bodies of IISc (the other being the Court).

The most influential of Mysore's representatives to IISc was Visvesvaraya, who replaced T Ananda Rao in the Council in 1913. Back in 1907, Visvesvaraya, already a celebrity engineer, had outlined his plan for the economic development of the state in his manifesto *A Vision of Prosperous Mysore*. When he became part of the Council, he saw a role for IISc in helping Mysore modernise. "Visvesvaraya, known for his dictum 'Industrialise or perish', was deeply interested in the industrialisation of Mysore State. His association with the Institute had its impact on the applied researches of the Institute," claims Subbarayappa.

Photo courtesy: IISc Archives

M Visvesvaraya influenced the nature of IISc's research

In the next five years, several industries came up as a direct result of research conducted at the Institute, according to IISc's Annual Reports. These included an acetone factory in Nasik, a thymol factory in Hyderabad (Sindh), a factory to make straw boards from bamboo in Bangalore, a soap factory in Bangalore and sandalwood oil factories in Bangalore and Mysore city. The Institute also provided technical help to Hyderabad State for producing alcohol from mahua flowers and to the Mysore Spinning and Weaving Mills in Bangalore to make a durable textile dye using sappan wood (wood from a local leguminous tree) and catechu (an acacia extract).

Several industries came up as a direct result of research conducted at IISc

The most successful of the industries were the sandalwood oil factories and the soap factory, which ensured that the wood and its products became synonymous with the state of Mysore, and eventually Karnataka. IISc's Annual Reports also detail how these factories were set up, a testimony to the encouragement and the influence exerted by Mysore in those years.

In 1914, Mysore State found itself with surplus sandalwood; World War I had broken out and exports to Europe ceased. It then requested IISc to carry out research to extract oil from sandalwood.

Image courtesy: OldIndianAds.com

A 1928 advertisement for Mysore Sandal Soap

Experiments at IISc were led by JJ Sudburough, a professor in the Department of General Chemistry, who had moved from the Department of Organic Chemistry, and HE Watson, an assistant professor from the same department. They were joined the following year by Venkataranga Iyengar and K Parthasarthi. Impressed with the research, Krishnaraja Wadiyar provided funds in 1916 to establish an experimental factory in the vicinity of IISc to manufacture sandalwood oil. Mysore also offered scholarships and deputed two students, B Rajagopal and B Sunderaraj Iyengar, to undergo training in the Institute. In 1917, they were given jobs as Assistant Chemists in the sandalwood oil factory nearby. Sudburough and Watson were also appointed as Consulting Chemists of this factory.

In the same year, Krishnaraja set up the second sandalwood oil factory in the city of Mysore. Meanwhile, another team of researchers comprising J Chakraborty and GA Mahmadi conducted experiments on making soap with local oils. Again, pleased with the results, Mysore set up a 5-tonne soap plant near the Institute. Much of the soap produced during these years was sent to British troops in Mesopotamia by the Red Cross Society. This experimental unit then gave way to a bigger and newer soap factory in early 1918. Later that year, the first Mysore Sandal Soap was introduced in the market.

Photo courtesy: IISc Archives

Metallurgy (now Materials Science) was one of the several engineering departments that came up when Visvesvaraya was President of IISc's Court in the 1940s

Visvesvaraya's tryst with IISc continued long after he gave up his position as the Dewan. He returned to IISc in 1938, when he was elected as the President of its Court, a position he retained until 1947. Visvesvaraya saw World War II as an opportunity for the Institute to refocus its efforts on doing research that would benefit the Allied forces, thus boosting the manufacturing sector. His words, once again, seemed to have an immediate effect on research priorities in IISc.

The 1940s was also a period when IISc expanded rapidly, particularly in areas of applied research, under its Director JC Ghosh. As the war was drawing to a close, the focus of the Institute shifted to nation-building, something that Visvesvaraya was keen to drive. It was during this decade that several new engineering departments came up in IISc: Aeronautical Engineering, Chemical Engineering, Metallurgy, Internal Combustion Engineering, Power Engineering, and Electrical Communication Engineering (it was earlier a section in the erstwhile Electrical Technology Department).

In the initial years of IISc, grants from Mysore were the largest by far that the Institute would receive, and in the years to come, the largest from a local government (only grants from the government of India were larger in subsequent years). Mysore also offered periodic grants and scholarships to students. For instance, the 1943 Annual Report shows that it provided Rs 1 lakh to the Institute – Rs 50,000 towards "normal" expenses and Rs 50,000 as capital grant for the institution of the Aeronautical and Automobile Engineering Sections. It also awarded two scholarships for students in the newly started course in Aeronautical Engineering.

Though it was the Dewans who had a more direct say in the running of the Institute, Mysore's Maharajas made it a point to visit the Institute regularly and offer their counsel. On 1 February 1911, a few months before the Institute opened its doors to its first batch of students, Krishnaraja Wadiyar came to IISc to lay the foundation stone of the Main Building. Speaking on the occasion, he praised the generosity of his mother for providing land and money to help make Tata's dream come true. He also used the opportunity to urge the Institute not to restrict scientific research to students of "independent means" and consider providing scholarships to those "who have no capital at their backs." (The entire speech is reproduced in this magazine.) His plea was taken seriously by the Council. In 1914, IISc announced that it would be offering 11 scholarships to economically disadvantaged students.

Photo courtesy: IISc Archives

Krishnaraja Wadiyar unveiling Tata's statue in 1922

A few years later, on 10 March 1922, it was again Krishnaraja who was invited to the Institute to unveil the monument dedicated to its founder. He was accompanied by his brother, Yuvaraja Narasimharaja Wadiyar, who also maintained an association with IISc. The Yuvaraja's son, Jayachamarajendra Wadiyar, Krishnaraja's successor to the throne, kept up the tradition of coming to IISc, even after he ceased to be the Maharaja in 1950 (he however continued to hold the title till his death). In 1958, besides inaugurating the open-circuit wind tunnel of the Aeronautical Engineering Department, he was also the chief guest for IISc's Golden Jubilee celebrations.

Photo: Meghana Shastry

Yaduveer Wadiyar, the current titular Maharaja, inaugurating a workshop on smart cities in 2018 in IISc

Even though Mysore's formal association with IISc ended with the abolition of monarchy, its legacy has endured. A close reading of the events that led to the establishment of IISc and its early years suggests that, without the backing of Mysore, IISc might still have come up. But the princely state's involvement in Tata's ambitious project ensured that it ended up in Bangalore. Moreover, Mysore's close association with IISc also influenced the size of the Institute, the nature of its research, and the scale of its impact.

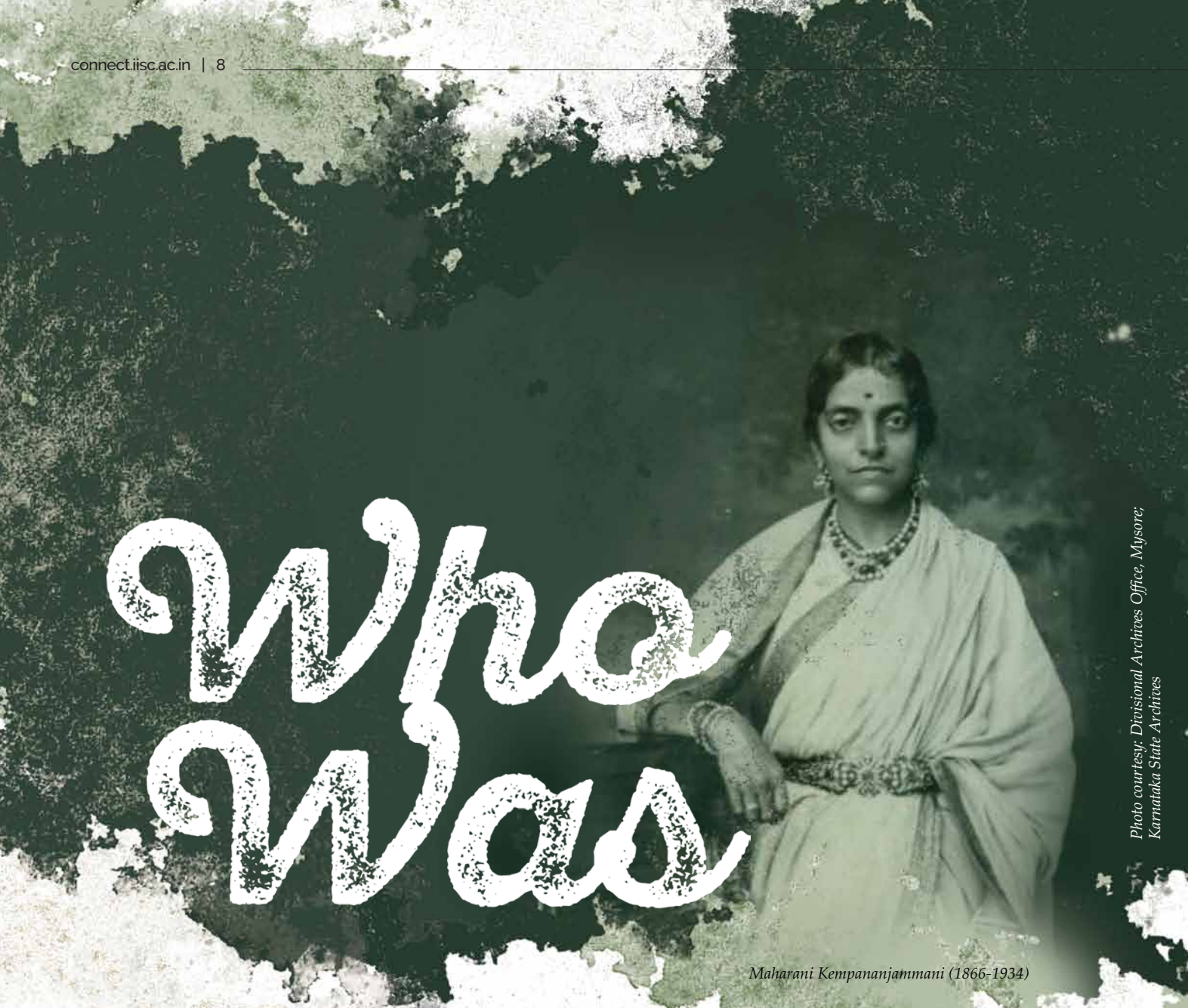


Photo courtesy: Divisional Archives Office, Mysore; Karnataka State Archives

Maharani Kempananjammani (1866-1934)

Who Was Kempananjammani Vani Vilasa Sannidhana?

Deepika S

While historical accounts have plenty to say about her husband, Chamarajendra, and her son, Krishnaraja, little is known about her life in comparison

IISc was set up in Bangalore because of the generous grant of land and money by the Maharani of Mysore, Kempananjammani Vani Vilasa Sannidhana, who headed the princely state of Mysore as Regent for nearly eight years while her son was a minor. Who was Kempananjammani, and what role did she play in the Mysore state? While accounts of the Mysore royal family tend to mention Chamarajendra Wadiyar, Kempananjammani's husband, who ruled from 1881 until his death in 1894, and her son Krishnaraja Wadiyar, who ruled from 1902 until his death in 1940, less is known in comparison about the life and reign of the Maharani.

GR Josyer's *History of Mysore and the Yadava Dynasty*, published in 1950, tells the story of how she came to be married. In 1876, the young maharaja Chamarajendra, who was 14, travelled with his entourage to Delhi to attend the Diamond Jubilee of Queen Victoria. On the way back, a bride was sought from the royal house of Rewa (a princely state at the time, and now a region in Madhya Pradesh). "The Dowager Queen [of Rewa] was not in favour of an alliance from a strange family," Josyer writes, and so Chamarajendra's entourage looked for a bride closer home. They chose an educated girl from the Maddur branch of an aristocratic family from Kalale (both places are in Mysore district today), and in May 1878, 15-year-old Chamarajendra was married to 12-year-old Kempananjammani, who was given the title of Maharani Vani Vilasa Sannidhana.

Photo courtesy: Wikimedia Commons

Chamaraja Wadiyar, the Maharaja who married Kempananjammani

Although Chamarajendra held the title of Maharaja, which he inherited on his father's death, the Wadiyar dynasty had not ruled Mysore for a long time. The British controlled the Princely State of Mysore – what was left of the Mysore Kingdom after it was annexed by the British and portions handed over to the Madras Presidency and the Nizam of Hyderabad. On 26 March 1881, Chamarajendra was installed as ruler of the Princely State of Mysore, with several restrictions. British evacuation was only partial, with the right of supervision. The Maharaja and his descendants had to remain in faithful alliance and subordination to the British Crown, and pay an annual sum of Rs 35 lakh for "protection". When it came to administration of the state, the Maharaja would have to conform to advice given by the British Governor General, and a British official termed the Resident would be posted in the state to ensure that the conditions were followed. If these conditions were breached, the British could resume possession of the state.

Despite taking charge under such challenging circumstances, Chamarajendra proved himself a popular and able ruler. A devastating famine in 1876 had had long-lasting consequences, but by 1891, the state had recovered from it. The number of government and aided schools more than doubled under his rule, and the first schools for girls were set up. Investing in new roads, railways, irrigation works and new industries had boosted the economy. Land revenue rose, and the area under cultivation expanded. Excise revenue nearly quadrupled, and revenue from forests, stamps and registration nearly doubled.

And then, on 28 December 1894, Chamarajendra died unexpectedly at the age of 31. Josyer writes, "He had gone on a cold weather tour to Calcutta, then the Capital of the Indian Empire. On his arrival at Calcutta a slight throat affection which he had been feeling during the journey developed into diphtheria and was beyond medical aid, and he passed away. His family, Maharani Vani Vilasa Sannidhana, and two sons and three daughters, as well as Dewan Sir K Seshadri Iyer who had accompanied him on the journey, were heartbroken, and cremating his mortal remains in Kalighat, returned to Mysore, widowed, orphaned, and bereft."

> ***On the Maharaja's unexpected death in 1894, the Maharani was appointed Regent until her son was old enough to rule***

Vikram Sampath, in his book *Splendours of Royal Mysore: the Untold Story of the Wodeyars*, narrates this incident with far more drama: "Darbar Bakshi Narasimha Iyengar informed Kempananjammani of her husband's death. Grief-stricken and hysterical, she rushed to the room where the cold, lifeless body lay. The baffled dewan rushed to the spot and tried consoling her. She cried and lamented loudly, cursing her fate and the will of Destiny, finally falling unconscious. The dewan informed Foreign Secretary Cunningham, who in turn informed the viceroy about the tragedy. Mysoreans could hardly believe the news when it began trickling in. The young and dashing ruler was no more!"

Photo courtesy: Divisional Archives Office, Mysore; Karnataka State Archives

Maharani Kempananjammani

Chamarajendra is described by Josyer as being cultured and having "refined" taste in art and music. He also travelled extensively and made connections with several important people across India. Perhaps his exposure to the world and to varied ideas had also meant a similar exposure for Kempananjammani, although she fades out of most historical accounts during the period of her marriage (except as the mother of five children: Jayalakshmammanni, Krishnajammanni, Krishnaraja, Narasimharaja and Cheluvajammani), only to resurface at Chamarajendra's death, when she was tasked with a new and important role.

Two days after Chamarajendra's death, on 30 December 1894, the Government of India announced to the people of Mysore that they would sanction the succession of Krishnaraja Wadiyar, Chamarajendra and Kempananjammani's eldest son, who was only 10 years old at the time. And so until he was old enough to rule, the Maharani would serve as Regent (at the time,

Kempananjammanni herself was around 26 years old) and the State would continue to run as it had under the Dewan, K Seshadri Iyer. The Dewan would have to "ask for, and follow the advice of the Resident on all matters of importance," and "so far as it is practicable and desirable, consult the wishes of Her Highness the Maharani Vani Vilasa Sannidhana."

Many accounts of the Maharani describe her role as being that of 'holding the fort' until her son came of age, as if she merely served as caretaker in the interim. Mysore did have an efficient administrative apparatus that carried on, in Josyer's words, "without a hitch" after the Maharaja's death. But she appears to have played a more active role than she is given credit for. Once she was made Regent, she appointed a council of three members to assist the Dewan. Under her reign, an outbreak of plague was brought under control, new extensions were added in Bangalore to house the growing population, and Bangalore's Victoria Hospital was built. A Cauvery power scheme, water schemes for Mysore and Bangalore, and the Marikanive irrigation project, were among the several other public works launched during her reign.

Education also received a boost: the first hostel was opened for students "coming for education from the moffussil" [sic], foreign travel for "post-graduate men" was sponsored and a Damodar Das Scholarship scheme was instituted. Many more girls were enrolled in primary school in this period. From the Rendition of 1881 to the end of the Regency in 1902, spending on education had increased four-fold, spending on public works had more than doubled, spending on healthcare had tripled, and state income and expenditure had almost doubled, according to Josyer. The Maharani also commissioned an architect, Henry Irwin, to rebuild the Amba Vilas palace after it burned down during the wedding of her eldest daughter Jayalakshmammanni to the Maharani's brother, M Kantaraj Urs (an administrator who would serve as her private secretary, and later as Dewan from 1918 to 1922). The palace, completed in 1912, remains the most visible symbol of the erstwhile royal family and a draw for hundreds – often thousands – of tourists every day.

When Dewan Seshadri Iyer died in 1901, the Maharani did not hesitate to give him credit for the achievements of the Mysore State, saying "The many reforms which have brought the Mysore administration up to a high level of efficiency are attributable in great part to his talents, fore-thought and resourcefulness." Several accounts show this praise was well-deserved, but the Dewan cannot be given sole credit, as Josyer writes: "No doubt the Dewan was a masterful personality, but whatever he wished to execute had to have the approval of the Councillors – who were certainly not very pliant, the Maharani Regent, the Resident who had to be consulted in all matters, and also the Representative Assembly consisting of some 300 uncurbable voices."

"Sometimes her enlightened suggestions and direction most agreeably surprised me and afforded ready solution of many difficulties"

The Maharani was herself popular, and Josyer quotes an "onlooker" on an occasion as saying, "[T]he people all over the State were loud in her praise. If she found the State prosperous and its people contented when her consort died, she left the State still more contented when she laid down the reins of her Regency on the accession of her son to the throne." He also quotes "a European observer" gushing in her praise, comparing her to Queen Victoria, saying, "In my opinion there is no nobler lady in India than her Highness of Mysore, and her name will go down to posterity coupled with those of the best and greatest women India has known!" She is often remembered as a maternal figure – mother to her children, and mother to the people of Mysore. The Viceroy of India Lord Curzon paid tribute to her at the end of the Regency, saying that she had set an example of "public and domestic virtue".

TRA Thumboo Chetty, a judge and one of the Council members she appointed to assist the Dewan, reveals that she was intelligent, informed, and an involved ruler: "In my repeated official visits I was really struck with her Highness the Maharani's capacity for business, fair knowledge of things, and amiable character. She listened to everything with exemplary patience. Her mind was bold and acute, and whatever be the subject of discussion, she came directly to the point and brought it to a happy completion. Sometimes her enlightened suggestions and direction most agreeably surprised me and afforded ready solution of many difficulties. Her anxiety to promote the highest and best interests of the country was always perceptible. I invariably retired from the interviews I had with a strong sentiment of devotion, as well as admiration and respect, for Her Highness' high character and intellectual qualities."

On 8 August 1902, the Regency ended when the young Maharaja Krishnaraja was given ruling powers. Historical accounts of Kempananjammani tend to fade at this point, even though she appears to have had a continued influence on Mysore – her son would consult her on official affairs. She also made the occasional public appearance. In 1917, she opened the Maharani's College for Women in Mysore, which taught women arts as well as science subjects.

Kempananjammani died on 7 July 1934, leaving behind a rich legacy. The Vani Vilas Women and Children's Hospital was opened next to Victoria Hospital in 1935, and several public works and projects in subsequent years bearing the name Vani Vilas stand in her memory.

'THE UND

The following extract is a speech made by Krishnaraja Wadiyar, the Maharaja of Mysore from 1894 until 1940, at a ceremony to lay the foundation stone of IISc's Main Building in 1911

Very deep is the responsibility which has fallen on me to-day of laying the Corner Stone of these magnificent buildings, the future home of an Institute which will be unique of its kind in India. I need not remind you that the India of to-day is almost entirely an agricultural country and that except in a few centres, such as Calcutta and Bombay, the large industries, which contribute so much to a nation's wealth and which are such a marked feature of Western civilisation, are practically non-existent. An agricultural population must of necessity be poor, as compared with an industrial one, and this poverty, in the case of India, is accentuated by periodical visitations of famine due to an uncertain rainfall. It is of course beyond the efforts of man to change the face of our vast Peninsula and to alter the conditions of life of its teeming millions of agricultural labourers, but nevertheless it should be possible by dint of sustained and well-directed efforts to improve the position of the working classes by not only expanding our existing industries but increasing their scope and number and in this way reducing the number of people who are dependent on the soil for a livelihood. Living under the conditions which surround him in India, every thinking man cannot but welcome a scheme like that of the Indian Institute of Research* which has as its object the development of Arts and Industries on scientific lines and I feel that I am echoing the voice of

Photo courtesy: V&A Collection, Wikimedia Commons

An oil on canvas portrait of Maharaja Krishanaraja Wadiyar painted by K Keshavayya

...ERDOG AS SCIENTIST ,

thousands of my fellow countrymen when I publicly acknowledge to-day the deep obligation which we owe to that eminent philanthropist Mr JN Tata to whose fore-sight and liberality is due the inception of this great scheme of an Indian University of Research, and to his sons and successors who have so readily and generously come forward to carry out their lamented father's wishes.

It is not too much to say that the family of Tata will be remembered by the people of India for many generations to come as princely benefactors and as distinguished members of that enterprising and virile race who have been among the pioneers of the commerce and industry of Western India.

I cannot help reflecting with pride that it is due to the public spirit and fore-sight of my own mother, when she was Maharani-Regent, that the Mysore Government occupies today a prominent position among those who have come forward to supplement the Tata family's original endowment, and has provided not only a building site and a portion of the building grant but also an assured annual for the upkeep of the Institute. Mysore will, I feel sure, reap a reward from the liberality of HH the Maharani-Regent's Government by having at her doors an University which will teach her sons to increase the material wealth of their country. Sir Dorabji Tata pays a just tribute to the late Sir K Seshadri Iyer, who was my mother's trusted adviser in this and all other matters connected with the welfare of the Mysore State.

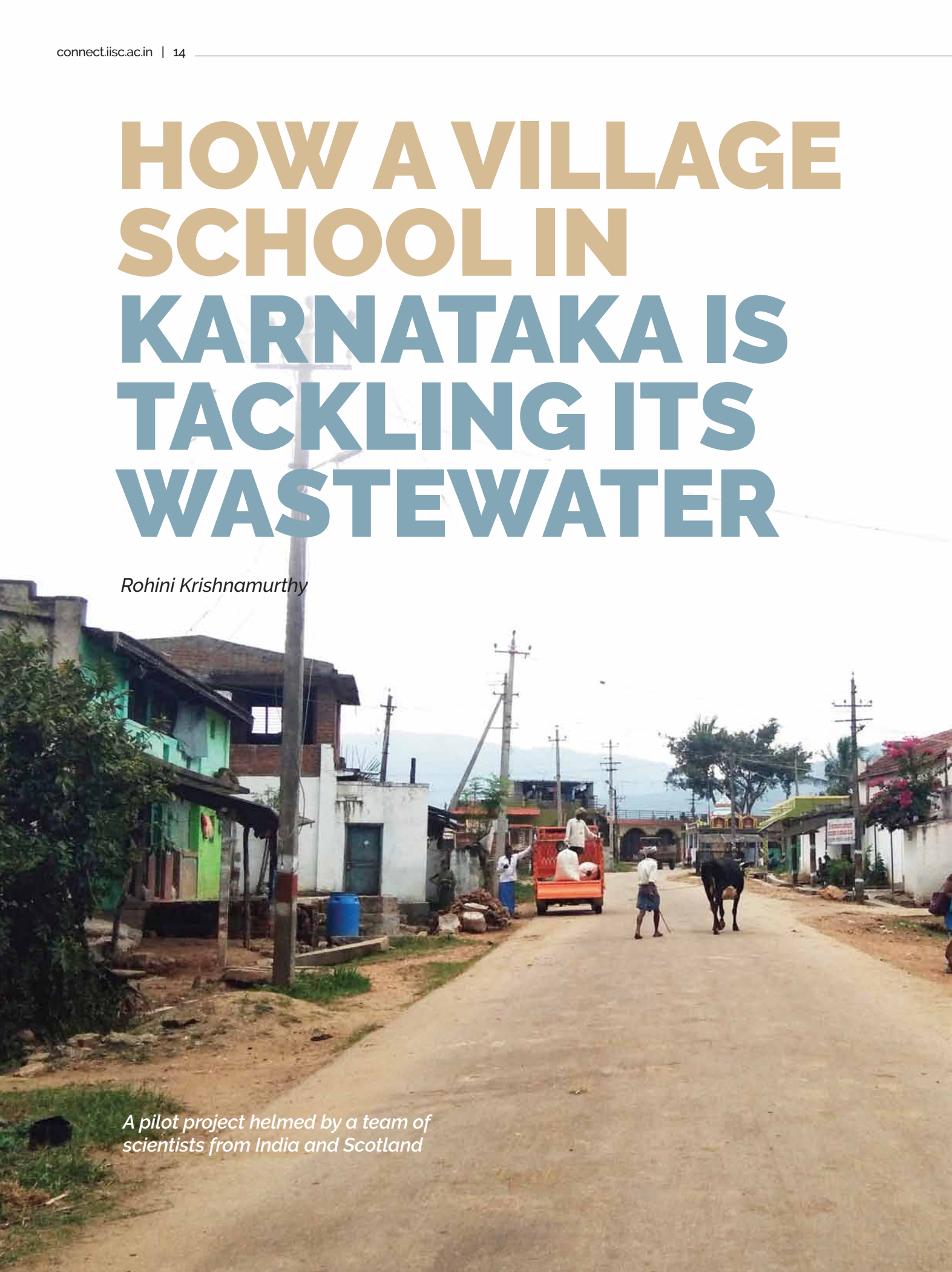
I would like, before I conclude, to draw attention to one rather important point in the Director's address. I refer to the question of scholarships. No doubt, it is to a certain extent a wise policy to try and restrict scientific research to students of independent means and to discourage a class of students who have no capital at their backs and therefore no prospect of making practical use of the knowledge acquired at the Institute, but it must not be forgotten that if a hard and fast rule is made against the grant of scholarships, the result may be to shut out an occasional student who has brilliant abilities without the means of supporting himself during his course of study at the Institute. It may also be fairly argued that the Institute should make some provision for students, who, though they possess no capital, are likely to turn a scientific training to useful account as salaried employees under capitalist manufacturers. There is of course a wide field for private enterprise in the matter of scholarships, for it is open not only to Provincial Governments and Universities but also to private individuals to either grant or endow scholarships. It is also true that the danger which I have pointed out will be minimised by the decision of the Council to charge no tuition fees, and to give some remuneration, after a certain period to students who have qualified themselves to work as Demonstrators, but nevertheless the danger will exist and I feel it my duty to sound a warning note against it. I cannot help feeling that the Council will be well advised to keep an open mind on the scholarship question until they are satisfied by actual experience that scholarships are not actually needed.

I will conclude, Ladies and Gentlemen, by wishing the new Indian Institute of Science the successful future which it so richly deserves from the loftiness of its aims and the liberality of its founder.

**Indian Institute of Research and Indian University of Research were both proposed names for IISc.*

HOW A VILLAGE SCHOOL IN KARNATAKA IS TACKLING ITS WASTEWATER

Rohini Krishnamurthy



A pilot project helmed by a team of scientists from India and Scotland

About 200 km southwest of Bangalore is Berambadi, a village nestled between mountains, swathes of agricultural fields, the Hirikere lake, and the Bandipur National Park. This verdant countryside with tidy roads that borders Karnataka's neighbours Kerala and Tamil Nadu is spellbinding. However, Berambadi, located in the rain shadow side of the Western Ghats, has been hit by drought several times in the last few years.

A small beginning has been made towards changing the situation. "We don't face water scarcity in our school anymore," says Jeevan S, a class eight student at the Berambadi government school – the site of a pilot project that, besides addressing water scarcity, aims to reduce pollution caused by untreated wastewater. This transformation has been enabled by an interdisciplinary team of experts from India and Scotland, including from IISc, working together to spruce up a sector which has perpetually been in shambles in India: the wastewater treatment system.

Photos: Rohini Krishnamurthy

Students from the Berambadi government school

Berambadi has water scarcity issues but it is not just this village that is facing the heat. According to a 2018 report by the NITI Aayog, 600 million people in India face water scarcity and 70 percent of the water supply is contaminated. The report also found that 54 percent of groundwater wells are declining and, at this rate, 21 major Indian cities may run out of groundwater by 2020.

One way to get around this problem is to treat and reuse wastewater. In urban India, wastewater is treated in centralised treatment plants. But only 32 percent of wastewater is treated, according to an analysis by the Centre for Science and Environment. The rest seeps into the ground, or finds its way into lakes, polluting them both along its way. Bellandur lake in Bangalore is a striking example of how such untreated wastewater can wreak havoc. The lake is fed with untreated sewage – rich in phosphorus, nitrogen and other industrial effluents – causing it to froth and catch fire, most recently in January 2019. The city struggles to treat its sewage because many of the existing treatment plants are in a dismal state. And rapid urbanisation and population growth mean that Bangalore is generating more sewage than it can handle.

To tackle this problem, the Karnataka High Court tasked apartment complexes in the state with more than 50 units to treat and reuse the wastewater they generate. This would reduce the burden on centralised wastewater treatment systems and freshwater sources and is hence considered a sustainable solution – but there are issues. Apartment complexes have to shell out lakhs of rupees to install such a decentralised system, depending on the capacity. Cheaper options exist, but function poorly. It was also reported that people are in a fix due to unclear guidelines on the kind of system to purchase and on how to maintain the plant. To make matters worse, several of these treatment plants have become dysfunctional, jeopardising the success of a decentralised system.

It is in this context that the project in the Berambadi school holds promise. "The idea behind this project", says Lakshminarayana Rao, assistant professor at the Centre for Sustainable Technologies, IISc, "is to demonstrate that a decentralised wastewater treatment system is the way to go."

How it all began

The project, funded by the Government of Scotland, is a collaboration between IISc, the Ashoka Trust for Research in Ecology and the Environment (ATREE), the James Hutton Institute, Scotland, and the University of Glasgow.

According to Rachel Helliwell, project coordinator and senior research scientist at the James Hutton Institute, the Scottish government wanted to put more resources into international projects under their Hydro Nation International programme. The programme aims to share Scottish expertise and experience in the area of wastewater treatment with the wider world.

As to why they zeroed in on Berambadi, Rowen Ellis, a social scientist at the James Hutton Institute, explains that the main rationale was the familiarity: the hydrology of Berambadi is well-studied by IISc and other institutions.

Besides the recent drought in Berambadi, the team factored in the local enthusiasm, the availability of land and the poor state of the school toilets. "All of this represents an opportunity to start from scratch and to construct a system that takes user experience and sanitation facility into account," she adds.

What makes this initiative special is the technology-meets-social-sciences approach. The team of scientists chalked out plans to devise low-cost and environment-friendly methods to treat and reuse wastewater, while the social sciences team interacted with the villagers and students, educating them about the importance of the project and good sanitation practices. Innovation and social sciences need to work in tandem, according to Ellis. "A study published in 2014 concluded that there are at least two key issues that characterise the failure of sanitation initiatives," she says. "First, is the poor, shoddy, unsuitable toilet construction and second, is that they failed to initiate any real and sustainable behaviour change."

Before initiating the project, the team decided to gauge the extent of problems in Berambadi, from water quality and energy consumption to sanitation practices and other challenges. The survey revealed a very troubling picture, says Ellis. "We saw that the village heavily relied on groundwater; septic tanks were failing, and the untreated grey water was flowing into the school ground and drains." A test of groundwater quality by Priyanka Jamwal, Fellow at ATREE, and her team found high levels of nitrates and faecal coliforms in the water. Armed with this baseline information, it took the team a year and a half to give the Berambadi school a new lease of life.

Going green

Rao and his team worked on a system to treat and reuse grey water – wastewater from the kitchen and hand wash – while the team from the James Hutton Institute focused on treating black water – wastewater from the toilet. The two systems function separately. "Keep it separate, clean it separately and your cost will come down," adds Rao.

> *The goal was to direct grey water for reuse in toilet flushes and gardening*

The goal was to direct the treated grey water for reuse in toilet flushes and gardening. To do this, they designed a system where grey water is subjected to a series of steps: first is getting rid of the remnant fat and grease in the wastewater using a grease trapper. Water free of grease is passed through a trickling bed filter (a bed made of gravel of different sizes) and an aerator, where microorganisms help remove pollutants in the wastewater. This water, after undergoing the final step of disinfection, can be reused.

Photos: Rohini Krishnamurthy

Chlorine is commonly used as a disinfectant, but it is not as effective as ozone, which is more expensive. Rao, however, wanted to develop a better technology at a lower cost. So he used plasma – ionised gas, the fourth state of matter – to generate ozone. "What we have developed in our lab is a high-throughput ozonator powered by solar energy, which can give out volumes of ozone at very low energy consumption," says Rao.

The high throughput ozonator from Rao's lab

To treat black water, the Scottish team channeled the flow of water from toilets into septic tanks, where the solid wastes separate and settle at the bottom while the liquid wastes or effluents flow into a trickling bed filter. Finally, the filtered water — high in phosphates and nitrates — is fed into the constructed wetlands, explains Samia Richards, environmental scientist at the James Hutton Institute. Constructed wetlands can be thought of as ponds with plants growing on the surface – in this case, Canna lily, a flowering plant that can absorb the excess nitrates and phosphates from the wastewater. "Treated water from the constructed wetlands is then released into the sewage," explains DK Manju, project assistant at Rao's lab. This step checks frothing caused by eutrophication and groundwater contamination.

On the road ahead

The team went beyond just constructing the decentralised wastewater treatment system. In about a year and a half, they helped equip the school with a new hand wash area, solar panels, toilets, incinerators for sanitary pads, and a rainwater harvesting system with a capacity of 60,000 litres.

The newly built hand wash area (top) and the toilets (bottom)

According to Rao, the school – with a strength of about 200 children – consumes about 4,000 litres of water a day. By recovering grey water and harvesting rainwater, the school should be able to halve its water consumption.

"Now, we are in the process of working out the costs involved," Rao says. "It's not very expensive. Even with the best of the technologies, it costs about 25-27 rupees per thousand litres. In our technology, we want to bring it [costs] down anywhere in between 10 and 12 rupees per thousand litres."

> *By recovering grey water and harvesting rainwater, the school should be able to halve its water consumption*

With the plant up and running, the team is relieved. But there is one major challenge. And that is to chart out the right maintenance plan. "If we don't get this [maintenance] right, our system is going to fail," says Helliwell. She explains that since the system mostly runs on its own, barring the ozonator and aerator, maintaining it on a daily basis wouldn't be a hassle – all it needs is someone to control the switches for the aerator and the ozonator. But long-term maintenance requires engaging with the locals. "There are a lot of sewage treatment plants right now and they are not necessarily running the best. A part of the reason might be that we don't have the skilled labour," rues Rao. So the team is planning to introduce a youth internship programme, where youngsters will be trained to understand the system.

Elaborating on this, Durba Biswas, Fellow at ATREE, says, "The genesis of the idea [youth internship programme] came from the fact that the school property is considered a public property by the village people, which meant that anybody could come and go when the school is closed. This meant that there could be damage to the property, whether it is windows, doors." So Biswas and her team decided to talk to the young people in the village, train those interested and give them incentives, maybe a certificate. The response, so far, has been good. "We received a lot of support from the school, even the community. Parents were willing to contribute 1 rupee per day, to help maintain the toilets. To you and me, it may not be a large amount of money. But to them, it is. This idea came from the community itself."

The internship programme will take some time before it is rolled out. The team wants to ensure that the system is working well, before training the interns. "That is not to say that the entire maintenance falls on the interns. No. The primary objective is to embed the knowledge about the system in the community so that these people should know why this system is important and how the system works after we leave," she adds.

Rao is positive about the course of this project. Expressing his desire to collaborate, he says, "We are very keen to take this technology to other places, such as apartment complexes, hospitals, schools, and communities. We can replicate either parts of it or the complete project in other locations as well." Though Richards shares Rao's optimism, she adds that "each area will be different, and we'll have to look at it differently. We have to look at the landscape, annual rainfall, vegetation and pollution."

Before taking this further, the team is deliberating over another maintenance issue: to decide on the fate of the sludge from the septic tank. One solution they are considering is reusing the sludge.

There is already a technology to do just that, used by a Bangalore-based NGO named Consortium for DEWATS Dissemination Society (CDD). This technology, the faecal sludge treatment plant, is housed in a small town in Bangalore Rural district called Devanahalli. To establish this plant, the CDD partnered with Devanahalli's Town Municipal Council. Here they co-compost treated faecal sludge with municipal wet waste, which, according to their laboratory tests, keeps pathogens out of the final manure. They also find that the co-composted manure improves the water-holding capacity of the soil, and increases crop yield. The co-composted manure, the CDD says, has seen demand from the farmers in Devanahalli.

Talking about support from the government, the CDD says that though the Swachh Bharat Mission — covering 4,041 statutory towns, cities and rural India — has a small budget, they believe that there is scope for public-private partnerships and new types of investment to come in. Of the states the CDD has approached, they have found Tamil Nadu to be the most progressive. Other states, including Karnataka, have not been as responsive, which they feel may have to do with the fact that Faecal Sludge Management (FSM) is still relatively unheard of.

Nevertheless, the CDD finds support at the national level. According to them, the central government has allocated budgets for sanitation or FSM, and the like. With an emphasis on FSM in AMRUT [Atal Mission for Rejuvenation and Urban Transformation, under the Ministry of Housing and Urban Affairs], they believe that the government is actively learning and doing the best they can.

It remains to be seen if faecal sludge treatment will be employed in the Berambadi project by the Indo-Scottish team. What they do plan over the next few months is to periodically test water quality in the Berambadi school, at different stages of water treatment. And if it all works well, the system could be replicated with support from the Government of Karnataka.

Meanwhile, a farmer living across the school in Berambadi named Swami, whose daughter studies at the school, is aware and happy about the developments. "Things are good and convenient now. My daughter is happy. I hope everything is maintained properly."

CRACKING THE PUZZLE OF THE MOTHER OF ALL MOLECULES

Karthik Ramaswamy

How is genetic information translated into chains of amino acids which combine to form proteins, the building blocks of life? In Gene Machine, *published by Harper Collins India, Nobel Laureate and the President of the Royal Society Venkatraman Ramakrishnan – better known as Venki Ramakrishnan – answers this fundamental question in biology even as he chronicles the behind-the-scenes drama that led to the unravelling of the structure and function of the ribosome, the molecule responsible for making proteins in all living organisms. For his pioneering work, he won the Nobel Prize in Chemistry in 2009, an award he shared with the Israeli crystallographer Ada Yonath and the American biochemist Thomas Steitz.*

In a brief sit-down during his visit to IISc, Ramakrishnan tells us about the book, the strange business of being a Nobel Laureate in India, what scientists are really like, and why the ribosome structure was so hard to crack.

Give us an elevator pitch for why you think people should read *Gene Machine*.

I would say in one go you'll learn about the mother of all molecules – the molecule that makes everything else in the cell or makes molecules that make everything else. At the same time you'll get an inside look into how science works and what scientists are really like.

The theme of you as an outsider crops up several times in the book: an Indian who went to the West to make a career and a physicist who stumbled upon biochemistry. What's been the biggest handicap and what's been the biggest advantage for you as an outsider – a cultural and an academic outsider?

I think [being] an outsider allows you to see things with a fresh perspective that isn't obvious to people who are either part of the culture or part of the field. They are used to thinking in a certain way. And you come in there and say, "Wait a minute. Why is everybody doing it like this?" When people come in from a different field or different country, they bring a new perspective sometimes. That's why I'm a big fan of people moving around in science. Science often benefits from this global [churn].

But I wouldn't say I was too much of an outsider in biology. If you remember from the book, I actually went back to graduate school in biology and I even took undergraduate courses. So it was not as if I wandered into a biology lab and didn't know anything. I made a deliberate decision not

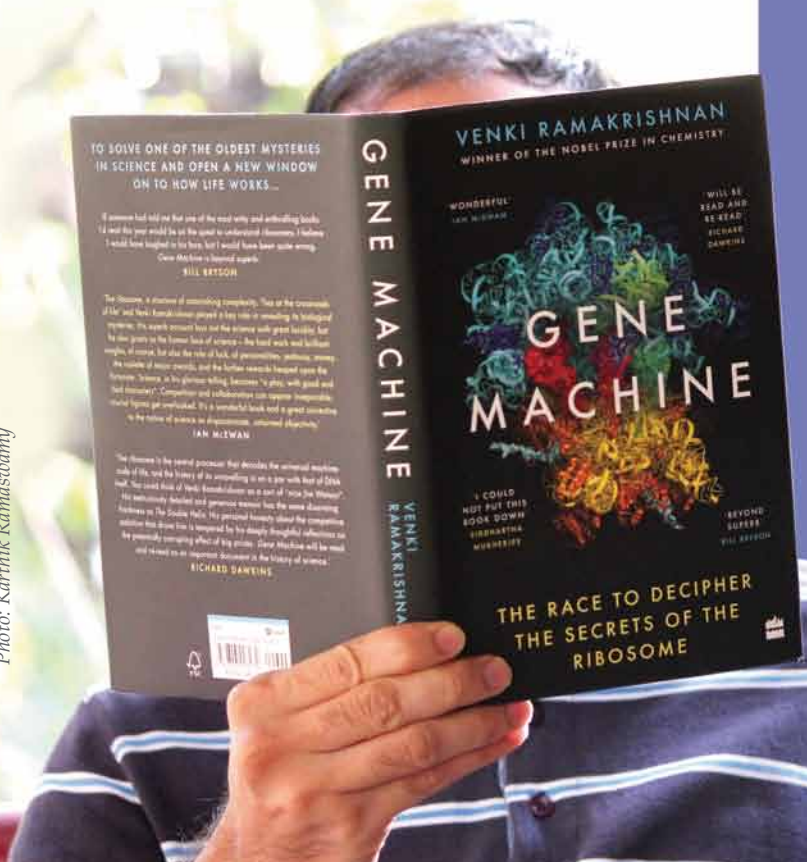


Photo: Karthik Ramaswamy

to just do a postdoc in biology [immediately after finishing my PhD in physics]. Then I really would've been an outsider and would've learnt a narrow part of biology. But I wanted to get a proper background.

> *That's why I'm a big fan of people moving around in science*

Like many immigrants, you saw America as the Promised Land. Would that also be a useful metaphor to describe the field of molecular biology in the 1970s when you decided to switch from physics?

The field was flourishing and new discoveries were constantly being made. What do you mean by Promised Land? What you mean is lots of opportunities. So in that sense you're right. In a way molecular biology was a Promised Land as well.

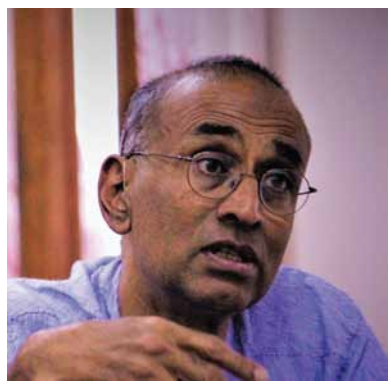


Photo: Nithyanand Rao

Venki Ramakrishnan

The book is written almost like a thriller involving a race with fierce competitors where the personal story is interwoven with the scientific story. That's not the most obvious way to write a popular science book. Why did you choose this narrative?

I realised that this – the ribosome story – had an interesting human drama about it because of the way it evolved and the people [in it] and so on. Even while it was happening, I said [to myself] that this is going to make a good story someday.

I was also very influenced by *The Double Helix* by Jim Watson. I read it as an undergraduate in Baroda (now Vadodara). At the time I was a physicist and biology was taught as a collection of facts to be memorised. *The Double Helix* for the first time gave me a feeling that biology was actually very interesting. There were goals. There was a mystery and you could go solve it. It's not just about collecting a bunch of facts. It was written in a very personal style. Again as you say, it wove the science with the personal stuff. And it was written very frankly. I thought it would be good to write in that genre. Of course, there's a fine line between being very, very frank and honest and being what I would call unnecessarily nasty. I would like to think that I'm on this side of that line and not on the nasty side.

One of the takeaways from the story of the discovery of the structure of the ribosome and how it works is that scientific progress is non-linear. But research papers and textbooks give us a sanitised version of the process. So how does one get the political establishment and society to appreciate the messiness of the scientific process?

Well, that's one reason I wrote the book – to educate the general public which hopefully will include decision makers. The former Science Minister in Britain has read my book and liked it. People in all walks of life need to understand how science is done. What is the process of science like? How do discoveries emerge? It's not like turning on a tap and discoveries flow out. It's more like planting seeds. That would be a better analogy. You plant seeds, you nurture it. Some of the seeds will flourish and become great big trees. Others may not. But if you don't plant widely, you're not going to get anything. That's the way I would look at it.

> The Double Helix *for the first time gave me a feeling that biology was actually very interesting*

You don't shy away from referring to your own insecurities, apprehensions, and also the occasional embarrassment. While you laud the vision of Ada Yonath, your main competitor with whom you shared the Nobel Prize, you are also critical of her in some instances. Richard Dawkins says you write with "disarming frankness". How hard was it to be brutally honest about yourself and your competitors when you were writing it? Did you think of editing some sections out at any point?

Some parts have been edited because the book has been carefully checked by lawyers. But even after the editing, it conveys the sense that the original draft had. Again *The Double Helix* was sort of a model. My view is that you want to tell people what science is like, what scientists are like, and how it felt [being part of the race]. If not, why would you want to write a book? If you're not going to be honest, the reader is not going to have a true picture. So it's almost an imperative to be completely honest. If you're worried about it, you shouldn't be writing it. Or you could write some other book.

You talk about the politics of recognition and warn against the corrupting influence that awards can have on researchers. You've even coined a term Nobelitis – both pre- and post- Nobelitis – that afflicts many scientists. How did you deal with it when it seemed like the carrot was dangling in front of you and after you received the Nobel Prize?

I go through that in the book. I think it's very, very hard. When you first go after a problem, you're not thinking of awards. You're thinking that this is the most important problem in the field. And I want to take a stab at cracking it. Soon you find yourself in the middle of a race. And then the problem is solved. You're happy, you're ecstatic that [the solution to] this very tough problem has actually been worked out. The gamble has paid off. Then what happens is that you go to meetings and conferences. And you go give seminars at top universities. After your talk or at dinner people say, "You know… this is going to get a Nobel Prize someday." And then it starts to slowly warp your thinking: "Maybe it is [true]. All these people are telling me. Not just my good friend who is not objective. All sorts of people are telling me about this." You start getting invited to meetings in Sweden and for other keynote talks and so on. Suddenly it affects your psychology. You start thinking, "Do I have a chance or don't I? Who else would be in the running? Oh, maybe I'm not good enough." It's not a good feeling. I talk in the book about how after one meeting in Sweden, I basically decided that I wasn't going to be in the running for one funny reason. Somebody with whom I had a disagreement ended up on the [Nobel] committee. [I thought] that settles that. In a way the moment I decided I didn't have a chance it was a huge relief. Because then I could go back to my old self and keep enjoying science for its sake and watch the other people worry about it.

Dawkins also calls me a "nice Jim Watson"!

And after you won the Nobel Prize…

I didn't expect that level of press and public recognition although oddly Britain was the one place where I was hardly recognised. None of the TV stations featured me on their newscast. I wasn't in the print edition of most of the British newspapers. You would've thought that the fact that somebody from the US took a factor of two in salary cut to come and do science in Britain would've made a great story for British science and for Britain. It was a little odd.

But the business from India was really strange because I'd left India when I was 19. I had almost nothing to do with Indian science except that I started coming to Bangalore and a few other places from about 2006. So the people who knew me in India were people in my field: molecular and structural biology. They knew my work. Nobody else cared about it. At all. I gave a lecture in honour of GN Ramachandran in 2008 in Chennai. The hall was maybe half full. The next year a hall that was about three times as big was packed. What was the difference between 2008 and 2009? My work hadn't changed. So I think it's a very strange business. And I talk in the book about [the fact that] people don't understand what the Nobel is. It's given for advancing a field by making a discovery or invention. But it does not mean that you're a genius. It doesn't even mean that you're very smart. There are Nobel Laureates who simply got lucky. They weren't great scientists even. I think it's a bit odd. I've learnt to go with the flow and try not to let it disrupt my life too much.

It [the Nobel Prize] is given for advancing a field by making a discovery or invention. But it does not mean that you're a genius. It doesn't even mean that you're very smart

When did you realise that you wanted to write this book? Or did you want to write a book and then decided that it was going to be this one?

It was this book. And it was gestating even before the Nobel Prize. Because as I said, [even] as events unfolded, this would make a great story. Soon after the Nobel, I started collecting material for the book and interviewing people. In fact some of the people I talked to are dead now. So it's a good thing I interviewed them a long time ago. And then I thought this has been going on long enough. Alex [Alexander] Gann at Cold Spring Harbor Lab, a very fine scientist and also a science writer – he edited the annotated version of *The Double Helix* – said, "You really should be writing this." He's been encouraging me all along. The last time I met him, he said, "Look, years have gone by. If you publish one more Nature paper, not many are going to read it. But if you write this book, you're going to reach thousands of people. Not just half a dozen people who are going to read your paper in depth." So I thought at some point it's worth sitting down and actually doing it. And once I found an agent, there really was the pressure to start writing it.

The ribosome, as you put it, lies at the crossroads of life itself because it forms the crucial link between genes and proteins. But after the discovery of the double helix, it's taken several decades for us to understand the ribosome and how it works. Is it merely because of the complexity of the molecule?

Yes. DNA by contrast is a very simple molecule – it has a simple double helix. It has a very symmetric structure, a very regular structure. You can think of it as a very simple coil, whereas you can think of the ribosome as a big mass of spaghetti. So it is a very complicated and enormous structure. I think it's probably why it took so long.

The ribosome was always a target, but people just didn't think it couldn't be done. To their credit, Ada Yonath and Heinz-Günter Wittmann (a German biochemist at the Max Planck Institute) got the first crystals. Ada had the vision that this is the way forward. We didn't know how to do it, but this is the way forward. Other people thought, "Why should we do it? She's got crystals and a huge group. What's the point in competing with her?" I think there was some feeling about that as well. Otherwise other groups might have joined in earlier.

The interview was conducted and published jointly by Connect *and* thewire.in

WHAT IS CRYPTOGRAPHY AND WHY DO WE NEED IT?

Rohini Krishnamurthy

A look at an evolving technology that has been changing how we communicate

It was February 2009. A 560 kg satellite named Iridium 33, whirling around the planet in the low earth orbit 789 km above the Taymyr Peninsula in Serbia, met a fatal end. It clashed with the defunct 900-kg Russian satellite, Kosmos 2251. This accident, the first of its kind, destroyed both the satellites and left behind thousands of fragments of debris, forming about 10 percent of all known space debris accumulated over the past 50-odd years. This is all the more poignant because it was an accident that could absolutely have been prevented.

Cryptography is the science of protecting sensitive data – just like satellite locations, which can even be of national importance, especially if they have military applications. Rather than share such information directly with other countries, most countries share classified information about satellite locations with a trusted third party such as the US-based Analytical Graphics, which then advises satellite owners about possible collisions. But this approach may risk leaking of classified information. This is where cryptographers swoop into action. They build powerful tools to protect sensitive input data – the satellite location, while still allowing two countries to collaborate – calculating the likelihood of collisions, thus eliminating third parties from the equation. Perhaps if the makers of Iridium 33 and Kosmos 2251 had relied on cryptography, the landscape of outer space would look rather different today.

Working on developing such cryptographic systems is Arpita Patra, Assistant Professor at the Department of Computer Science and Automation (CSA), IISc. According to her, cryptography enables secure communications because we live in the age of information and there is distrust in this world.

Photo: KG Haridasan

Arpita Patra (right, standing) heads the Cryptography and Information Security Lab

Her work, which enables distrusting parties to collaborate while still keeping their data private, is built on a sub-field of cryptography called Secure Multi-Party Computation (SMC). SMC's foundations were laid in 1982 by a computer scientist, Andrew Yao (who later won a Turing Award), and finds applications beyond preventing satellite collisions. It could allow a startup to train its machine learning diagnostic app – which requires feeding in tonnes of patient data – while preventing the start-up from learning unique identifiers of the patient, including name, age or medical history. SMC could also set the stage for conducting fair e-elections or e-bidding: it lets people compute the number of votes or the highest bidding amount, without revealing names, votes or an individual's bidding amount.

Cryptography wasn't always this advanced. "Before the 1960-70s, cryptography was more an art than science," explains Patra. But the basic idea behind safeguarding secret messages has been the same – a key – shielded by people who share a secret. Except that the key isn't a physical construct but a mathematical one. The sender would lock or encrypt the message using the key, scrambling this message. Upon receiving this message, the receiver would use the same key to unlock or decrypt this message.

It is believed that Julius Caesar used a primitive form of cryptography, now called Caesar's cipher, to communicate with his aides. To scramble or lock his secret message, Caesar substituted every letter with another letter by moving down the order of alphabets, by a set number. This number is the key. For example, if Caesar wanted to send ATTACK to his aid and if they had agreed upon a key '2', the locked message would be CVVCEM. But this doesn't mean an intruder couldn't hazard a guess: it would take at most only 26 guesses to figure out the original message.

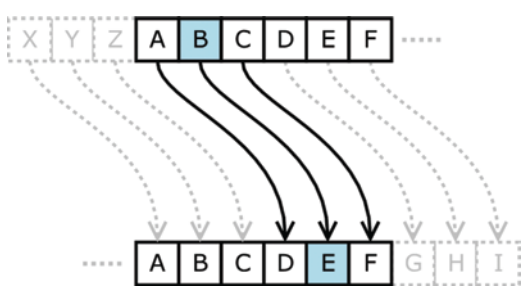


Photo courtesy: Matt Crypto/Creative Commons Licence/ Wikimedia Commons

Substitution of Caesar's cipher using a key '3'

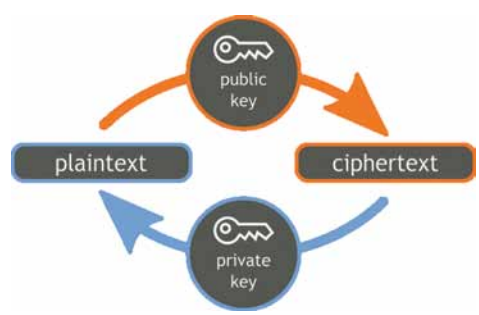
In the years that followed, cryptography began to evolve to cater to the needs of military organisations. Instead of using a single key to scramble the whole message, the new cryptographic algorithms or cryptosystems used different keys to scramble each letter in that message. If they wanted to send the same message ATTACK using a longer key 621098, then the locked message would be – GVUALS.

Such cryptographic systems, however, didn't stand the test of time. Modern computers with high processing speed could easily break such systems. And in the 1990s the Internet began taking the world by storm and has since made some aspects of our lives effortless, from instant communication to online transactions. But the Internet's Achilles' heel is its open network, making private information – browsing history, bank account details, passwords, credit card information and the like – vulnerable to leaks and manipulation.

This created a need for stronger cryptosystems, which meant cryptographers had to come up with longer keys that would make modern computers stumble. Computers understand the binary language: they store and process data in binaries, only zeros and ones. So they built keys that were 256-bit long – a bit is represented by a zero or a one. The breaking of 256 bit keys requires 2^{256} guesses at the most. It would take hundreds or even thousands of years for modern computers to crack this puzzle. But there's a problem when the sender and the receiver use a single key for secure communication. They have to meet in private to agree upon a shared key, making it impractical. Or they have to use the Internet to share the key, increasing the risk of leaks.

So cryptographers tinkered with this concept and developed a more sophisticated cryptosystem that would rule out the need to share keys. That would pave the way for online transactions and set a platform for e-commerce companies to flourish. This new system, called Public Key Cryptography (PKC), would soon become ubiquitous in the lives of common people. It would find takers from private organisations, hospitals, and banks, to WhatsApp.

The feature that sets PKC apart is that instead of using one key, PKC employs one set of keys: public and private. The public key which is used to lock a secret is known to everyone, while the private key is used to unlock a secret. Talking about WhatsApp's end-to-end encryption, Sanjit Chatterjee, Associate Professor at CSA, explains, "You will have a public key, so to say, known to everybody. There will be some kind of mapping based on your mobile phone number which will give you some identity, then there will be a public key, which will be useful to lock messages that are sent to you. The message that you receive can only be unlocked by you because your private key is only known to you."



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Public Key Cryptography

Another widely used application of PKC is to ensure secure browsing on websites such as those of banks or e-commerce companies. The public key functions as a website's identity card, which is verified by a certifying authority. This appears in the form of a lock on the address bar of your browser. The lock and the certificate assure users that they are on an authentic website and any information exchanged, including passwords, will remain private, adds Chatterjee.

Explaining how keys achieve this, he says that the public and private keys have a mathematical relationship. This relationship is centered on the difficulty of certain mathematical problems such as finding prime factors of large numbers. Prime factors of 10, for example, are 2 and 5. This is easy to figure out for a number this small, but as the number gets larger, finding the right factors presents a formidable challenge, even for a modern computer. The American company that commercialised this system, RSA Security LLC, launched the RSA Factoring Challenge in 1991. And people haven't been successful in factoring the larger numbers. The challenge is closed now, but it does show that some of the cryptosystems that we have today are close to inviolable.

Can a system remain secure even when an intruder or adversary uses brute force to try to enter? This is something Bhavana Kanukurthi, Assistant Professor at CSA, is focusing on. This domain of study is called Information-Theoretic Cryptography. The goal behind it is that the adversary should not have the necessary information to break into the system, despite having unlimited computing power.

Another feature of Information-Theoretic Cryptography is developing systems that can withstand quantum computers – computers with the ability to topple current cryptosystems. Modern computers have limited computing powers because they can either run a zero or one at a time. On the other hand, quantum computers which run on qubits, can be in a combination of both zero and one simultaneously, making them faster and powerful.

> *"The cryptosystems that we aim to develop should be able to fight an adversary with access to a quantum computer"*

While researchers predict that it could take more than 15 years for quantum computers to become practical, Chatterjee thinks it is important to be cautious. "After 15 years, if somebody develops a quantum computer and if we don't have a cryptosystem that is resistant to these computers, and then all our data will leak. You cannot switch over to a new system overnight." His research focuses on developing a quantum-safe cryptosystem that can run on modern computers. "The cryptosystems we aim to develop should be able to fight an adversary with access to a quantum computer."

To make quantum-safe cryptosystems a reality, cryptographers and cryptoanalysts have to work together. "We [the cryptographic community] have some candidates. The cryptographer will build the cryptosystem while the analysts will try to break it. We are discussing, debating and writing papers. And slowly some consensus will emerge. There will be a certain system which people will accept, which can be used. People will still improve upon it and make replacements. So this game continues."

Just like Chatterjee, Patra and her team are trying to build efficient cryptosystems. In her case, she aims to make SMC usable in a practical context. Denmark was the first country to use SMC, to help with their sugar beet auctioning. While some countries have already started embracing SMC, India hasn't yet.

From her collaborator at UC Berkeley, Patra learned that banks and hospitals in the US have technical teams that are constantly on a look out for the latest developments in cryptography. These teams stay in touch with cryptographers in universities, and once they are convinced of the capabilities of SMC, they take it up with their institutions. Patra suggests that India does the same. "A lot of talking has to happen, we need to understand their [banks' or hospitals' or government organisations'] problems and tell them how our technology will fit in. But the reach has not yet happened."

While the goal of SMC is to eliminate the need for a third party, it also becomes important to ensure consensus among the collaborators. Called distributed consensus systems, it also finds its use in the world of digital currency or cryptocurrency: users don't pay a fee every time they transact with each other, they can make global transactions in shorter periods, and the technology is bolstered by cryptography. When people use cryptocurrency, they perform transactions by doing away with third parties such as banks. Blockchains replace banks – they serve as online diaries holding records of transactions made by people – and are accessible to all their users.

"Everyone is part of the same network and all of them can maintain the data, making it democratic in nature," says Patra. But one of the major issues with blockchain that researchers, including Patra, are grappling with is consensus, which is to get the records of all the participants or collaborators in sync with each other every time someone makes a transaction. Sometimes, the records don't get updated, due to some error. In such cases, there are chances that a participant can cheat by spending a given set of coins twice. So Patra and her team are aiming to build a technology that guarantees that all the participants will reach a consensus over a transaction.

Most of what cryptographers at research Institutes come up with are proof of concepts. Bringing them into practice demands more expertise, which falls outside their domain. Elaborating further, Patra says, " A lot of people, including security experts, computer security experts and software security experts have to come together to make cryptosystems really secure."

A BRIEF HISTORY OF CEDT: A PERSONAL ACCOUNT

Arvind Shah

The Centre for Electronics Design and Technology (CEDT, now the Department of Electronic Systems Engineering), was established in 1975. The initiative for this Indo-Swiss collaboration was taken by Arvind Shah, who recounts the events in this 2014 memoir.

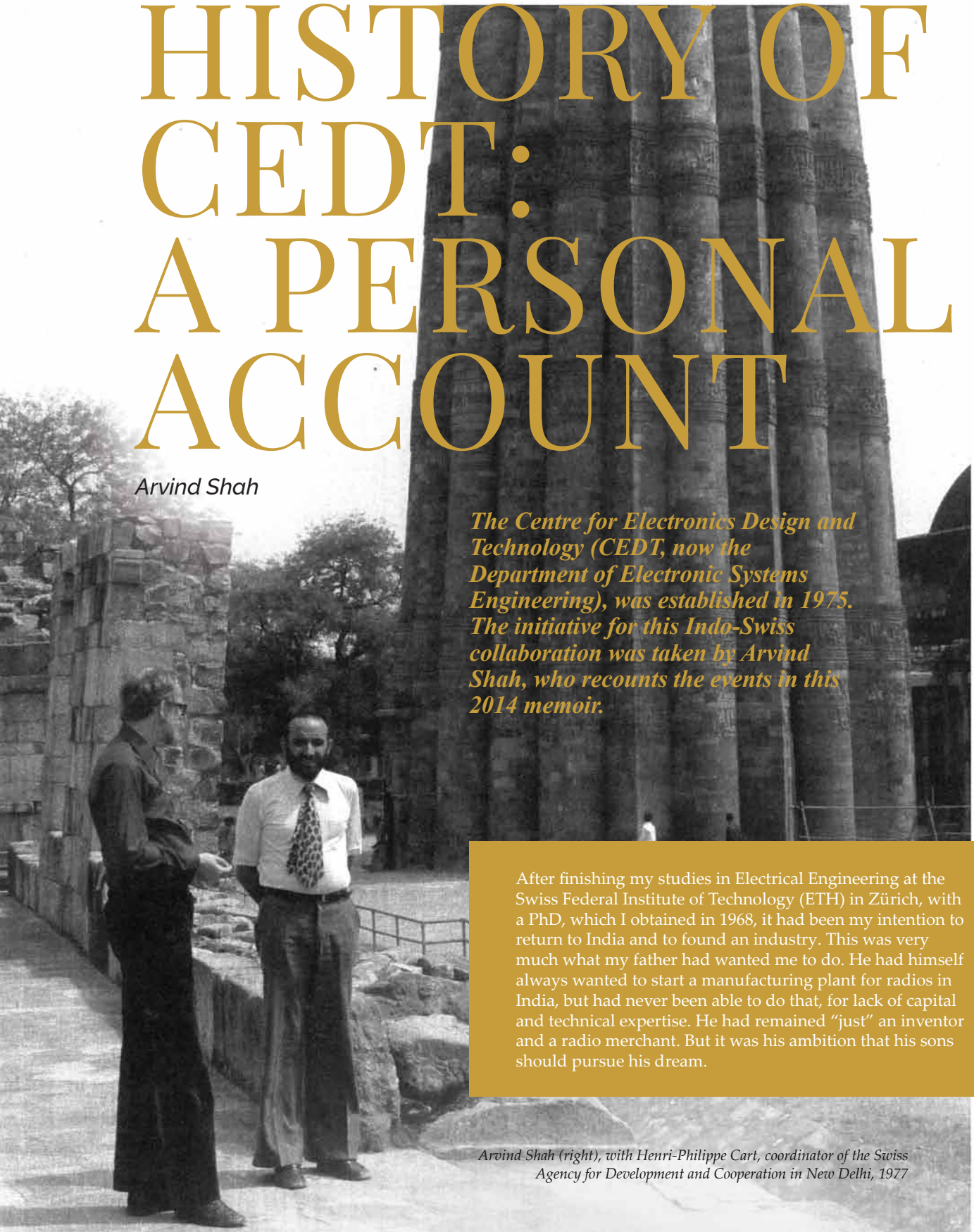

Photo courtesy: Arvind Shah/IISc Archives

After finishing my studies in Electrical Engineering at the Swiss Federal Institute of Technology (ETH) in Zürich, with a PhD, which I obtained in 1968, it had been my intention to return to India and to found an industry. This was very much what my father had wanted me to do. He had himself always wanted to start a manufacturing plant for radios in India, but had never been able to do that, for lack of capital and technical expertise. He had remained "just" an inventor and a radio merchant. But it was his ambition that his sons should pursue his dream.

Arvind Shah (right), with Henri-Philippe Cart, coordinator of the Swiss Agency for Development and Cooperation in New Delhi, 1977

My father passed away in 1960. Our whole family was then living in Switzerland, as my mother had Swiss origins. At the time, my elder brother was already married and had five children, so he was hardly thinking of leaving Switzerland. The task of carrying out my father's dream and implementing an industrial fabrication unit in India became, thus, my own mission.

In 1969, one year after my PhD, I travelled to India – to Bombay, Delhi and other places, mainly in the North, and met with many people who were already connected with industries in India. I had drawn up, together with another Indian graduate from ETH Zürich, a short description of the type of manufacturing firm which we wished to start. It was to be called the Yantra Co., and we intended to produce electronic measuring instruments, such as oscilloscopes, impedance metres, etc. During my trip it became very clear to me that the plan my friend and I had drawn up was still very far from being viable, that we would have to solve a number of problems before we could think of starting a factory, and that neither of us had any experience in manufacturing at all. During my trip I also repeatedly heard, from Indian industrialists, the complaint that the engineers which they were able to recruit in India were totally unsuited for work in an industry, as they completely lacked skills in electronic equipment design. The background of these engineers was (so I was told) purely academic and theoretical. This gave me the idea that I myself would be of greater use in contributing to improve the education of electronic engineers in India, rather than in founding my own firm.

1969 was a decisive year for me in many other ways too. At the time, I was employed as lecturer and postdoctoral researcher at the Institute for Technical Physics and Department for Industrial Research of ETH Zürich, and was entrusted with the task of setting up training facilities for undergraduate students in Electrical Engineering (EE). The programme I developed for practical training of electrical engineers met with large success; our lab was selected by a majority of the EE students at ETH Zürich for doing their Diploma (Masters) project.

During that period, I met my future wife Brigitte, who was deeply interested in India, and together we started to make plans for our future tasks there. Brigitte was not very convinced of the idea of me setting up a manufacturing unit in India, especially as I had not been able to find a fully reliable partner for this endeavour. (The other Indian graduate from ETH Zürich had shown great interest and even enthusiasm in the beginning, but he had in the meantime found other centres of interest; he was becoming more and more of a "sleeping partner".)

Based on these factors, I myself took the decision of abandoning my first ambition of founding an industry. Instead of pursuing the industrial road, I decided that I should continue, in India, to do what I best knew how to do, i.e. to train EE students to become useful and competent engineers.

In spring 1970, my wife and I spent a few weeks of holidays in a rather secluded place in northern Italy, a place called Valsesia, from where my maternal grandfather had originally come. It was in this region of hills and forests that I drew up, together with my wife, the idea of a Centre for the Practical Training of Engineers to be implemented somewhere in India. It was a handwritten document of about 20 pages.

We then sent this document to the Department for Technical Cooperation of the Swiss Foreign Ministry, i.e. the Swiss Government agency responsible for development projects (now called the SDC, the Swiss Agency for Development and Cooperation). It was a tremendous stroke of luck that this document fell into the hands of Henri-Philippe Cart, an economist responsible at the SDC agency for university projects and somebody with a very open mind.

Dr Cart wrote back to me that he very much liked the ideas that I had jotted down in my handwritten notes and he invited me to work together with SDC to turn these ideas into an actual full-fledged project for the Indo-Swiss development programme. Dr Cart also convinced me that "my" project would best fit into one of the existing IITs in India. It was to be my task to find an IIT which would take up "my" project and agree to implement it.

Satish Dhawan took the decision of implementing "my" project at IISc

In October 1970, I travelled with my wife to India. We met my relatives in Bombay, and I showed my wife many places in India. At the same time I strived to make contacts with several IITs and with the Indian Institute of Science (IISc) in Bangalore. IISc had been recommended to me by Thomas Kailath, an Indian professor whose acquaintance I had made in the summer of 1970 when visiting Stanford University. I had shown Prof Kailath my "handwritten document of about 20 pages" and he had told me that he knew one place where such a centre (as I dreamt of) would be welcome: That place would be IISc in Bangalore. He had given me an introduction to the Director of IISc, who, at the time, was Prof Satish Dhawan.

Bangalore was the last stop in our trip; I had already met with the persons responsible for Electrical Engineering at the IITs of Bombay and Kanpur, but had only obtained very lukewarm reactions.

Satish Dhawan accorded me, at very short notice, a few hours of his time for an in-depth discussion with him, and during that discussion took the decision of implementing "my" project at IISc. He entrusted Prof BS Ramakrishna, Head of the Electrical Communication Engineering (ECE) department with doing all the groundwork on the Indian side. That was truly the birth of the CEDT.

There followed five long years of negotiations, evaluations and budget-hunting, until in May 1975, I could finally travel to Bangalore with my wife and our two small daughters, Devika and Chandrika (aged 3 and 2), to implement the Centre for Electronics Design and Technology, as a part of the Indian Institute of Science. Whereas I myself had pushed the files with the Swiss government authorities and convinced committees and critics within Switzerland of the viability of the project, it was Prof BS Sonde who had done all the spadework on the Indian side and had made sure that IISc could administratively integrate the CEDT. Both of us had met with government officials in India and Switzerland.

The Electronics Commission of the Government of India played an essential role in financing the CEDT on the Indian side. Again I was lucky: Once, I happened to travel in the same plane as Prof MGK Menon, the Chairman of the Electronics Commission. I had the occasion to talk to him about the future CEDT. He gave useful suggestions and from then on took a special interest in this project. It even turned out that the nephew of my friend with whom I had originally wanted to found a manufacturing company in India was working with the Electronics Commission at the time. He too was very helpful. And Henri-Philippe Cart, the first supporter of the CEDT, became the coordinator of all Swiss development projects in India. He reported back to the Swiss government that they better hurry up with taking a positive decision of implementing the CEDT, because the Indian government was counting on Swiss support here. Without all these people taking a personal interest in implementing the CEDT, the project would have got stuck in the meanders of both the Swiss and the Indian administrations.

From May 1975 onwards, I spent four years in Bangalore bringing up the CEDT, together with Prof Sonde, to a certain level of success and recognition. It was again a stroke of luck that Prof Sonde was my partner in this, because the two of us made a good team: We had complementary outlooks and talents, and had often to argue for hours and hours until we came to a consensus – but it was precisely the fact that we represented different cultures and visions which turned the CEDT into a success story.

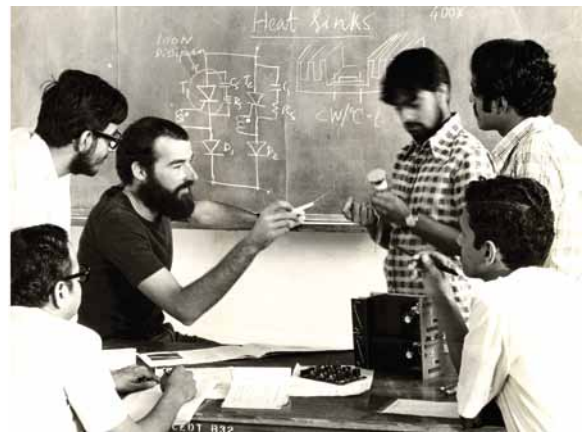

Photo courtesy: Arvind Shah/IISc Archives

Walter Bosshart, a Swiss engineer, with HS Jamadagni (third from right) and students at CEDT

But the first months at IISc were quite a shock for me. I had left India in 1954, at the age of 14, and returned since then only for short visits to my relatives in Mumbai. I had really no idea of daily life and of work routines in India.

When we arrived in Bangalore, it seemed to me that many insurmountable problems were facing me. The future CEDT had been allotted some space within the building of the ECE department. But this space, in May 1975, consisted only of a few empty rooms; the furniture for our future laboratories and offices was still in the process of being fabricated. There was no equipment at all; some of it was still to be bought in India, another part of it, which had been ordered outside India, based on funds from the Swiss government, was held up by customs in Chennai. There was no staff as yet, except for a secretary; two future faculty members, Dr Jamadagni and Dr Bhat, were still in Switzerland for their "training period"; the technical staff was yet to be engaged. Meanwhile, the first batch of students were scheduled to start their Diploma programme within a few months, but I just could not see how we could get ready within such a short time.

During the first months in Bangalore I remember having, almost every day, long discussions and even quarrels with Prof Sonde. I do not remember what these quarrels were about, but I do remember that they had something to do with our different backgrounds. And I suppose we were both extremely nervous about how the new Centre would fare. With time, the situation would completely change – with a lot of goodwill from each of us, we would learn to communicate effectively and form a good team.

But right in the beginning it seemed to me that everything was going wrong. I was just sitting there in my empty office within the CEDT and waiting for things to happen. And all that I got was news of some new problems and further unexpected delays.

After the first two months, I was totally disappointed and discouraged. I remember telling my wife, who had, in the meantime, found an interesting task to accomplish at the section for mentally retarded children of Sophia's High School in Bangalore: "Look, you have found something useful and interesting to do here in Bangalore, but for me, my stay here is just a pure waste of time – if it was up to only me, we could return to Switzerland tomorrow."

Luckily my wife did not at all want to return to Switzerland – and so we stayed on, for totally four years: four years that became one of the most productive and interesting periods in my whole professional career. Together with Prof Sonde and with the whole team of Indian and Swiss staff we were able to setup a Centre that was quite unique and met with tremendous success.

A lot of our time, in the early period, was spent in getting the laboratory ready. I remember traveling to Chennai together with Prof Sonde, in order to discuss with Customs officials there and get our equipment through Customs in record time. I remember how many evenings both Prof Sonde and I remained at the CEDT to handle all the administrative tasks. I remember going with him to the carpenters, in an attempt to hasten up the completion of our furniture. I remember sitting, together with Prof Sonde, in interviews and committee meetings, so as to engage the necessary staff within the short time remaining before the students were to come.

It was precisely the fact that we represented different cultures and visions which turned the CEDT into a success story

But when our first batch of 10 students arrived for their one-year Diploma programme in August 1975, we were indeed ready to receive them and to put them to work in our labs, which were just coming into shape. The 10 first students were all very dedicated and hardworking. We had set as a precondition that they should have a few years of professional experience and that their present employers should send them to the CEDT on deputation. This system worked well for engineers from government laboratories and large firms, but it did not work at all for engineers from small-scale industries. After all, which small-scale industry can afford to send away a capable young engineer, for a full year of further training, without replacing him? Therefore, in the beginning of CEDT, we had great difficulty in finding enough candidates to fill the twenty seats we had for our Diploma course.

Photo courtesy: Arvind Shah/IISc Archives

An electronic moisture meter developed as part of an early project at CEDT

The CEDT course was several years later modified to become a Masters programme and to accept young engineers directly from university, without professional experience and without industrial sponsorship. From then on, there was no difficulty anymore in finding enough students and the CEDT students definitely had more intellectual brilliance. But I have always felt that in the process of changing the CEDT course and the conditions for joining it, we also lost a lot. We did not anymore have a majority of very practical down-to-earth engineers studying at CEDT, a bunch of engineers whose main goal was to start their own industry. CEDT has, thus, become much more like any other department of IISc.

This is, indeed, an eternal dilemma for CEDT: Either be true to its own originality and then continuously run into administrative and other difficulties with the rest of IISc, or adapt to what the other departments are like, become more academic, and in the process lose track of its mission.

In the early years we had a very hard time with the rest of IISc, who did not understand us at all. But we were, on the other hand, well esteemed by industry, and did an almost heroic job of introducing new concepts in technical education. Most of the other professors at IISc just barely tolerated us, feeling that we were lowering the academic standards of IISc. In the meantime, CEDT has become well-integrated within IISc. But maybe is it now too integrated, too adapted to the more academic education given by IISc in general?

BS SONDE:

‘ELECTRO WAS BECOMING ALL-IMPORTANT, BUT WE HAD DONE VERY LITTLE’

Nithyanand Rao

BS Sonde, retired professor of electrical communication engineering, was the founding chair of the Centre for Electronics Design and Technology (CEDT), renamed the Department of Electronic Systems Engineering in 2012. In this interview, he recalls why the need for CEDT was felt, and how it was founded with Swiss collaboration.

Photos courtesy: BS Sonde

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What were the developments from the Indian side that led to the establishment of CEDT?

It all started with the Bhabha Committee report. The Government of India had appointed Dr Homi Bhabha and a group of very distinguished scientists and technologists to the Committee [in 1963], to recommend what should be done in the country in the next five years in order to make better use of electronics. Electronics was becoming all-important, especially for national security, but we had done very little. It was pointed out that if we don't take immediate measures we would be left in the lurch and others would score over us. Also, the electronics industry had to grow to bring in employment opportunities for our people, and we had to become self-sufficient. So for all these reasons the Committee gave its recommendations in 1966.

But Dr Bhabha died in an air crash in January that year. Dr S Bhagavantam, former Director of the Institute, who was Scientific Advisor to the Defence Minister at the time, completed the report on behalf of the Bhabha Committee. Soon thereafter the Government wanted to set in motion some things; the Department of Electronics was carved out to coordinate the efforts.

In 1970, the Government of India wanted to review what had happened to the Committee's recommendations. So the government organised a week-long National Conference on Electronics at the Tata Institute of Fundamental Research, Bombay in March 1970. The Institute was invited to participate, and Prof Satish Dhawan, the Institute's Director, put together a small delegation for the conference. Its members were Prof BS Ramakrishna, the head of the department of ECE [Electrical Communication Engineering]; myself; Prof G Suryan from Physics; Prof Joseph Vithayathil from Electrical Engineering; and then we had a visiting professor from the US, Prof Thomas Kailath. The conference had a session on education, in which industry people told us that the knowledge imparted to students in classrooms was not suitable for their requirements – they wanted the students to develop something new. They asked us to do something about it. We told them we cannot keep changing the syllabus too often and include industry-related requirements. We provide students with good knowledge, enough for them to move from one area to another easily, but the industry people felt that that is not enough – you have to make the students more practical.

When we came back, we started discussing this in the Institute in smaller groups. We found that there could be two routes – one route could be an entirely new programme on electronics design and other things. But if there is a change in the nature of the electronics industry, the students would find it difficult. The other route was to superpose a one-year design- and technology-oriented programme, meant for good people who are trained in the traditional way. This would give us a shorter turnaround time.

> *The industry people felt that we have to make the students more practical*

In that discussion, Prof Thomas Kailath was also present. He was a worldwide traveller. He said, "Look, I know Dr Arvind Shah [then at ETH Zurich]. He has also been talking of this, and planning similar things." Similar problems were also arising in Switzerland because technology keeps changing so rapidly. The Swiss watch industry was getting into difficulties. Because of the progress in electronics and miniaturisation, conventional mechanical watches were being left out. So they were looking at how to give new training to people so that they can rejuvenate the industry. So Prof Kailath gave us the contact to Dr Shah. Shah came to India sometime later, and we had a short discussion here for a couple of hours, to begin with. We got some inputs from him and that was useful. He brought his plan, and we also had one.

With the help from the Chairman of the Electrical Sciences Division at that time, Prof BN Narayana Iyengar, I brought together people from industry for a discussion meeting at the Institute on what is to be done, and many people agreed that we can work out a one-year or a one-and-a-half year program, which will superpose on the BE degree. But how to bell the cat? First, we needed money. We required new equipment, new facilities and the like, and the Institute did not have funds at the time. We were getting just a couple of crores in a five-year period for any development work. Compared to the Institute's prosperity today, in those days it was very difficult. Fortunately, Dr Shah contacted the Swiss Agency for

Development and Cooperation [SDC], who could support the programme. And finally, the Governments of India and Switzerland signed an agreement in August 1974 to establish CEDT at the Institute. Prof Dhawan assigned me the responsibility of steering the programme.

Did the plan from the Institute match up with the plan that Arvind Shah had?

There were a lot of similarities because the goal was similar.

Photos courtesy: BS Sonde

Members of CEDT with participants at the Indian Society for Technical Education sponsored winter school in Digital Design and Technology, 1978. Seated from L to R: SR Bhat (second), Arvind Shah (third), HS Jamadagni (fifth) and BS Sonde (sixth).

After CEDT was established, what was the nature of the exchange between the two sides?

First, laboratories and technology facilities had to be set up at the Institute. This costs money, and the SDC gave us a grant. The greatest advantage of this grant was that they said it was not necessary that we buy equipment and services only from Switzerland. But there was a need for a matching contribution, just like with any foreign collaboration. Fortunately, at that time, both the Electronics Commission and the UGC readily agreed to support this effort from the Indian government's side.

How important was Swiss expertise?

It was very important. They brought good practical knowledge of state-of-the-art electronics equipment covering many areas: instrumentation, communication and industry needs. Also, the new facilities planned and procured had to be set up quickly to launch the new postgraduate diploma programme. All the Swiss experts actively participated in this work along with us. Besides, we could also receive orientation at Swiss institutions and industries under this programme. This helped create a strong base towards self-sustenance in chosen areas of electronics design and technology for the future.

In later years, the one-year postgraduate (PG) diploma programme gave way to MTech and PhD programmes. How and why did the focus evolve from being industry-focused to being more academic?

It happened because of the Institute's environment and academic freedom. Also, as a national policy, the MTech programme duration was shortened to one-and-half years by early 1980s, from the earlier two years, which led to a growing clamour from the students – even those sponsored from industry – for MTech in preference to the PG diploma. At the same time, young faculty members at CEDT were keen to benefit from the research opportunities on campus and advance their careers. In the initial years, I was able to resist their temptation of taking up PhD research as we were building up CEDT, which required all their time and energy. However, in later years, it is creditable that many of our young faculty took up part-time PhD research at ECE, EE [Electrical Engineering] and other departments of the Institute, and did exceedingly well and became PhD supervisors themselves in later years. These measures also helped CEDT to receive the status of a department at the Institute many years later.

B Nag, Chairman, Electronics Commission, Government of India (second from left) visiting CEDT in 1980. CEDT members in the photo (L to R): KR Srinivasan, HS Jamadagni, S Boada (Swiss Expert, Group Leader), BS Sonde and Nanjunda Rao, Registrar, IISc.

Photo courtesy: Bitasta Das

Students of the course "Mapping India with the Folk Arts" with their instructor, Bitasta Das (kneeling, centre)

WHY I TEACH SCIENCE STUDENTS ABOUT FOLK ARTS

Bitasta Das

A faculty member reflects on an unusual course offered to undergraduate students

This year, I am teaching the sixth edition of the undergraduate humanities course "Mapping India with the Folk Arts". In this course, we delve into indigenous knowledge, or common people's knowledge, focusing on a different form of Indian folk art every year. By understanding the variations of this art across the country, we explore, infer and map cultural continuity and diversity. The assignments given to the students form an important component of the course, and it is through these assignments that a dialogue is established between science and art. Having conducted this experimental course for a significant amount of time, I thought it was a good time to look back and reflect on the intention, process and outcome of the course so far.

Humanities subjects were incorporated in the academic curriculum of IISc from 2011, when the four-year undergraduate Bachelor of Science (Research) programme began. The Centre for Contemporary Studies (CCS), under Raghavendra Gadagkar, assumed responsibility for designing and teaching the humanities curriculum. Students compulsorily undertook to learn humanities subjects in six out of the eight semesters of their BS programme.

While the conceptual thread across the courses remains the same, the humanities curriculum is designed to introduce the students to an array of disciplines and methodologies within the social sciences and humanities. Unlike in other science and technological institutes, the curriculum does not attach the humanities courses as disconnected subjects, rather, they are composed to provide a socio-cultural background to learning and understanding science. Taking this philosophy forward, "Mapping India with the Folk Arts" treats the art of the common people as windows to their way of life. Drawing from the discipline of Folkloristics, the aim of the course is to understand the country, not from the outside in, but from the inside out.

An example of worli art used by the students to represent entropy

As for my own education, Folklore formed a large portion of my studies for a Master's degree in Cultural Studies at Tezpur University (Assam), and I qualified for the University Grants Commission's National Eligibility Test (UGC-NET) in Folkloristics. My first job in Bangalore at the Art Resources and Teaching Trust (while I was pursuing my doctoral degree on ethnic identity and conflict), was to manage and commission an art exhibition involving 65 folk artists from across the country. Travelling to various pockets of the country for two years, meeting and interacting with indigenous artists, gave me practical exposure to the dynamic world of Indian folk art.

When Prof Gadagkar asked me to design and teach a course, I decided to offer a hands-on course rather than a theoretical one. I turned to my experiences with the folk arts, but was initially apprehensive about teaching a course of this nature here. I was not sure if at IISc, where cutting-edge scientific research takes place, a course on common people's knowledge would be welcomed. I was anxious that the folk arts would be taken too lightly, as a mere source of amusement.

My intention was to invoke and engage with the arts to sensitise the students to the values of diverse people. I lay out the course to the students as follows – A "folk" is any group that expresses inner cohesion by sharing common traditions, whether the connecting factor is language, place, ethnicity or occupation. In this sense, a group of scientists is also a folk group! India, with its multicultural populace, is home to a wide range of rich folk art traditions. To understand the nation, we must understand its people. The category "folk" provides an agreeable premise for appreciating various kinds of people that the category "citizen" is unable to include, like diaspora, refugees, nomads, people who are displaced, and so on.

Since we take up a different folk art form every year, it is imperative that I keep finding new study material. The methodological approach and teaching also varies every year, though the assignments always focus on the interaction between science and art. If enquiry in the field of art and science is rare, works on folk art and science are even rarer. The folk art of this country has a large vocabulary, yet the processes of science have never been its subject. I decided that the students, who have enough scientific understanding, could deploy folk art to create pioneering art works. I create the theme, which they have to deliberate on and represent.

Every year, we discuss beforehand how folk arts entail skills that are passed on within families and communities for generations and generations, and folk arts are as much about the artists as they are about the product itself. To claim that first-timers trying their hand at it can excel in the art would be grossly wrong. But it is the beauty of folk art that it is not standardised or codified. We can work in that flexible space, and explore what we generate. And it often comes as a surprise to the students when we are discussing a folk art from their region, and they realise they have been completely oblivious to it. Sometimes students see it as a "homecoming" to create art works from their region that they only know of, but have never tried to understand its intricacies. In class, we also discuss questions like these: Can common people make sense of the workings of science? Can art represent science effectively?

Photos courtesy: Bitasta Das

Students during a folk dance performance

In their assignments, students have to use folk arts to present complex scientific concepts. Paintings, music, plays, and dances about science, using folk vocabulary, have been created so far. Workshops on Dollu Kunitha, kite-making and Chittara art have been conducted. Public performances like "Folk Theatre Festival", "Sway with Science" and "Jal Jungle Zameen and Science" were put together by the students. A pictorial book, *Arting Science*, published by IISc Press, compiles the paintings that were made. Another book, *Jal Jungle Zameen… in the age of Science and Technology*, is in the works. The Institute has earmarked a distinct section on its official website to showcase the students' art works, under the category "Arting Science".

> *It is the beauty of folk art that it is not standardised or codified. We can work in that flexible space, and explore what we generate*

The assignments are planned consciously so that the creations are not just objects of communicating science, but both science and the folk arts demonstrate their tenability. The students are told that their works are not primarily for securing marks but are opportunities to co-create novel art. The course has demonstrated creative ways of expressing science, at the same time, a new realm of content has been opened for the declining folk arts of the country – that of science and technology. The media has lauded this pioneer course at IISc and has frequently reported on our activities. This year the focus is on Indian folk tales, and we examine how the country can be understood by these stories. This year is significant for another reason too – CCS has been reconstituted to form the Centre for Society and Policy (CSP), headed by Anjula Gurtoo. Humanities courses from now on will be conducted by CSP.

There are numerous examples where indigenous values and knowledge have enabled communities to live harmoniously with nature and with one another since ages. It is my argument that in the present times, when sustainable modes of living are sought, the philosophical foundations that inform community life calls for a deeper understanding. Every batch of students has contributed to unfolding this understanding. Our efforts in treading untraveled paths have been filled with wonder and have been deeply enriching.

And for me, personally, it is satisfying to be able to work with the arts of India. It is saddening that so many of them are fading – they are soulful and bear the essence of the country. Discussing, engaging, and creating with them in a space like IISc gives them a new lease of life.

REMEMBER
SR VALLURI

Srinivas Bhogle

Photo courtesy: Roddam Narasimha

Photo courtesy: IISc Archives

A tribute to the life and achievements of the IISc alumnus who left his mark on Indian aerospace engineering

SR Valluri (right) with Satish Dhawan (centre) and Raj Mahindra at the First Asian Congress of Fluid Mechanics, held in Bangalore in 1980

The name of Dr Sitaram Rao Valluri, who passed away on 23 January 2019, aged 94, will forever be linked with the National Aeronautical Laboratory (NAL; now National Aerospace Laboratories).

Valluri had many stellar accomplishments in his distinguished career, but his 19 long years (1965-1984) as NAL's Director were so intense, passionate, and momentous that everything before and after those two decades pales somewhat in comparison.

Valluri was born in Eluru in Andhra Pradesh (AP) on 25 June 1924, as the first child in a family of 10 children. From his father, a doctor, Valluri inherited a liberal attitude, the virtue of being truthful, and a short temper, which, he candidly admitted, was always a trifle embarrassing.

Student days at BHU and IISc

The young Valluri, who apparently ran behind a light aeroplane while in school, was sure he wanted to become an aeronautical engineer. This wasn't going to be easy for someone staying in the middle of nowhere in AP, but help came from an unlikely benefactor: India's future President Sarvepalli Radhakrishnan. Then Vice-Chancellor of Banaras Hindu University (BHU), Radhakrishnan offered Valluri admission in BHU's Engineering College in 1942 after reassuring himself that the young man had the requisite ability.

ING

IISc's Department of Aerospace Engineering on 15 August 1947. Valluri, listed here as "V. Sitarama Rao", is in the middle row, third from left

After obtaining his BSc (Engineering) from BHU, Valluri spent a few valuable years (1946-1949) at the Department of Aeronautical Engineering in the Indian Institute of Science (IISc), where he had the opportunity to interact with stalwarts like VM Ghatage and OG Tietjens. Then came the big moment: obtaining the Pauley Scholarship and joining the Guggenheim Aeronautical Laboratories at California Institute of Technology (Caltech) in September 1949.

Valluri at Caltech and Douglas

Caltech, and more generally USA, impressed and overwhelmed Valluri. There were opportunities to meet the aeronautics master and high priest Theodore von Karman; be a student of the brilliant Hans Liepmann; establish a lifelong friendship with Anatol Roshko; bond with that "extraordinary human being" Satish Dhawan (those days in Caltech); and suddenly realise that the person sitting next to you at the lunch table is Richard Feynman.

Valluri's PhD adviser at Caltech was the brilliant Chinese scientist YC Fung, but it was Ernest E Sechler's work, on design practices for aircraft structures, that excited Valluri the most. Sechler went on to become a mentor of sorts: he also probably opened doors that allowed Valluri to work as a design consultant for Douglas Aircraft Company during the late 1950s and early 1960s.

It was during this phase that Valluri established a considerable reputation as an expert in aircraft fatigue and fracture. His research interests were also getting more diverse: he enjoyed designing complex experiments with high-speed cameras, making intricate measurements, pondering over the parameters that influence fatigue crack propagation, worrying about factors that could lead to catastrophic fatigue failure etc. It wasn't, therefore, a surprise when Valluri won the coveted Wright Brothers Medal in 1963. Valluri would later describe this as the "most satisfactory research period" in his life.

Valluri accepted an IIT Madras offer to be a Senior Professor. Within months of joining, Valluri started getting disillusioned, and even considered the idea of returning to the US. But a series of events intervened to completely change the course of Valluri's life: NAL's Director P Nilakantan passed away suddenly on 18 April 1964. Eventually, Valluri, not yet 41, was picked to become NAL's second Director.

> *Valluri, not yet 41, was picked to become NAL's second Director*

It was an inspired choice. Valluri suddenly found himself with an enormous empty canvas that he could paint any way he liked. It helped that his boss, CSIR's Director-General S Husain Zaheer, was personally fond of Valluri (Zaheer's relation with Nilakantan had been frosty). It helped even more that the Chairman of NAL's Executive Council was the legendary JRD Tata (JRD) himself.

Director of National Aeronautical Laboratory

Valluri officially took charge on 23 November 1965, ignoring his father's plea not to join on the inauspicious amāvāsyā day. His first task as NAL Director was to make sure that Nilakantan's big unfinished task, to build the 4 ft trisonic wind tunnel, never lost momentum or steam. It was a very special moment for Indian aerospace when the roar of the tunnel's first blowdown reverberated across the (then clean and serene) Bellandur Lake on 29 May 1967.

Arguably, Valluri's biggest game-changer in his early years as Director was to introduce project accounting at NAL. The classical CSIR budgeting schema only had account 'heads' for salaries, capital expenses, consumables, maintenance, travel etc., but didn't report expenses project-wise. "I had no clue how much money we spent on each project, or which was the division on which we spent the most money. This simply wasn't on," Valluri would later explain. It would take CSIR thirty more years to implement the project monitoring process that Valluri first introduced at NAL in 1966!

Photo courtesy: NAL

Valluri

As NAL's Director, Valluri had an electric presence. He walked briskly, talked rapidly and bristled with energy. He took decisions, and made things happen. Often big decisions required the concurrence of CSIR HQ, so the impatient Valluri would fly to Delhi to argue his case and quickly close the matter. There were occasions when Valluri's decisions evoked dismay or discord, but he rarely flinched: "I'm here to run a national lab, not win a popularity contest," he would declare matter-of-factly.

Valluri also realised that, to succeed as Director, he needed to be strongly connected with NAL's natural partners: IAF, HAL, IISc and DRDO. In particular, Valluri always hit off very well with the IAF top brass, with the Air Chief often becoming a personal friend. An outstanding outcome of NAL and IAF working together was the full-scale fatigue testing facility that NAL created in the early 1970s. This facility allowed the IAF to significantly extend the service life of its operational aircraft such as the Gnat, Ajeet and, later, the MiG-21s.

As Valluri grew in stature and success, awards and distinctions started coming his way. He was elected Fellow of the Indian Academy of Sciences in circumstances that can be best described as unusual. While speaking at the Academy about crack propagation in 1970, C V Raman suddenly asked Valluri to define a crack. Raman was so impressed with his reply that he remarked that Valluri deserved to be a Fellow. The Fellowship came in 1971, just after Raman passed away. Valluri would receive the Padma Shri in 1974 and the Vasvik Award in 1978.

'I'm here to run a national lab, not win a popularity contest,' he would declare matter-of-factly'

"He built NAL"

Making NAL the best lab in CSIR wasn't just Valluri's endeavour; it was his crusade. He created NAL's grand foundation; but, just as important, he also created a formidable supporting infrastructure. Visiting NAL's library used to be a thing of joy, NAL's photo and printing facility was led by arguably Bangalore's best photographer of the time, and NAL's health centre offered excellent medical care. It was in the fairness of things that NAL's doctors intervened successfully to diagnose Valluri's meningitis as he collapsed into a deathly coma in February 1989.

How would one rate Valluri's performance as NAL Director? Without a doubt, it was exceptional, but, rather curiously, the Valluri years overlapped with a period when Indian aeronautics itself went into a bit of a coma. After the heady adventures of the 1950s and the 1960s, there was a lull in the 1970s following the HF-24 crash on 10 January 1970. NAL, however, continued to prosper: Valluri initiated the first moves to develop composite technologies, built remarkable capability for failure analysis and accident investigations, created even more testing and modelling infrastructure, and lobbied for funds so that NAL could build its first small plane. This prompted Satish Dhawan to remark that NAL looked like "a beautiful bride, all decked up, but with nowhere to go!"

So where could this beautiful bride go? The 1980s held great promise, and Valluri was eager and excited. Having been Director, NAL for over a decade, and being actively involved in every national initiative in aeronautics, Valluri held the vantage position. His big dream was to help create an Aeronautics Commission, serviced by a Department of Aeronautics, along the lines of the Space and Atomic Energy Commissions. The Aeronautics Commission would integrate aircraft research, design, development, manufacture and operations under a single umbrella.

It always seemed like a bridge too far. In an informal conversation at an awards event, Professor Roddam Narasimha, who would succeed Valluri as NAL's third Director, asked Prime Minister Indira Gandhi why her government didn't support programmes in aeronautics the way it supported programmes in space and atomic energy. The PM replied that she would "if everyone stopped quarrelling".

SR Valluri with VM Ghatage (centre), a pioneering aeronautical engineer who had been the general manager at HAL, at the First Asian Congress of Fluid Mechanics in 1980

While the Aeronautics Commission never happened – and Valluri would regret this all his life – the next best thing did happen. Narasimha, who had taken time off from IISc to spend a few years at HAL in the late 1970s, argued that it was both feasible and desirable to build an Indian light combat aircraft (LCA) in large numbers. Narasimha's arguments achieved a rare resonance: IAF changed its perception, and Raja Ramanna, then the Scientific Adviser to the Defence Minister (SA to RM), was sufficiently enthused to ask Narasimha to lead a team of experts from IAF, HAL and DRDO to visit Germany, France, Sweden and England to obtain more insights and data. The team returned with a unanimous verdict endorsing the LCA concept. For the first time all the principal actors in Indian aeronautics appeared to be on the same page.

In response, the Government invited Valluri to head a high-level committee, which included all the big aeronautical players such as IAF, HAL and DRDO, and of course Narasimha, to make the final recommendation on the light combat aircraft (LCA) concept. A new entity, Aeronautical Development Agency (ADA), was created to fund, manage and monitor the LCA programme, and Valluri would be its Director-General (DG-ADA).

Director-General of Aeronautical Development Agency

Valluri assumed office as DG-ADA on 2 July 1984, after receiving a fond and emotional farewell from NAL; I remember being chosen to hand him a bouquet at the farewell event because I was then NAL's youngest scientist. Valluri didn't merely transform the contours of NAL during his 19 years, he also completely changed the context of my life by offering me a position at NAL. I shall always be immensely grateful to him for that.

ADA, which was to build India's first supersonic fighter, didn't even have four walls when it started its existence. Valluri operated out of an NAL office – that we used to fondly call the 'blue room' because of its somewhat hideous blue carpet. I have memories of some truly enjoyable conversations with Valluri in the blue room: he could be at his eloquent best when he talked of self-reliance in aeronautics or of Caltech's 'honor code'. I also became familiar with Valluri's favourite expressions: It was immediately apparent that 'apparently' was a word that he truly relished, then there was 'high-science-high-technology', and, above all, the most intriguing 'Hobson's choice with a Faustian bargain'. Valluri was such a charming and adorable old man!

Photo courtesy: Roddam Narasimha

It was hard to kick-start ADA – it is very hard to kick-start any new establishment with public funding – but Valluri invested all the energy and passion that he could, and NAL, now under Narasimha's tutelage, responded with commendable alacrity: The Advanced Composites Unit was off to a promising start (today's LCA, now called Tejas, has almost 45 percent composite structures), the wind tunnels started preparing in right earnest for the impending avalanche of tests, and 'fly-by-wire' soon became a buzzword in NAL's corridors.

But all was not well with ADA's (and Valluri's) interactions with DRDO and its leadership. It would be pointless to talk, at this juncture, about events in 1985 that led to Valluri and Raj Mahindra's exit from ADA. Valluri felt hurt and aggrieved – and even privately speculated how the story would have panned out if he had accepted the Government's offer to become SA to RM in 1981.

Retirement

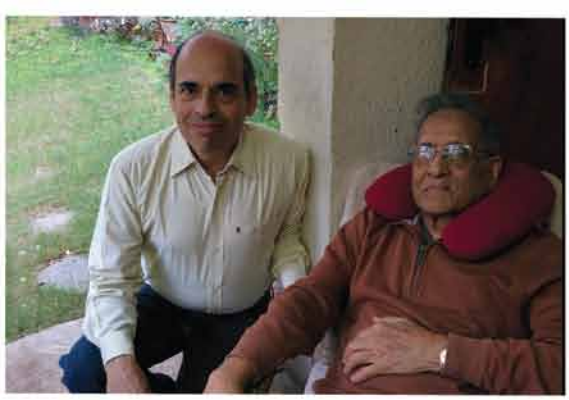


Photo courtesy: Srinivas Bhogle

The author with SR Valluri at his home in Indiranagar

Valluri's early retirement years were not the most comfortable; he must have felt like a batsman hoping to hit a century but being suddenly given out lbw for 62. To make things harder, his pension was meagre, and would stay meagre till his US Social Security benefits kicked in early 1988.

Valluri's early retirement years were not the most comfortable; he must have felt like a batsman hoping to hit a century but being suddenly given out lbw for 62

But Valluri plunged headlong into other interesting ventures: realising that Bangalore's HAL airport would soon start choking, Valluri prepared a comprehensive plan about how and where Bangalore's new airport should be (one of Valluri's recommendations was indeed an airport beyond Yelahanka at Devanahalli; another was to 'take over' the runway at Yelahanka Air Force Base and move the IAF base elsewhere).

Valluri also proposed a scheme to revise Bangalore's house numbering. Alas this scheme never took off and Valluri lived all his life horrified how his house number 659 on Indiranagar's 100 ft Road was barely hundred feet away from house number 284.

For some years into retirement, Valluri also readily accepted invitations to speak at public functions. His talks were always scintillating: he had great stories to tell, a commendable turn of phrase, a twinkle in the eyes, and unabashed honesty. Most of all, he had a phenomenal memory, both for names and numbers. At one of his lectures I was surprised to see him read from a prepared text. I confronted him: "Please don't ever do that again. It cramps your style!". Valluri admitted that he was "beginning to forget a few things", but promised to resume his extempore style.

All his life Valluri championed ethical professional practices and personal honesty. His criterion to judge the integrity of every action was to ask: "Would Satish (Dhawan) approve?". Valluri would be outraged every time he saw a lapse, digression or failure, and spoke out (and wrote) loudly against the misdemeanour. He could get really angry and it was hard to face his wrath. But he was always open to dialogue and debate and did not hesitate to apologise publicly if he discovered that he had erred.

I last met Valluri when UN Sinha and I went to greet him on his 93rd birthday. He seemed only slightly frail, and easily recognised both of us. He spoke for a few minutes with customary warmth, provided us a brief glimpse of the famed Valluri charm, but then lapsed into silence. We knew it was time to go, and, deep down, I sensed that this would be our last meeting.

Valluri was a towering Indian. We will miss him.

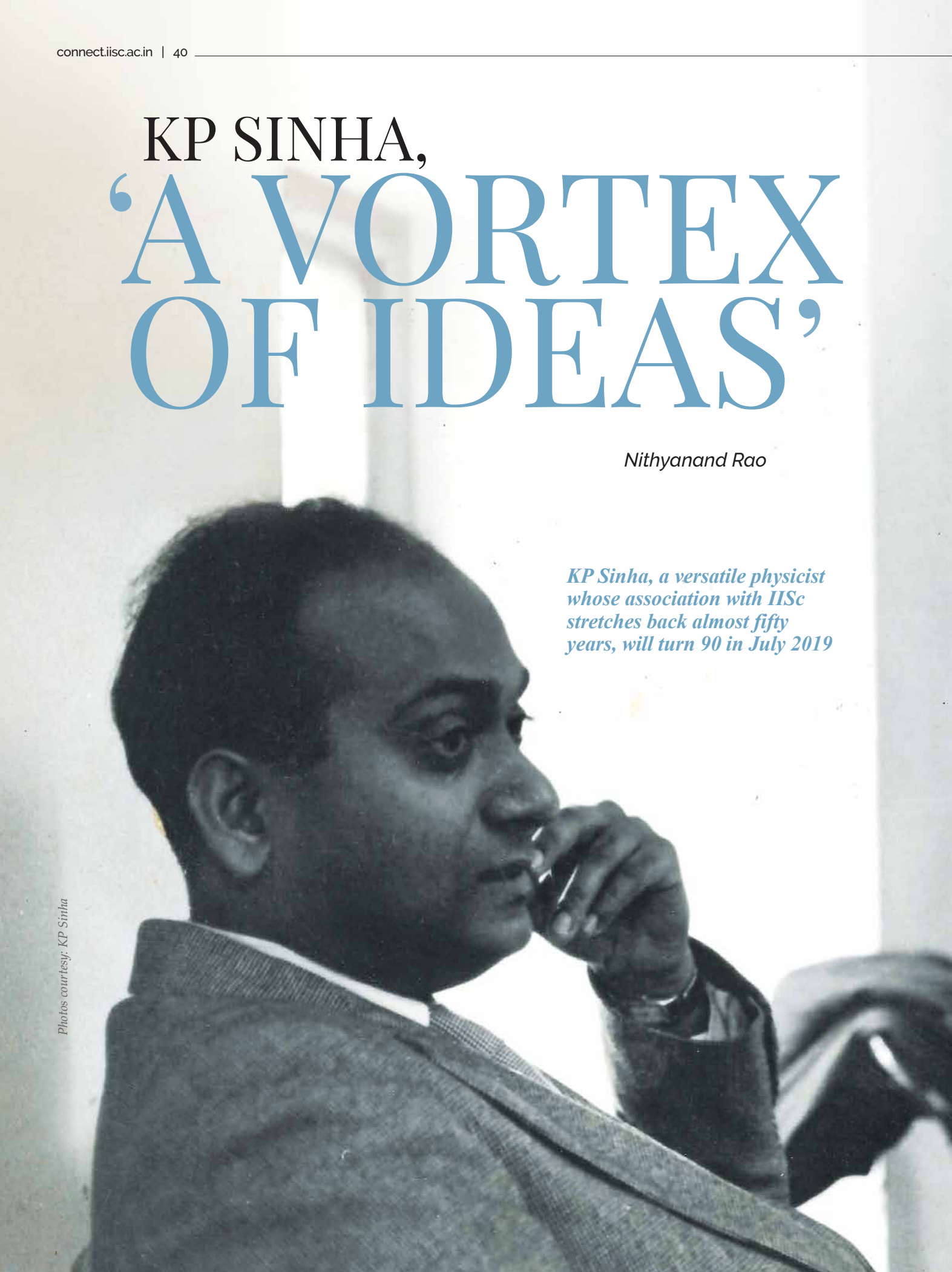
Srinivas Bhogle headed NAL's Information Management Division for many years, and reported on practically everything that happened in and around NAL during the period 1986 to 2006.

This is an edited version of a longer piece originally published on Srinivas Bhogle's personal blog: https://bademian.wordpress.com/2019/02/21/remembering-s-r-valluri/

KP SINHA, 'A VORTEX OF IDEAS'

Nithyanand Rao

KP Sinha, a versatile physicist whose association with IISc stretches back almost fifty years, will turn 90 in July 2019



Photos courtesy: KP Sinha

KP Sinha is an unusual man. Getting one PhD is hard work, but he chose to do two. And rare though it is for theoretical physicists to work in more than one field, Sinha mastered several, taking to cosmology with as much ease as his forte of condensed matter physics.

“This was a unique fearlessness of Prof Sinha,” says G Baskaran, one of Sinha’s earliest students at IISc, and now an emeritus professor at the Institute of Mathematical Sciences, Chennai. “It was good for young people like me. We grew in that atmosphere, not scared by subdivisions.”

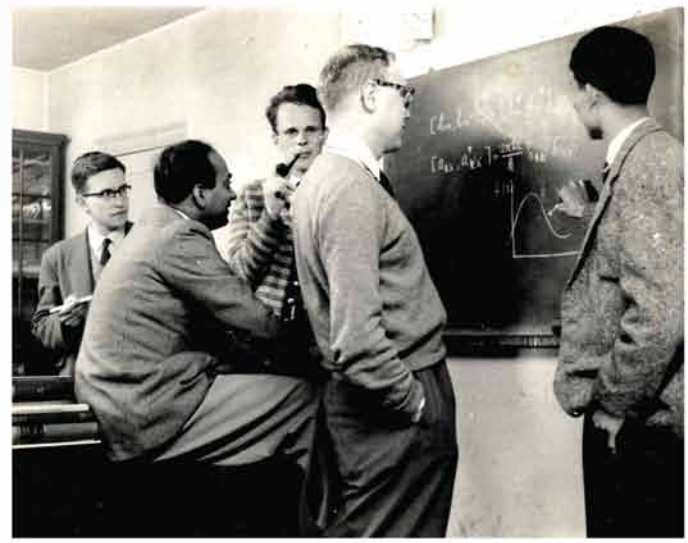
Sinha arrived at IISc in 1970 on the invitation of the then Director Satish Dhawan, as a full professor in the departments of Applied Mathematics and Physics. Dhawan had met Sinha in New York, where Sinha was a researcher at the legendary Bell Labs, Murray Hill.

But Sinha’s first tryst with IISc goes back further, to 1951, when a chance meeting changed the course of his career. After his MSc at the University of Allahabad in 1950, he taught at a college in his native town of Arrah, Bihar. On a trip to Bangalore to attend the Indian Science Congress in 1951, held at IISc, he happened to meet JW McBain, the first Director of the National Chemical Laboratory (NCL), Pune. “He invited me to come to Pune,” recalls Sinha. “So on the return trip, I went to Pune, and they offered me a job. I came back to Arrah, resigned from my teaching job, and went to Pune.”

Sinha arrived at IISc in 1970 on Satish Dhawan's invitation

Soon, McBain arranged for Sinha to go to Stanford University (where McBain had been a professor of chemistry before coming to NCL). But a change at the helm of NCL forced a change of plan. McBain retired, and GI Finch, an Australian chemist from Imperial College, London, arrived as director of NCL. Finch was a man of varied interests, having studied physiology in Paris, and chemistry and physics in Zurich. (He was also a mountaineer who pioneered the use of bottled oxygen at altitude.) Sinha stayed at NCL and worked with Finch, an expert in electron diffraction, studying magnetic properties of iron oxides. This work earned him a PhD in experimental physics from Poona University (now Savitribai Phule Pune University), in 1956.

Sinha then moved to the University of Bristol to work with the British physicist MHL Pryce, whom he remembers as "a very difficult man". Pryce was studying the magnetic properties of atoms, and the effect such properties had on the lattice of crystals. In some materials, such as perovskites, the electronic state of the transition metal ions distorts the material’s lattice. This is because the electrons try to rearrange themselves to reach the lowest energy state. When all electrons associated with the transition metal ions try to do this, there is a distortion of the lattice as a whole, a phenomenon known as the cooperative Jahn-Teller effect. Sinha worked with some of the leading lights in this area, such as Pryce and the Japanese physicist Yukito Tanabe.



Sinha at Bristol during his second PhD

His work during this stint at Bristol earned him a second PhD, this time in theoretical physics (awarded in 1965). He returned to NCL in 1959, as group leader of the Solid State and Molecular Physics unit.

It was during Sinha’s time at NCL that he met the young Narendra Kumar, who went on to become a distinguished physicist and Director of the Raman Research Institute. (He passed away in 2017.) Kumar was a Senior Scientific Officer at the Institute of Armament Technology in Pune when he wrote a paper in *Nature*. That got him noticed in NCL, where he was invited to work as a replacement for the nuclear magnetic resonance (NMR) spectrometer operator who was going abroad on study leave. “As it happened, the NMR operator was not granted a visa after Kumar moved to NCL as a Scientist B,” noted an

obituary of Kumar in *Current Science*, "and Sinha nobly allowed the young engineer to work full-time on his passion – theoretical physics." Kumar worked with Sinha, obtaining his PhD from IIT Bombay.

Their work in this period, which Sinha continued later with others, made headlines in 1994. "A theoretical physicist from India has been pushed into the centre-stage of world science," announced a news report in *Times of India* on 4 June 1994, "after scientists around the world confirmed a prediction of great importance he had made 25 years ago."
What they had theorised was a new kind of superconductivity. In most materials, electrons repel each other and collide with the lattice ions, experiencing resistance, and dissipating energy, as they travel. In a superconducting material, however (at the right temperature – usually much below room temperature – and pressure), the electrons "pair" together, and "flow" without resistance. This interaction between the paired electrons is mediated by phonons, which are the quantised form of the lattice vibrations. Sinha and Kumar took another boson, the photon, and asked if it too could mediate such a pairing between electrons.

"They were partly inspired by an experiment where you shine microwave radiation on a superconductor," says Baskaran, "causing the superconducting property to become stronger." This is because the microwave radiation causes the transition temperature, at which the material becomes superconducting, to increase. Sinha and Kumar wondered if photons could do the trick on their own in certain materials that are otherwise semiconductors, at a relatively high temperature. In their theory, the superconducting property would vary according to the intensity and wavelength of light, making the superconductor tunable.

This transient phenomenon, known as photo-induced superconductivity, was observed in 1994 in semiconducting films made of oxides of yttrium, barium and copper. But this discovery hasn't turned out to be quite as revolutionary as the news report anticipated. "It's an interesting observation, but whether the Sinha-Kumar mechanism is at work or not is a separate issue," says Baskaran. "But they were far ahead of their time."

Their work was published in a 1968 paper. The same year, Sinha left NCL for Bell Labs, a career move that, once again, was due to a chance event. He was attending a conference in the US, where, he admits, he "had the habit of asking too many questions." Among the attendees was a senior researcher from Bell Labs. "He was impressed, and he met me and said 'Why don't you visit us at Bell Labs?'" Sinha took up the offer and was soon offered a position there.

Photo courtesy: KP Sinha

Sinha with MGK Menon, the well-known physicist and policy maker

When he came back to NCL, he approached the Council of Scientific and Industrial Research, CSIR (of which NCL is a part), requesting leave to join Bell Labs. "CSIR saw how much money I'd be getting at Bell Labs – they converted it into rupees – and they felt it was too much. They said, 'We'll give you leave, provided you give us a part of your salary at Bell Labs,'" says Sinha, laughing. "I declined and resigned my post and went to Bell Labs with my family."

And it was while Sinha was at Bell Labs that Dhawan invited him to IISc. Kumar too arrived at the Institute in 1972. Around the same time, Baskaran, who had joined as a student in the Applied Mathematics department, shifted to the Physics department to work with Sinha and Kumar.

> *"Both KP and Kumar changed the scene in the department"*

"Both KP and Kumar changed the scene in the department," Baskaran wrote in a souvenir marking IISc's centenary in 2009, "by making student-teacher relations very informal and cordial." He credits Sinha and Kumar for starting work on theoretical condensed matter physics at IISc. "There were lots of beautiful experiments going on already at the department, but theory work was started by them," he says. "In some sense it prepared ground to take the Physics department to newer heights when Prof TV Ramakrishnan [also a professor in the department] arrived later."

At IISc, Sinha continued to work on the magnetic properties of solids, in particular, the interactions among excitations in magnetic systems. Just as ordinary solids carry sound waves, magnetic materials carry magnetic waves. In the quantum mechanical picture, the energy that such waves carry is in discrete form, called quanta – known as phonons

for sound waves, and magnons for magnetic waves. Sinha, with several of his students, extensively studied how magnons interact with phonons and electrons. In fact, he studied all possible such interactions in magnetic solids – among magnons, phonons, photons, neutrons, and electrons – and associated phenomena such as heat transfer, and worked out mechanisms for how magnetic waves damp out in materials like yttrium iron garnets, or in a class of materials known as Mott insulators.

"The kind of studies that he started are very popular now, in the context of what is called spintronics," says Baskaran. "Also, with many new experiments including neutron diffraction and neutron scattering, we can directly see the coupling between magnons and phonons [that Sinha studied]."

Sinha became the first Chair of the Division of Physical and Mathematical Sciences

This was an exciting time at IISc for other reasons too. Dhawan's efforts to expand research activities saw him invite ECG Sudarshan, renowned theoretical physicist at the University of Texas, Austin, to spend a few weeks each year at IISc. Sudarshan, Sinha, and others became founding members of the Centre for Theoretical Studies (CTS) in 1972, which sought to bring together researchers from different backgrounds to work on theoretical problems in subjects ranging from ecology to cosmology. The same year, the departments in the Institute were reorganised into four Divisions, and Sinha became the first Chair of the Division of Physical and Mathematical Sciences.

CTS had a unique programme of inviting researchers for extended visits. "We got outstanding visitors in all fields," says Baskaran, who relished the freedom Sinha gave him. The two only wrote one paper together. "He encouraged me to meet people, informed me about visitors," says Baskaran. "I'd interact with them, and even wrote papers with them."

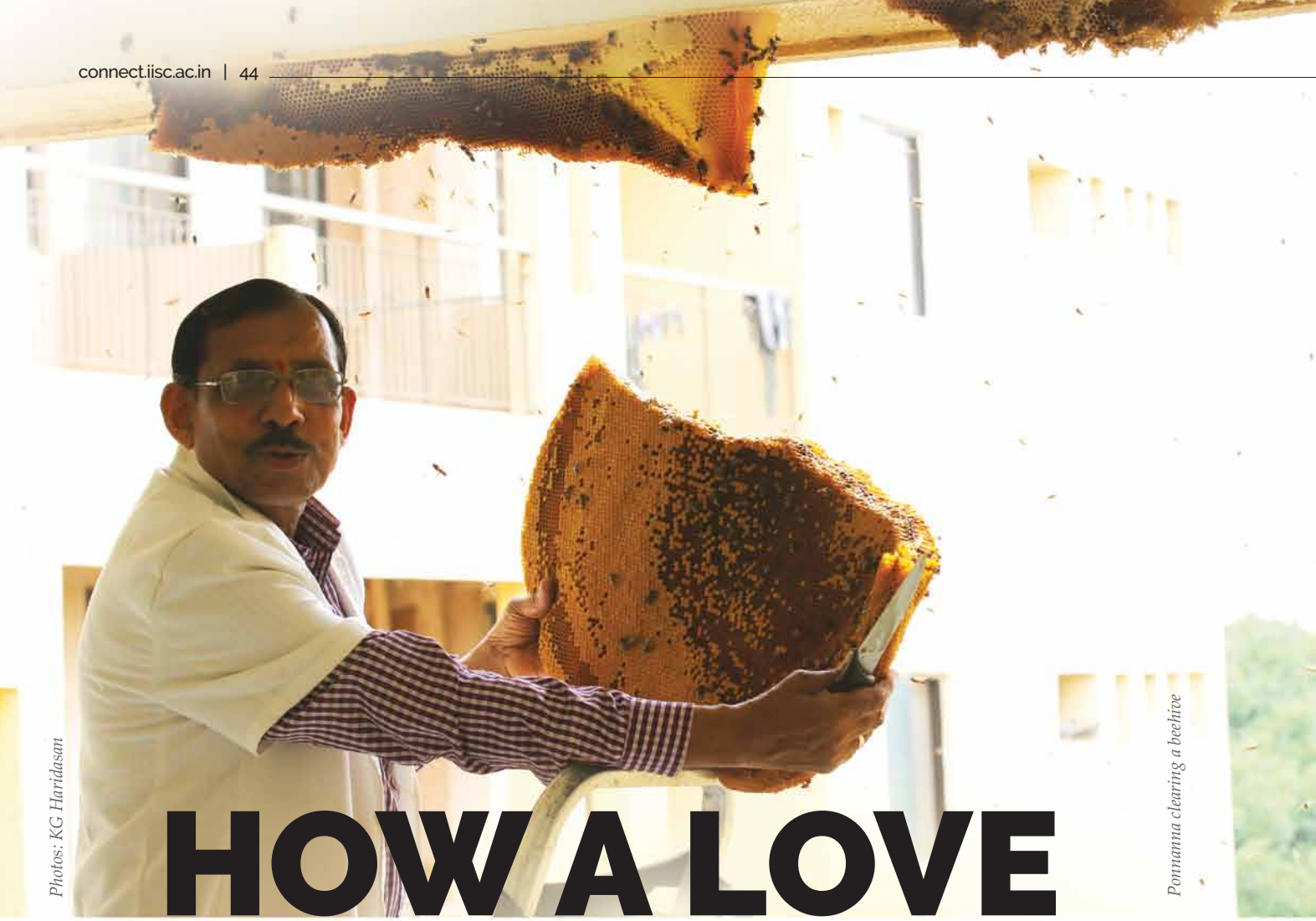
Others, too, remember Sinha's generous nature. Eric Lord, a British mathematician who had come to the Institute of Mathematical Sciences, Chennai, for a postdoctoral position in the early 1970s, didn't want to leave India when the funding ran out. He wrote to various places in India looking for a job. "And the first reply I got," says Lord, "from about a dozen letters, was from KP Sinha, Indian Institute of Science." Upon arrival, Lord was asked to give a series of lectures on general relativity, which Sinha, though he was a solid state physicist, attended. "And then he picked up enough knowledge from me and my lectures to take on students in that subject," says Lord, who worked with Sinha and his students – C Sivaram (retired professor at the Indian Institute of Astrophysics) and BS Satyaprakash (professor at Penn State University) among them – on problems in cosmology.

Sinha has other traits unusual among physicists, too. He, along with Sudarshan and Brian Josephson (known for the Josephson effect, which won him the Nobel in 1973), were into transcendental meditation, and were associated with Maharishi Mahesh Yogi. And, for more than a decade now, Sinha has been publishing papers seeking a theoretical basis for cold fusion, the controversial claim that nuclear fusion occurs at room temperature. This work began after he took up a visiting scientist position at Harvard University in 1999, followed by one at the Massachusetts Institute of Technology (2000-03), during which he also consulted for the Charles Stark Draper Laboratory. In this period, he met Andrew Meulenberg, and the two of them have been working on cold fusion under the aegis of the Science for Humanity Trust, which they founded. "Much of this effort," says Meulenberg, "made use of Sinha's remarkable memory that includes specific details from the so many physics papers that he had read during his student days and career. He is a vortex of ideas. He would make an apparently casual comment and suddenly the listener would discover a 'picture' that did not exist a moment before – but often containing the solution to a problem."

Sinha retired from IISc in 1989, though he continues his association with the Institute as an INSA Honorary Professor. In July 2019, Sinha will turn 90. While Lord remembers Sinha as "very quiet and shy", Baskaran recalls Sinha's hard-working nature. "He would come to the library and browse through every new issue of every important journal and would often come up with ideas. Jokingly, one of my classmates used to say that Prof Sinha will throw ideas at you, you should duck. He had that kind of energy."

Photo courtesy: KP Sinha

Sinha with Brian Josephson, who was a visiting professor at IISc, in February 1984



Photos: KG Haridasan

Ponnanna clearing a beehive

HOW A LOVE FOR ANIMALS SPURRED A CHANGE IN CAREER

Kavitha Harish

The Institute has many unsung heroes, whose contributions often go unnoticed. One among them is KA Ponnanna, a former security guard. He is often called upon when people in IISc encounter a mongoose in their lab or a snake in their homes.

Ponnanna recounts his childhood in Kodagu in Karnataka, and his journey from being a security guard at IISc to rescuing animals on campus and working at the Centre for Ecological Sciences (CES).

When did you first get interested in animals and wildlife? Did you have pets as a child?
I grew up amidst the forests of my native Kodagu. As a result, I am quite familiar with many wild animals including honeybees, wasps and reptiles. At home, we looked after deer, wild rabbits, and lion-tailed macaques, which were my pets. I also used to clear beehives to collect honey.

What did you do before joining IISc?
I worked as a technician in the field of communications equipment in the School of Artillery, which is part of the Indian Army. My job took me to places such as Nasik, Hyderabad, Devlali, Jammu and Dharangadhara. After leaving the defence organisation, in 1993, I joined the Institute as a security guard.

Can you recall your first impression of IISc?
Yes. My first impression was that IISc was cool and pleasant, which is quite similar to the conditions in Kodagu. The greenery made me feel at home.

How did you make the transition from working as a security guard to helping CES?
In my initial days at IISc, I cleared a beehive at the mens' hostel near the Health Centre. A few people saw that I was fearless and enthusiastic, and recognised my talent. And soon, this news reached Raghavendra Gadagkar [Professor at the Department of Ecological Sciences]. I have been the key person on campus to clear beehives or wasp nests from rooftops and work areas, since then. And I have also provided shelter to honeybees and wasps by placing boxes at certain locations in the campus, where they don't cause hindrance to the campus community.

I can differentiate between various types of poisonous and non-poisonous insects and reptiles. And so I have been an integral part of CES: I help maintain insects for research, and accompany students on their field trips. I have always been ready to share my knowledge about dealing with snakes with the students of CES or with anybody who is interested to learn.

What happens if you encounter an animal in distress?
I sometimes rescue creatures without harming them and release them in forest areas of this campus. I have also offered medical assistance to animals at times.

Why do you feel it is important not to harm the animals that you are trying to relocate?
A balanced environment is necessary for the coexistence of all living beings. All our efforts must be directed towards the same. Our need for expansion has to be balanced with the need for conservation of the environment in which we exist.

What kind of equipment do you use in your work?
There is no special equipment, in particular. I have a gown to cover myself when I am clearing a beehive, and when I catch snakes, I use a normal stick with a self-made 'U' type hook. Sometimes, I immediately figure out some way of making my own equipment, depending on the situation at hand.

What if it's the people who are in distress?
I have provided first aid relief in case of attacks by the wild insects or creatures to the campus community. To treat bee and wasp stings, I use leaves of certain plants that stop the poison from spreading. I have also treated myself after being attacked.

How did you get attacked?
Once, I was assigned to clear a very big wasp nest. Though I covered myself with the safety gowns, the wasp stung me. The poisonous chemical caused swelling in my face and it turned red. It took me a few days to come back to normal.

Do you have a favourite animal?
I normally do not wish to name a particular animal as my favourite. All animals and insects are my favourites. I wish to explore being with all types of animals and insects, and I have loved doing this since my childhood.

What keeps you busy after retiring from IISc?
After I retired from the Institute in 2012, I have been given the opportunity to continue serving in CES. I continue helping students who are conducting research on honeybees, wasps, and the like.

Ponnanna clearing a beehive from IISc's main building

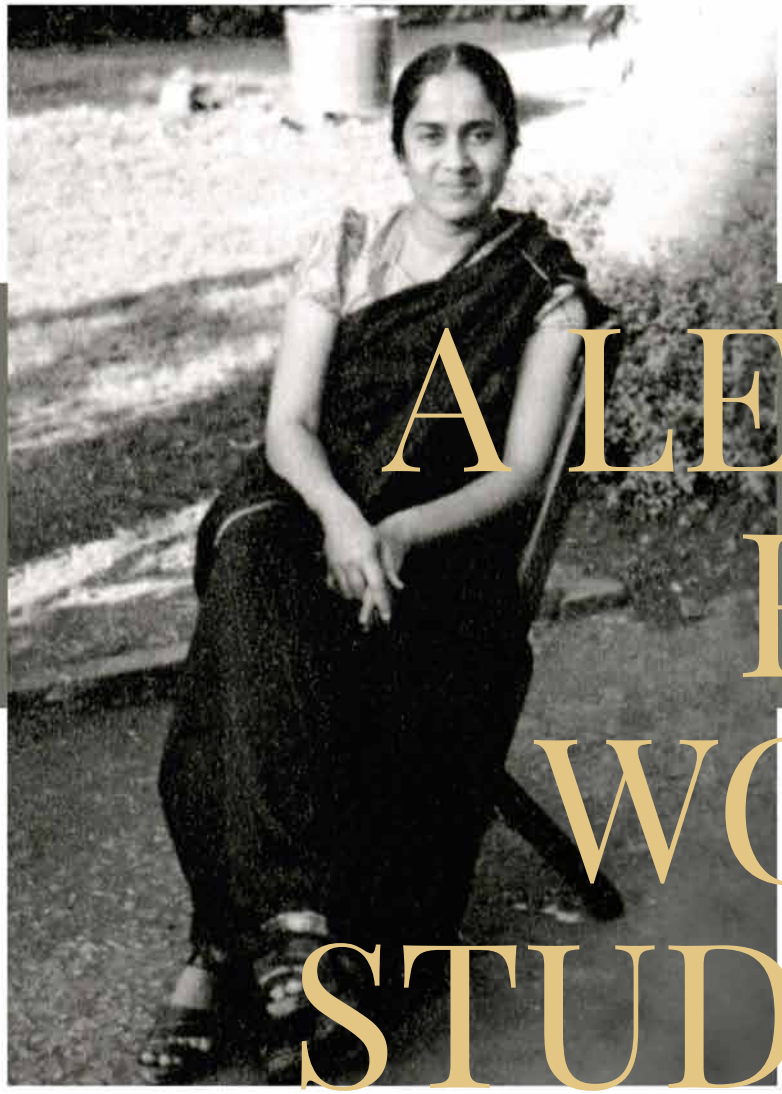


Photo courtesy: Anil Sohonie

Kamala Sohonie, a renowned biochemist, once studied at IISc

A LETTER FROM WOMEN STUDENTS IN 1936

"We wish to suggest that the Ladies' Hostel may be permanently located"

Kamala Sohonie (née Bhagvat) studied biochemistry at IISc in the 1930s. She had struggled to gain admission as CV Raman, who was IISc's Director from 1933-1938, was resistant to allowing women to study at the Institute. But she didn't seem the kind to take no for an answer. In the first of this set of two letters recently unearthed in IISc's archives, we see that Sohonie (who would go on to become Director of the Institute of Science, Mumbai) and two other women students wrote to Raman suggesting that the Institute publicise the fact that women could live on campus. They also demanded that the temporary women's hostel be made permanent, and that more facilities be provided to them. This document is significant as IISc's records show that a women's hostel existed only from 1942 onwards – from this letter, we know that women were provided temporary accommodation on campus even before this. Though the letter is addressed to Raman, it was delivered to his wife, Lokasundari Raman, who served as Honorary Warden of the Women's Hostel, who was requested to forward it to him after going through it herself.

The second letter reproduced here is from Mrs Raman to Mr Raman, forwarding the womens' letter with her own comments and thoughts about their demands.

Dear Sir,

We beg to bring to your notice a few matters concerning the Women's Hostel.

At present, no mention is made in the Calendar regarding the facilities offered by the Institute for the accomodation [sic] of lady students in the premises of the Institute – in a ladies' hostel under the care of a lady warden. By drawing prominent attention to this fact in the calendar such of those parents who wish to send their daughters to the Institute for research would be encouraged to send them.

Since the Hon. Warden is very busy and finds little time to attend to details pertaining to the hostel, for example the proper maintenance of the rooms and furniture, we wish to suggest two alternatives. (1) An appointment of a person who may be able to attend to the routine matters, (2) or that one of the inmates of the hostel, by turns, may be entrusted with the responsibility of looking into these details. Such an arrangement would also serve to secure contact with the authorities.

We wish to suggest that the Ladies' Hostel may be permanently located to avoid frequent shiftings which has caused considerable inconvenience to us. On a previous occasion, that is during the last shift, on our return from leave, some of us were driven to awkward situations. One of us went to the old place only to be directed by a kind gentleman to another building. Another of us found some of our belongings in the old building but in a room opened and occupied by someone else. This situation perhaps arose under circumstances over which the authorities had no control, but if a permanent building is put up exclusively for the Ladies' Hostel, none of us need have to face such awkward situations.

Another matter that we wish to point out is that great difficulties have been encountered to replace servants when they go on leave on account of illness, or for holidays, or when they are dismissed. It is necessary that some measures be taken to replace them immediately. We wish to suggest that there should be some understanding with the Hon. President of the Men Students' Hostel so that the services of one of the mess boys would be made temporarily available.

No watchman is provided for the Ladies' Hostel and there had been times when we found the presence of a watchman absolutely necessary, for example, when a theft had taken place in the Hostel and when a murder had happened nearby.

We wish to suggest that the Ladies' Hostel be provided with a peon to go on necessary errands to the City. If this is not possible, we suggest that the services of the peons of the Men Students' Hostel or of the Office should be rendered available to us.

We request that some facilities for Indoor Games be provided for the Ladies' Hostel.

Trusting that you will give the above matters your earnest and sympathetic consideration,

We remain,

Yours obediently,

K Bhagvat
P Devi
M Mather
Members of the Women's Hostel.

Photo courtesy: RRI Digital Repository

CV Raman, (third from left) IISc's director from 1933 to 1937, and his wife Lokasundari Raman

Dear Sir,

I enclose herewith an application received from the members of the Women's Hostel for your kind consideration.

I may be permitted to point out that the statement made in para 3 of their letter is incorrect. Ever since I accepted the position of Hon. Warden offered to me by the Council, I have made it my duty to devote considerable part of my attention to looking after the comforts of the students entrusted to my care. I therefore find myself unable to support either of the two alternatives mentioned in their letter.

In order to avoid inconvenience to the members, I recommend that their present residence need not be changed any further. The matter of constructing a separate block for them is a matter for decision by the Council, but in my opinion, the present strength of the Hostel does not warrant it.

I do not agree to the transfer of mess boys from the men students' messes when the cook of the Women's Hostel is absent or is dismissed. I suggest that the "servant" employed in the Women's Hostel should be a person who should be able to cook on such occasions when the regular cook is absent.

I recommend that a general servant be appointed for the Women's Hostel to go on errands during the day and also be a watchman at night. With regard to the statement about the theft of some money from the Hostel from an open drawer, I am inclined to the view that with a little more care on the part of the student the incident would not have happened. I am not aware of any murder happening anywhere near the Women's Hostel in the past.

With regard to indoor games, I recommend that a suitable sum be provided this year for this purpose which will be sufficient for the present members.

Yours faithfully,

Lokasundari (Raman)
Hon. Warden,
Women's Hostel.

ABSTRACTS

IISc Photography Club