CONNECT

WITH THE INDIAN INSTITUTE OF SCIENCE

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Mental wellbeing
Addressing a growing problem

Taking on traffic
IISc's contributions

Life at IISc
Perspectives and challenges

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EDITORIAL

What is life as a researcher really like? There's the science, of course, but what of the many other aspects that make up a researcher's experience?

Students from all over the country come to IISc with ambitions and aspirations. But the way science is practiced, especially in India, places unreasonable demands on the mental health of students. Though science is meant to be a cooperative enterprise, it can often be excessively competitive. Students need support, at the institutional as well as community levels, to get through this system. In this issue of *Connect*, we report on initiatives at IISc that focus on mental well-being and aim to break the stigma around mental health by encouraging more discussion about it. We also provide a psychiatrist's set of tips that faculty can follow to create a more positive lab environment, and that everyone can follow to build emotional resilience.

The well-being of students is something that deeply concerns MR Chandrashekhar, the Institute's Security Advisor, too, as you'll read in our interview. And IISc's denizens are mindful not only of each other but also of the abundant non-human life on campus. Evolutionary biologist Raghavendra Gadagkar has spent his entire career studying them. Abhijeet Bayani, an instructor for the undergraduate courses, tells us how he uses the campus itself as his classroom.

We also hear from a PhD student and from postdocs about the opportunities and challenges of research life at IISc. And carry stories about two students who passed through this campus decades ago and went on to leave their imprints on research and industry in India – Vikram Sarabhai who founded India's space programme and Jawaharlal Vaid who had a distinguished career with Philips. Or, in the case of Max Born, arrived here as a celebrated figure. Throughout all this history, the Institute's own journal has endured but with drastic changes. Its former editor, Guru Row, recounts that story.

The campus is also a place where ideas and products are incubated. You'll find one such story in this issue, of how IISc helped Wipro take its first steps towards becoming an IT major from a vegetable oil company. As IISc continues to partner with Wipro – it is going to study how to adapt the idea of an autonomous vehicle to Indian conditions – we feature an article on how the Institute is using its expertise to address issues of traffic congestion.

TEAM CONNECT

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How can we prioritise mental health on campus?

– *Deepika S*

Students at IISc are pushing for crucial conversations and concrete action

The IISc Empaths along with Rudra Pratap, IISc's Deputy Director (standing, centre), and mental health professionals at an event in November 2019

"Do people in highly competitive spaces lack empathy?"

That was a question a student had for a panel of mental health professionals at an event on 9 November 2019 called *Shades of Blue: Understanding Depression.* With increased concerns about students' mental health on campus (two students took their lives this year), this was a student-organised initiative to offer support and break the stigma that surrounds issues with mental health by talking about it more.

Is IISc doing enough for student welfare? Are students sensitive to the suffering of their peers? Is help available in times of a crisis? These are some of the questions that have been raised often in informal conversations on campus, and they formed the subtext to the student's question about empathy. Suicide rates, the student pointed out, were high at other top institutions in India as well as at Ivy League universities in the USA. Does a focus on academic excellence mean a lack of humaneness in dealing with human problems?

Photo courtesy: IISc Empaths

Science and stress

Much recent conversation has centred around the stresses of academia and how young scientists' struggles with mental health might be the result of structural causes. On the science media platform *The Life of Science,* Riddhi Dastidar writes, "What is it about Indian science today that leaves scholars unsupported and at risk of deteriorating mental health – contributing, in case of the worst outcome, to suicide?" Based on interviews with 20 scholars across eight institutes, including IISc, she identifies "a stressful, isolating, deeply hierarchical and unsupported academic environment, which seems almost designed to trigger mental illness, and completely at odds with the environment required to do innovative research – an intrinsically creative pursuit."

This isn't just an Indian problem. A recent article on *Nature's* homepage is titled "PhDs: The tortuous truth", which includes the results of a 2019 survey of over 6,300 graduate students from across the world and across scientific fields. Among its findings is that while most were satisfied with their decision to pursue a PhD, 76 percent of respondents worked over 40 hours a week (the majority working between 40 and 60 hours a week, and some even working over 80 hours a week), and this was taking a toll on their wellbeing and mental health – 36 percent had sought help for anxiety or depression related to their PhD.

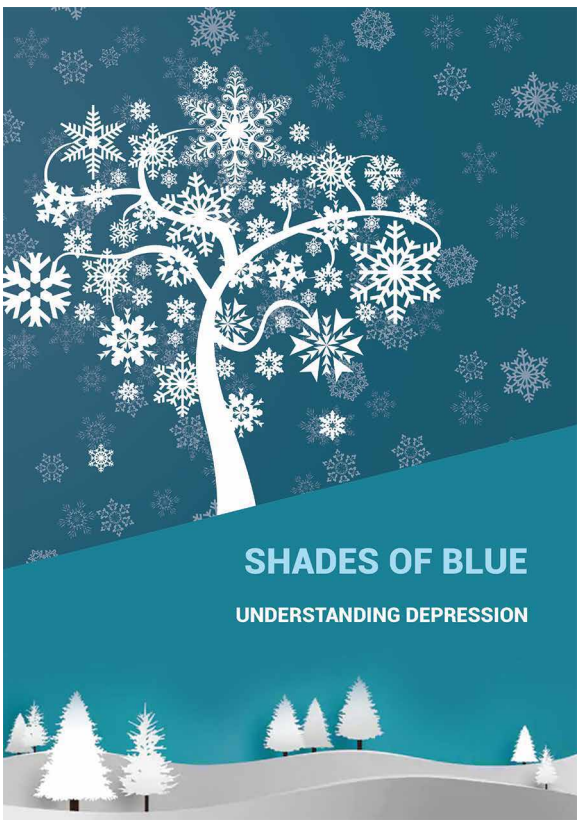
But it is clear that issues with mental health aren't just a feature in the sciences or academia. More and more people are considering the possibility that it is the way modern working lives are structured that leads to constant fatigue. Millennials have been termed the "burnout generation", having to be constantly productive in jobs that one is "passionate" about, even though these jobs may have few benefits and low pay and security. "Workism" in white-collar jobs – the belief that work is necessary for the economy but also central to one's identity and purpose – has been identified as a source of distress. Although much of these analyses have been of American society, it is easy to spot elements of these in Indian society and work culture, and to see how it affects Indians too.

Which leads to the question – what can be done to improve work cultures and environments at Indian institutes such as IISc? And how can the Institute community make sure that everyone has access to the right support to stay mentally healthy?

The Empaths

When a student asked the aforementioned question about competitive places lacking empathy at *Shades of Blue*, a member of the panel – Vyjayanthi Subramanian, Associate Professor of Psychiatry at MS Ramaiah Hospital and consulting psychiatrist at IISc – said, "Empathy can be learnt." She added that human connectedness was as important as professional achievements, and that empathy was something that could be taught and developed, in the way that one learns other life skills.

Image courtesy: IISc Empaths



The cover of a pamphlet with resources distributed at the event

Emphasising the importance of empathy, different groups of students have been trying to create a culture of support at IISc. One group launched an initiative during Mental Health Week in October called ChinUpandGreet – encouraging students to greet each other with a smile, in order to help create a friendlier, livelier campus.

Another group began its efforts with the creation of a closed Facebook group called the IISc Survivor Diaries, where students can anonymously share their experiences – of trauma; of depression and suicidal thoughts; of emotional pain. "We all need a safe space to express our inner struggle, shed feelings of shame, and find the courage and capacity to be vulnerable," says Rakshita Joshi, a PhD student at IISc and one of the creators of the group. IISc Survivor Diaries creates a confidential space for students to speak about what they're going through and in the process chips away at the silence around mental health. Only verified IISc students with an ID number can join the group, and comments on posts are moderated. The only non-student member of the group is one of IISc's counsellors, who comments on posts to offer words of support and affirmation.

Because a few of the group's creators had shared their own stories and waived their anonymity in doing so, they became identifiable among other students as being empathetic to mental health issues. They were sometimes called upon to deal with distress among students, though they weren't always equipped to. In October this year, the group's creators, along with a few other volunteers, received training to respond to students in distress from Subramanian. Formed as a peer support group under a newly set up Wellness Centre Committee, they are called the Empaths, and describe themselves as a "baseline structure to facilitate better mental health in the community", supported by professional counsellors and psychiatrists. They're still evolving, they caution, but aim to be a campus-wide network of trained student volunteers to provide a parallel platform for students to reach out and share their concerns, as well as organise outreach activities and events to spread awareness about mental health issues.

Shades of Blue was the first initiative by the Empaths, and the first of a series of events on campus to discuss mental health issues. Held on a Saturday evening with a considerable audience, the event began with a few students sharing experiences of overcoming depression and suicidal thoughts, speaking with emotional honesty, maturity, and at times even with humour about their struggles. This was followed by a series of questions answered by panelists, some collected before the event, some submitted anonymously by the audience members present, and some put to panelists directly. The panel consisted of Subramanian, Ajit V Bhide, Head of the Department of Psychiatry at St Martha's Hospital, M Manjula, Professor of Clinical Psychology at NIMHANS, and Rashi Vidyasagar, Director of the Alternative Story, an organisation that provides mental health services in Bangalore. The questions and the discussions that followed showed the many ways that mental health can be addressed at the institutional, community and individual levels.

Top-down efforts

According to a *Nature* editorial accompanying the results of its 2019 PhD survey, "The solution to this emerging [mental health] crisis does not lie solely in institutions doing more to provide on-campus mental-health support and more training for supervisors – essential though such actions are. It also lies in recognizing that mental ill-health is, at least in part, a consequence of an excessive focus on measuring performance – something that funders, academic institutions, journals and publishers must all take responsibility for." Changing this system sounds like nothing short of a total overhaul, and the road to get there is perhaps a long and difficult, albeit necessary, one.

At IISc, for example, perhaps the most obvious first step is to provide access to professional counselling and psychiatric services on campus. Students have been pushing for the setting up of a Wellness Centre on campus dedicated to mental health, with consulting psychiatrists and counsellors following professional standards such as maintaining patient confidentiality, overseen by a Wellness Centre Committee that has representatives from faculty, students, and mental health professionals. "Establishing better support systems including the hiring process [for more mental health professionals on campus] is expected to start soon," says Vishwesha Guttal, Associate Professor at the Centre for Ecological Sciences and a member of the Committee. Rudra Pratap, IISc's Deputy Director, addressed the students at *Shades of Blue* saying that the physical infrastructure for the Centre was already being planned and emphasising the management's "100 percent" commitment to improving the wellbeing of the community on campus.

Changes in research culture

The *Nature* editorial also says, "[T]he truth is that the system is making young people ill and they need our help. The research community needs to be protecting and empowering the next generation of researchers. Without systemic change to research cultures, we will otherwise drive them away."

To a question from an audience member at *Shades of Blue* about how changes to space and environment might affect one's mental health, Vidyasagar said that one way to make labs and common areas more welcoming towards people with mental illnesses was to have posters displayed prominently, featuring information about helplines, resources and whom to contact for mental health services. This, she said, would enable conversations about mental health as well as provide support to those searching for it, making mental health less of a taboo subject.

Subramanian firmly believes that faculty have a large role to play in deciding research culture and setting the tone for interactions in the lab. Encouraging an overly competitive culture and student rivalries, picking favourites, and power plays all contribute to a toxic environment, she says, while encouraging students and being careful about the way in which feedback is delivered can contribute to a positive one.

Some faculty members have also expressed a desire to receive training on how to deal with students' problems. Narmada Khare, an instructor in the undergraduate programme, wrote in the September 2019 issue of *Connect* that issues with mental health and emotional breakdowns were a common concern. "Instructors are willing to help, but are untrained. My colleagues and I often have a tremendous feeling of helplessness, hopelessness. We have tried to help students in great distress, but we aren't equipped."

"The only thing faculty were trained in when we were students and postdocs," says Guttal, "is how to do good research, how to publish well and how to make a name for yourself in your field." He points out that when a new faculty member sets up a lab, it can be easy to be consumed by a focus on research and the logistics of setting up a lab, and therefore actively thinking about what it means to be a leader or mentor often gets sidelined. "There is bound to be a huge variation in what everyone does, partly based on their experience and what they think is the right way of doing things, for want of training on how to be a good leader in the lab. Some people think strict discipline is the way to go. With the culture of publish or perish, that can easily slip into a toxic environment. Others might take a more liberal approach by mentoring students to choose their own path and trying to empower them in the process." He believes that active mentoring of young faculty would be a step towards helping them building a positive and productive lab culture, as well as having more discussions among faculty and students about why some approaches work better than others.

In the meanwhile, the Empaths are pushing for more discussion at multiple levels. At *Shades of Blue*, people talked about the difference between being sad and being depressed. They talked about how depression didn't necessarily lead to suicide, and how suicide didn't necessarily have to be a result of mental illness. They talked about a range

of factors that contribute to poor mental health including adverse childhood experiences or discrimination based on gender, caste, sexuality and economic background. They talked about the misconception that depression happens to "other people", not to oneself. They shared a pamphlet with information on symptoms of depression, when and how to seek help, how to offer support to someone else (including what not to say) and whom to reach out to on campus for professional help. And they conveyed the message that while there may not be a one-size-fits-all solution for everyone's problems, there were certainly people on campus who cared – and were willing to help.

Dr Vyjayanthi Subramanian's tips for faculty on building a positive lab environment

- Students look up to faculty and take behavioural cues from them, so it is important to think about the impact of one's actions. Insulting a student in front of others, for example, makes other students think it is okay to do the same.
- When giving feedback on a student's work, start by appreciating its strengths and give praise where it is due before moving on to what can be improved.
- If you have negative feedback, make sure that it is not personal, so that it is clear you are critiquing the work and not the students themselves. This can also be delivered in person rather than publicly.
- Times are different and young people today may have different habits, values and methods of working than what you grew up with. Accept this rather than hold it against them. Try not to be judgemental and try not to police them for it.
- Begin each day in the lab by ensuring that everyone greets each other, smiles, and makes eye contact. Collectively go over what was done the previous day or what will be done today, perhaps over tea or coffee. Have lunch together, as a lab or as a department, at least once a month. This encourages talking, exchanging ideas, and sharing thoughts and feelings. This way you get to know about people and their backgrounds, humanise your atmosphere, and leave channels open for communication in the event that someone would like to reach out for help.
- The more you reinforce empathy, the more you will build it.
- To understand what your students might be going through, try a group activity like role-play. You could play a victim or an individual with depression or anxiety. Guide and student can interchange roles and this can be hilarious and break the ice, while also putting you in their shoes, however briefly.

Tips for building emotional resilience

- If you are being encouraged to compete against others where it isn't necessary, you have to identify it and consciously decide not to participate in it. You have to understand the limitations of competition and say, "I will be my own competition".
- Make sure that rivalries do not dilute your friendships.
- Take the time to identify and acknowledge your feelings. Don't ignore or suppress your feelings so that your job gets completed. It isn't necessary to always compartmentalise your emotions and lock them away, which is what we often do in our day-to-day lives. It's fine if your emotions spill over once in a while – over a period of time, the "spillage" becomes less because it has found its vent.
- Make feelings and emotions a part of your everyday vocabulary. This could mean saying something like, "Oh, even you're feeling weepy-weepy? I went through that spell last week."
- Try to keep your sights on the bigger picture. No test can really assess an individual or his or her capacities. There is life beyond the lab, beyond IISc, beyond science.
- Try not to isolate yourself or push other people away. Your friends and loved ones will help build resilience in you. They may not be able to solve your problems, but they can help you feel better about them.
- Try not to avoid problems; try to find solutions to them and deal with them head on.

For mental health support, here's whom you can contact:

The Empaths:
iiscsurvivordiaries@gmail.com

Consulting psychologists at Faculty Club:
Shridhar BG (8904335065, shridharbg@iisc.ac.in)
Savitha MS (9741503499, savitams@iisc.ac.in)

Consulting psychiatrist at the Health Centre:
Dr Vyjayanthi Subramanian
(Timings: 2-5 pm on Tuesdays and Thursdays)

To view resources put together by the Empaths and Shridhar BG, scan this QR code

Thirty years of guarding IISc

– *Kavitha Harish*

Photo: KG Haridasan

IISc's Security Advisor MR Chandrashekhar in his office with his file of newspaper clippings about IISc

MR Chandrashekhar was IISc's Security Chief for nearly 30 years from May 1989 until his retirement in May 2018. Before joining the Institute, he had been in the Karnataka State Vigilance Commission as a Class II Gazette Officer posted to the Sericulture Department, and had been deputed as an Intelligence Officer to the HMT Watch Factory. Now serving as IISc's Security Advisor on an extension, he says he's seen it all – from protests, terrorist acts and instances of crime to VVIP visits and suicides on campus. He spoke to Connect *about the highs and lows of managing security at IISc, the elaborate arrangements that may be required on campus, and the lengths that the security team sometimes goes to, even outside the campus, to keep the IISc community safe.*

What does the job of a security officer involve?

A security professional's prime concern should be prevention of crime and providing security. Security is not only restricted to physical security – it should also be extended to the mind. At an institution of higher learning like ours where we have intellectuals, it is the duty of the security department to provide the necessary support to create an atmosphere conducive to research and free from fear.

Being physically fit, tolerant, and having good communication and interpersonal skills really helps when you work in security. You have to be ready to tackle any situation and be able to join hands with the community when taking measures to improve safety. For example, when we designated the entry and exit gates a few years ago it was met with opposition from the campus community because it restricted their movements. We did it as a proactive step to minimise the number of entry points, and not as a punitive action. Ultimately, it was only possible for us to pull it off with community awareness and support.

Over the years, safety has improved considerably on campus. We have over 100 CCTV cameras, and have increased the number of personnel and level of patrolling and surveillance. These are continuous processes; if the need arises we adopt new methods to handle the situation, and ensure we take the community into confidence! It is common for people to feel that security checks are a little cumbersome and time-consuming, but when compared to other places like airports, for example, it is easier to manage here. And of course, there is always scope for improvement.

Do special visitors require special measures?

We do have to take extra measures during VVIP visits. We first assess the nature of the event – we assess the threat perception depending on the profile of the visitor. We screen the entry and exit points, and record contact details of all those who enter campus. We arrange to depute our security personnel during such events.

In my 30 years of service, three Prime Ministers and four serving Presidents have visited IISc, and each such visit requires close coordination by the security personnel. We also need to liaise with the police and service providers like BESCOM, BSNL and others. Following strict protocols during such visits is very important.

What about when Nobel Laureates come to IISc?

When Nobel Laureates visit, we term them 'unobtrusive visits'. We usually deploy security personnel in civilian clothes to make the visitor feel comfortable. We ensure that the visitors are well taken care of and leave no room for shortcuts or negligence.

Photo courtesy: MR Chandrashekhar

CNR Rao, IISc's former Director, handing over the keys for the new Security Office building in 1991.

Have there been any serious security threats in your time?

Yes, as everyone knows, in 2005, during a conference held at the JN Tata Auditorium, we heard the sound of bullets being fired and a commotion, and subsequently we came to know that it was a terror attack. In this incident, a Professor Emeritus from IIT Delhi, MC Puri, was shot in the neck and died before we could reach him to the hospital. No one would normally expect a terror attack on an academic institution, and it was a big challenge for us and the police. Investigations and inquiries went on in the campus for over six months. Since I had a good rapport with the local police authorities in all the cadres there were no serious inquiries made into the campus community in connection with the attack. It was an eye-opener for all of us and showed that we needed to improve our security system in many ways.

Another incident happened in the same year when the Chinese premier Wen Jiabao visited the Institute on April 10. As is usual with such a visit, media coverage was planned. Before they entered the Main Building, we suddenly saw pamphlets falling from the Main Building's tower. Someone had climbed up and we had to immediately get up there and bring him down with the help of the police. We found out that he was not from the Institute [he was the Tibetan writer and activist Tenzin Tsundue] and had come to the campus two days before to protest the policies of the Chinese against Tibetans.

This was such a security breach that we immediately received a message from the Prime Minister's Office asking for an explanation. We have to be level-headed and patient to overcome any complications arising out of such incidents.

Your department sometimes has to deal with unusual incidents that aren't always related to campus security. Could you tell us about some of them?

It is a very painful experience for me to attend to a situation in which a student has committed suicide. There have been more than 15 suicides during my service and I have been involved in the inquiries that follow. In some incidents, I have been the first witness when we have to break open the door of the hostel room. I have always gone out of my way to support the families of such students; it is a very painful job for us to inform the parents about this news.

I wish to recall one incident that took place in 1990 on Christmas day. A student (I remember his name) from Andhra Pradesh took his life and left a note in his room saying that he was sorry and had been unable to bear the pressure. He wrote that his parents were very poor, and he had saved Rs 5,000 from his scholarship. He requested that the money be given to them. It was very hard for us to find his parents' contact details, because there was no proper address in the Institute's records. Finally, through my contacts, we were put in touch with the Hyderabad police and we located his parents. I went personally to that place, which was in a slum, and found his father, a tailor who earned Rs 30-40 a day. This student was very meritorious and had studied hard to win a scholarship. There have been several such incidents when I empathised with the concerns and deep feelings of the parents.

But one thing I can proudly say is that my team in the Security Office has saved countless more students from committing suicide. We try to keep track of students, either through their friends or hostel staff, and when we come to know that such an incident may happen we immediately take action. In a few cases we have also been able to save students' lives by rushing them to the hospital in time. Even though several years have passed in some cases, a few of the students we were able to save have come back to talk to me when they visit the Institute. I feel really honoured and thank God for giving me the opportunity to serve people in this way.

There was an incident in 1993, when one of our students went trekking alone to Kumara Parvatha in Coorg and he lost his way. We were able to locate him seven days later through my contacts within the Police and Forest Departments. We sent one of our security guards, Mr Bhyrappa, who was from that area, to track him. He found the student weak and lying by a river bed, his legs covered with leeches and other insects. We brought the student back and got him treatment and he survived.

I should also recall something else: There have been more than 10 incidents where we have caught people involved in sandalwood theft on campus. The Police Department has acknowledged our efforts.

Photo courtesy: MR Chandrashekhar

MR Chandrashekhar, IISc's Security Chief, escorts the former President APJ Abdul Kalam during his visit to IISc in 2013

We've heard that you maintain a record of newspaper articles about the Institute. Is this true?

Yes, I cultivated this habit right from the time I joined this prestigious institute. Whenever I saw news published about IISc I would feel as if it was my own achievement – that's how I started collecting the newspaper clippings. Over the years, I continued doing it so that I could refer to them if any data was required, because in those days, there were no computers or Internet to help with this. Whenever I am free I look back at those clippings and I recollect my earlier days attending to these incidents and seeing many achievements at this Institute, such as faculty receiving honours or awards.

Is there anything related to the Institute that you think people would be surprised to find out about?

That the research done here is a matter of curiosity in other parts of the world. Some time back there were attempts at hacking, so when we received information about it from intelligence agencies we took corrective steps at the right time and were able to save a lot of data and ensure that safety was not compromised. We need to take care of the confidential/sensitive work done here in collaboration with many defense establishments.

What is your most memorable event in connection to the campus?

Apart from our professional duties, I wish to share many proud moments such as knowing Prof CNR Rao who received the Bharat Ratna, many Padma Bhushan awardees, and so on. I feel very proud that so many people from one place have received so many prestigious awards and that I have interacted with them very closely during my 30 years of service. I have also been able to interact with many VVIPs like Dr APJ Abdul Kalam, four Presidents, and three Prime Ministers of this country. Many artistes have also visited, like Hariprasad Chaurasia, Pandit Ravishankar, Kavita Krishnamurthy, M Balamuralikrishna, Gulzar, and others, and I have seen many dignitaries from all walks of life. It has been a great privilege.

I am thankful to this Institute, which has given me so many opportunities. I have never missed attending a lecture that caught my interest. So, sometimes I feel like I have become a Jack-of-all-trades. This is a great temple of learning.

My children were born and brought up on the campus, and are now well settled. I have spent my best years here as Security Chief.

Life of a PhD student: Navigating Challenges and Exploring Opportun

Photo: Shruti Soni

Navjot Kaur working on lyophilizing chemicals used in the diagnostic tool that the Bhushan Toley lab is developing for microfluidic bioengineering

ities

– *Navjot Kaur*

A fourth year PhD student discusses how she made her PhD a more productive and satisfying experience

"A long time ago, people who sacrificed their sleep, family, food, laughter and other joys of life were called SAINTS, now they are called PhD STUDENTS," said a humorous post that I came across on social media.

Like all good humour, there is perhaps an element of truth in the statement, as most PhD students would tell you. A PhD requires sacrifice. But it can also be an enriching, even delightful, experience, as I have come to discover during my time as a PhD student at IISc. In this piece, I trace my journey from questioning my decision of joining a PhD programme to reclaiming faith in my resolution, to illustrate what I have learnt from my experience.

Research about research

Before joining the PhD programme, I was passionate about science, and dreamt of becoming a professor. What better place to start my research career than IISc? But I was unaware of the exceptionally rigorous standards of education and research here, as I am sure would be the case in other eminent research institutes as well. I was thoroughly unprepared for the challenges in my path. By the end of the first semester, I felt overburdened and troubling thoughts about job offers I gave up to pursue research started to surface in my mind.

Making the right choices

Stuck in this quagmire of negative thoughts, I decided to share my concerns with a professor and a senior PhD student in my department. Their remarkable guidance taught me how to mould my PhD experience to suit my style of working and temperament. I also realised the importance of being more communicative about my issues and how to deal with them. Yet another significant lesson I learnt back then was about the art of choosing: I chose to seek help when it was required and I chose the right people to talk to. I practiced the skill of choosing wisely again when it was time to select the lab for my PhD. I made a well-informed decision this time, going around all labs in the department, discussing the quality of professional and personal life the students experienced. I then made a list of factors that were important to me and finally chose my mentor based on my research. I can proudly say today that for me it turned out to be a perfect match.

In my lab, we have activities like regular individual meetings with our professor, group meetings and a journal club. This has provided me and my labmates with opportunities to grow professionally – improve our communication skills, expand our knowledge base and learn to understand and critique various fields of research. It also helped me understand the value of having mentors who are open to the idea of letting their students explore, both about their field of research and themselves. This, I believe, helps students find their own niche and in the process contribute to the growth of the research group as well. An encouraging and understanding mentor can go a long way in nurturing budding researchers. I have been exploring both commercial and academic research worlds because I have been blessed with a very supportive mentor.

> *I realised the importance of being more communicative about my issues and how to deal with them*

Owning my PhD

I have also come to realise that ownership of one's choices is as essential as making the right choices. My time at IISc made me more sensitive to the significance of asking my own questions. It took me quite some time to hone the skill of solving problems independently and this continues to be a work in progress. These experiences are making me more prepared to manage stress and anxiety, both of which are an integral part of the life of a PhD student.

Exploring the world outside

Research students spend a major chunk of their day, and sometimes night, working in their labs and life can become quite monotonous. Fortunately, I found a few interesting ways to spice up the PhD life. This allowed me to break the taxing routine, feel happier and more satisfied.

On the professional front, I made – and I continue to make – efforts to take my research outside the lab. I explain my research to family and friends, participate in technical conferences, business competitions, attend workshops and write about my research. Two very interesting experiences on this front have been participating in the 'United Nations Winter Youth Assembly 2018' at the UN headquarters in New York City, and presenting a tech pitch on my research at Falling Walls Labs India 2019.

The UN Youth Assembly was a gathering of enthusiastic, young leaders from all over the world dedicated to achieving Sustainable Development Goals 2030. This opportunity provided me with a platform to interact with people my age from around the world, understand the challenges of their worlds and explain to them the challenges in my country. I was inspired by the efforts people were making in their own small ways to improve the lives of those around them. Like the story of a girl who travelled through water bodies in different cities, raising awareness about water conservation. Or the story of another young woman who was building a self-sustaining jewellery startup for indigenous people of her community.

The experience at Falling Walls India was even more enriching as I developed skills to present my research to a diverse audience. The participants were asked to present their research using two slides in exactly two and a half minutes. This challenge made me think deeper about how to put across my ideas in a crisp manner while incorporating all the major details of my work. Listening to the other participants also helped me build perspective about the existing technologies and markets in different fields of research.

Photo courtesy: DAAD India

Kaur presenting her research at the Falling Walls Lab India 2019 competition in Mangalore, India.

On the personal front, I make sure I spend time outside my lab every week on hobbies and activities not directly related to my work, allowing me to feel more relaxed. I dance, write, cook, and socialise with family and friends. More recently, I have discovered yoga, which helps me to rejuvenate. Learning these new skills every now and then boosts my confidence and provides a sense of accomplishment.

There is no denying that the life of a PhD student is filled with challenges. But it can also be the most rewarding phase of one's life. I can vouch for that.

Navjot Kaur is a PhD student in the Department of Chemical Engineering, IISc.

The postdoc predicament

- Namrata

Why do some find life as a postdoctoral fellow in India so challenging?

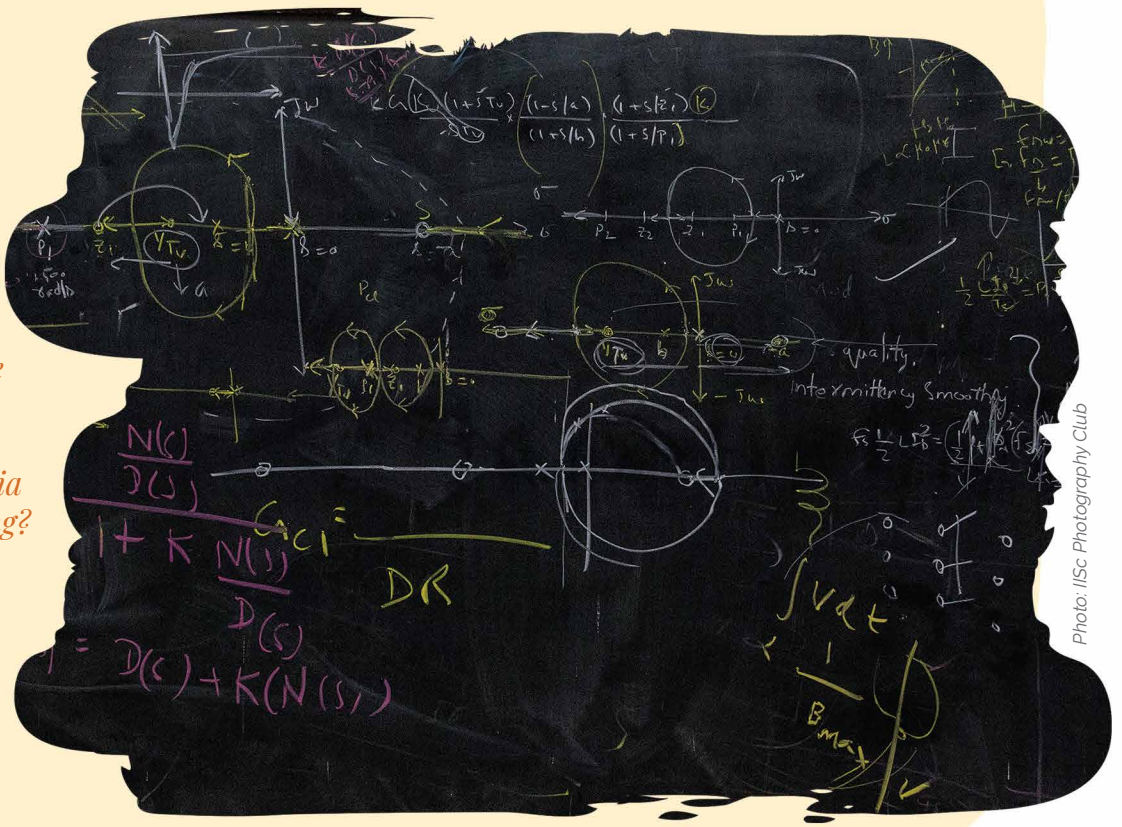


Photo: IISc Photography Club

Ask any PhD student about their next endeavour and the most common answer you would receive is a postdoctoral stint, preferably abroad. Postdoctoral positions allow one to pursue independent research in one's field of interest, paving the way for a future academic career.

Postdocs add value to a research lab. They bring with them expertise in their respective fields, along with the experience and training to comprehend and write scientific papers at a quicker pace and with a deeper understanding than PhD students. Their PhD background gives them the foundation to pursue independent research of their own, while also augmenting the ongoing research in the lab they join. Additionally, postdocs can help guide PhD students with their experiments and academic challenges.

A significant proportion of fresh PhD graduates from India prefer going to universities or institutes in Europe or USA for postdoc opportunities. In comparison, there are fewer graduates who decide to stay in or return to India for their postdoctoral position. IISc, for example, is one of the most sought-after institutes for research in the country. Its legacy of publications and high-impact research attracts many young researchers. Yet the number of postdocs working at the Institute is not very large. IISc currently has more than 400 faculty members and 2,700 PhD students (including integrated PhD) in various departments, but only 174 postdoctoral researchers.

What could be the major issues that might discourage graduate students from joining Indian institutions as postdocs, and what are the challenges they face during their postdoc tenure?

What could be the major issues that might discourage graduate students from joining Indian institutions as postdocs, and what are the challenges they face during their postdoc tenure? I spoke to a few postdocs at IISc to find out.

A couple of postdocs I spoke to mentioned that one of the challenges they face is limited flexibility to pursue independent research, which is contrary to the expectation that postdocs should work on new and interesting projects. Many postdocs are recruited through their Principal Investigator's (PI) existing projects and they may end up working on that same project throughout their tenure. This may further the PI's career aspirations rather than giving postdocs more time to build their own skills. Fortunately, this is not an issue all postdocs face. Some postdocs say that they do have the freedom to pursue independent and exciting research, in line with their expectations. "I always expected to contribute something novel and meaningful to research, which I believe I am doing here," says a postdoc in engineering. "I am in the right place and have found a good environment for research."

Independence in pursuing research is critical for postdocs so that they can continue publishing papers. Publishing in a high quality and high impact publication while working in an institution in India can be challenging. This is particularly important for postdocs since they are not yet established in their field of study and need a high impact publication to make their mark.

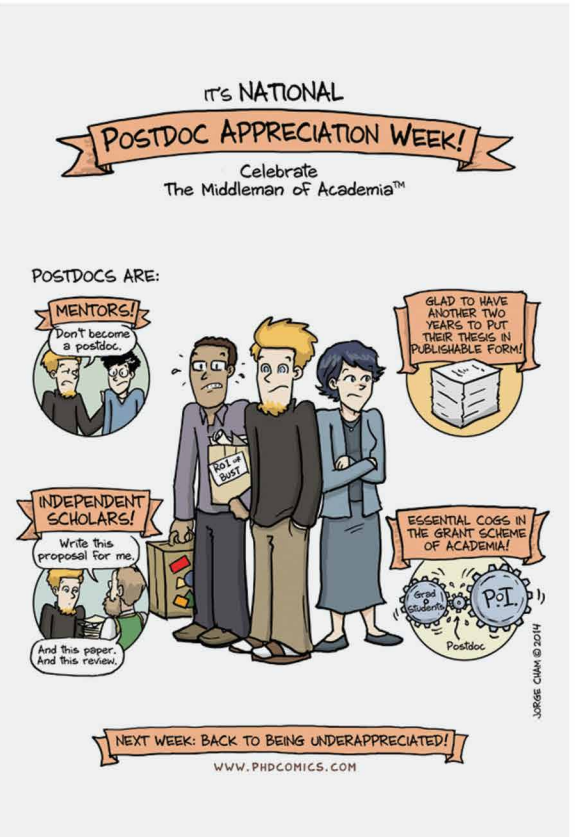


Image courtesy: "Piled Higher and Deeper" by Jorge Cham; www.phdcomics.com

The fellowship scheme under which one joins as a postdoc can also make a difference. There are multiple fellowships that postdocs in India can apply for, and the opportunities each one offers vary. Sveta Chakrabarti, who joined IISc as a Wellcome Trust/DBT India Alliance postdoctoral

fellow in 2016, says that the choice of the postdoctoral scheme has made a significant difference in her career. The India Alliance scheme has allowed her to work both at IISc and a university in the UK simultaneously, and she has received valuable guidance from both of her mentors, in addition to a contingency grant for her work. Although she cannot train and mentor a PhD student under this scheme, she can hire project assistants who have helped her shape her current work, she says. Sveta asserts that, during her time in the Institute and at the Division of Biological Sciences so far, she has received help from other faculty members and built successful collaborations, which will help her substantially in her career. The India Alliance scheme also allows their fellows to focus more on publications around the middle of their fellowship term, which is usually not seen in other fellowship schemes.

> *The fellowship amount disbursed varies significantly across funding agencies*

Postdoc salaries range anywhere from Rs 50,000 to Rs 1,00,000 a month. A postdoc who receives the Dr DS Kothari Postdoctoral Fellowship says, "The fellowship amount is the least among other postdoctoral fellowships in India and disbursal of fellowship payment is chaotic, which affects research."

He asserts that he has personally faced a lot of issues with receiving his fellowship and has even had to file an RTI application. "Getting my fellowship regularly is still challenging. Earlier, I used to get my fellowship from the National Board of Higher Mathematics (NBHM), and payment disbursal was equally poor. It took me eight months to get my first scholarship through filing RTI," he says. "There was never a fruitful response from NBHM. I called them over the phone and wrote emails several times. The same scenario was repeated in the second year of the fellowship." Sveta, too, says that a couple of her colleagues face problems due to the irregularity in fellowship disbursement, which can be stressful, especially for those who are the sole earning members of their families.

A postdoc in the Division of Biological Sciences who has a SERB fellowship also expressed concern at the difficulty in procuring consumables and equipment, and the fact that she has to seek permission to purchase every item. This can create a demotivating environment, she says. Another postdoc from one of the engineering divisions voiced a similar opinion, highlighting that access to and use of common instruments was poorly managed in her department.

The lack of "postdoc culture" in the Institute is another concern. There are very few seminars or symposia organised specifically for postdocs. Yearly or bi-annual presentations are a part of PhD life anywhere in the world, and students are made to present their work at least once in front of faculty members and other students. Such forums provide opportunities for critical assessment of research work, which is important for any researcher and will aid in improving their science.

One postdoc at IISc had some related suggestions. "I feel that there should be regular workshops for PhD students or postdocs regarding the different fellowships available, intramural or international. It would be good to form a postdoc association to help each other, and a guidance committee to help clarify uncertainties about building their future," she says. An alumnus of IISc, Lakshmi Nararsimhan T, who is presently a faculty member in IIT Palakkad, suggested that introducing schemes which allow postdoctoral researchers to work in collaboration with universities abroad will also help improve the quality of research.

While there are numerous problems postdocs face, there are also new schemes being introduced to address some of these issues. IISc, for example, has recently started the Raman fellowship scheme for postdocs as part of its Institution of Eminence status. The fellowship comes with a generous salary of Rs 1,00,000 per month and an annual contingency grant of Rs 8,00,000. Around 25 fellows may be recruited per year for a term of one year, with the possibility of extension for another year after review. Vikram Jayaram, Chair, Division of Mechanical Sciences, explains that the scheme has been implemented to provide a comfortable working environment for postdocs, and attract bright young researchers to supplement research in the lab of their choice. The contingency amount, he says, is given with the idea of allowing the postdoc to attend various workshops and conferences. He believes that the programme could significantly help to attract high calibre postdoctoral fellows to the Institute.

These perspectives give a bird's eye view of the current situation of postdoc life. There is certainly a lot that could be improved for these fellows to have a fruitful research career.

Namrata is a PhD student at IISc.

Half a Century of Worship at "Tata's Temple of Science[1]"

– *Raghavendra Gadagkar*

Photo: Thresiamma Varghese

The evolutionary biologist recounts his love for the campus of IISc which has also served as a laboratory for his research

[1]*Worship = feel great admiration or devotion for; Temple = a place devoted to or seen as the centre of a particular activity or interest: a temple of science. Source: built-in dictionary-macOS Cataline Version 10.15.*

The year was 1963, and it was my first week in Bangalore. As a 10-year-old boy, I was travelling with my parents and my two siblings, in the Bangalore Transport Service (BTS) bus no. 11, from my grandmother's house in Jayanagar to our new home in Yeshwantpur. The bus conductor was a flamboyant young man who clearly took great pride in his work, moving up and down the aisle loudly announcing the name of each bus stop with great flair in chaste Kannada. At the last-but-one stop he roared, "*Tata ravara Vignana Mandira*" (Tata's Temple of Science). I was intrigued. I was already hooked on science and the name 'TATA' was inscribed on the bus I was travelling, having been made by the Tata business house. But what was the connection between the business house and science? There was no Google at that time, but I soon found out that IISc was founded by the Tatas in 1909 on 1.5 km^2 of land donated by the Maharaja of Mysore Krishnaraja Wodeyar. IISc is still locally known as the 'Tata Institute' in homage to JN Tata, who could not build the institute in his lifetime but left money for it in his will [see *In Pursuit of Excellence: A History of the Indian Institute of Science* by BV Subbarayappa]. And what luck? India's premier institute of science was located just 1 km from my house in Yeshwantpur! I soon found out that I could just walk in and observe this 'big school' meant for adults interested in science. The name of the Nobel Laureate Sir CV Raman was closely associated with the Institute. I also found out that the adults in this school had time to play tennis and that they were rich enough to discard tennis balls which were good enough to play cricket with for several months! And they sold them at 25 paise a piece, and we could go across the road and play cricket in the part of the campus which is now the gymkhana. That was my first encounter with the Institute.

> *At the last-but-one stop he roared, "Tata ravara Vignana Mandira" (Tata's Temple of Science). I was intrigued*

My second encounter with the Institute was in the year 1968 when, aged 15, I was a PUC student in St Joseph's College, Bangalore, and trying my hand at research, studying the oestrous cycles of laboratory rats, which I kept at home. I went to the Institute's main library – called the JRD Tata Memorial Library – and was not let in. When I insisted that I needed to consult the *Journal of Endocrinology*, I was taken by the confused security staff to the head librarian, one Mr TKS Iyengar. He kindly let me in, albeit with a very skeptical smile. His skepticism I must say was justified because I did not understand a word of what I read in the *Journal of Endocrinology*! Nevertheless, it paid off in the end. My research was in preparation for the National Science Talent Search Scholarship Exam. Thus, my third encounter with the Institute was later that year when I was invited to the Department of Biochemistry of the Institute to be interviewed by a galaxy of experts headed by Prof PS Sarma, and I won the scholarship.

My fourth encounter with the Institute was in the year 1971 when, aged 18, I was a final year undergraduate student at Central College. I was smitten by two subjects, Animal Behaviour and Molecular Biology, neither of which were taught with any degree of passion or competence in my college. But for all its faults, Central College had an excellent library and enlightened librarians. My love for animal behaviour was born from reading *King Solomon's Ring* by the Nobel Laureate Konrad Lorenz and fuelled by the discovery of many colonies of the Indian paper wasp *Ropalidia marginata* on the windows of the Zoology and Botany departments. And my love for molecular biology was born from reading *The Double Helix* by another Nobel Laureate, James D Watson, and fuelled by the discovery of an exquisite organism, the lysogenic bacteriophage lambda, which unfortunately lived only in the pages of journals in the library. But I soon found its local avatar. One day, I jumped up from my chair in the library when I read in the pages of *Nature* [Vol 228, October, 17, 1970] that one CV Sunder Raj of the Microbiology and Pharmacology Laboratory of the Institute, had discovered our very own, Indian lysogenic bacteriophage. I promptly came to see him, and he showed me beautiful Petri plates in which the mycobacteriophage I3 had made transparent holes on a lawn of the bacterium *Mycobacterium smegmatis*. The 'I' in I3 was meant to denote Isolate 3, but I had no qualms about thinking of the 'I' as denoting India.

Photo: Thresiamma Varghese and R Gadagkar

My favourite species on the campus, from left to right, top row: Ropalidia cyathiformis, Ropalidia marginata and Apis florea, bottom row: Diacamma ceylonense, Vespa tropica, and Vespa tropica with the envelope removed

My fifth and final encounter with the Institute happened in the year 1974 when, aged 21, I was lucky enough to be admitted to the single vacancy in the interdisciplinary field of molecular biology and joined the by-now re-christened Microbiology and Cell Biology Laboratory for my PhD. I spent the next 5 years studying the alter ego of bacteriophage lambda, our own bacteriophage I3. Imagine my delight when I saw that the Institute campus was also home to innumerable colonies of my other love, the Indian paper wasp *R. marginata.* I managed to make bacteriophage I3 the subject of my professional study and the paper wasp *R. marginata* the subject of my hobby during those five heady years. At the end of my PhD, entitled *Physiological and Biochemical Studies on Mycobacteriophage I3*, I was in a serious dilemma, being equally in love with both I3 and *R. marginata*. The difficulty, or should I say impossibility, of doing cutting-edge research in molecular biology under Indian conditions was brought home painfully to me every day of my PhD. If I were to continue with molecular biology, it would have to be in the USA or some such developed country and then of course I could focus directly on the original bacteriophage lambda itself. It was very tempting – not so much the USA, but lambda. But if I could switch animal behaviour into my profession and molecular biology into a hobby, then of course I could stay in India and spend the rest of my life studying the Indian paper wasp *R. marginata*. I chose the latter option; I refused to go abroad even for a postdoc, stayed back in the Institute, with soft money for many years, and in the eyes of my 'mol-bio' mentors, moved backwards from molecular biology to animal behaviour! And I have never regretted it.

Imagine my delight when I saw that the Institute campus was also home to innumerable colonies of my other love, the Indian paper wasp R. marginata

I have never forgotten that the reason for my shifting to animal behaviour while staying in India was to be able to do cutting-edge research. Very soon, it became all too easy, and fashionable, to practice even the science of animal behaviour with sophisticated laboratories, expensive technologies, large grants, and indeed with an infusion of molecular biology techniques. Nevertheless, I have carefully designed my research so as to need as little money and technology as possible. This has been made possible because the Institute campus is a laboratory par excellence. All my research in the last 40 years and more has utilised naturally occurring ants, bees and wasps on the campus of this remarkable Institute. The Indian paper wasp *R. marginata* has received the lion's share of our attention. Indeed, my goal has been to understand everything humanly possible about this fascinating species of social wasp, as I describe in my book, *The Social Biology of Ropalidia marginata* (Harvard University Press, 2001). Having discovered it by accident and admired it as a layman in Central College, having encountered an abundant supply of its colonies in the Institute and having decided after my PhD to focus the rest of my research career on the species, I was delighted to find that authorities in the field had opined that the genus *Ropalidia* holds the key to our understanding of the evolutionary forces that mould social behaviour. Twenty of my 22 PhD students have worked entirely on *R. marginata*. We study the wasps where they occur naturally, on the buildings and vegetation of the campus or bring them to the laboratory for more difficult experiments. Our laboratory, which we call the Vespiary, is a simple large room enclosed in wire mesh on all sides, permitting the wasps to fly in and out as they please. All studies on naturally occurring colonies have been carried out on the campus and most of our wasps brought into the laboratory have also come from the campus. Only because we were concerned about depleting the population of wasps on the campus, have we sometimes collected wasps for laboratory work from outside the campus.

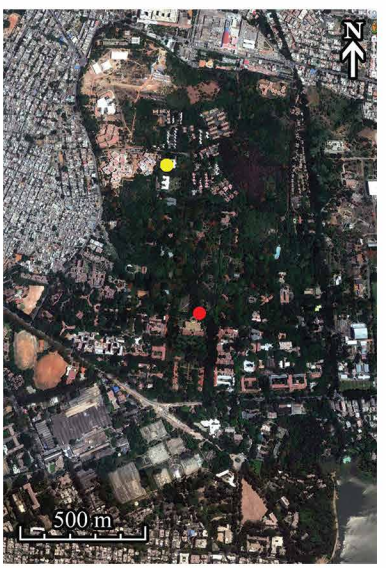


Image courtesy: Souvik Mandal

A satellite image of our study site on the campus

Occasionally, we have turned our attention to the related species *Ropalidia cyathiformis*. For reasons that we do not understand yet, this second species does not fare well in the lab, and therefore all our work has been on natural colonies on campus. Two of my PhD students chose not to work on the wasps.

One of them studied the Asian dwarf honeybee *Apis florea*, also on the campus, and the other studied the queenless ant, *Diacamma*, and yes, also on the campus. We have conducted a long-term study of the population dynamics of the ant *Diacamma ceylonense* entirely in the Jubilee Gardens of the campus. During this study, we also found a remarkable karyotypic instability in this ant species. One of my more recent students decided not to investigate the wasps at their nests. Instead, he chose to research the homing and navigational abilities of the wasps when outside their nests. All his sophisticated field studies were done entirely on the campus. We undertook a two-year study developing and standardising sampling methods for estimating the diversity and abundance of forest insects in the Western Ghats. All the pilot experiments in preparation for this study were of course most conveniently done on the campus. My students and I have undertaken a detailed survey of ants of the campus, finding 112 species so far.

> *I have carefully designed my research so as to need as little money and technology as possible. This has been made possible because the Institute campus is a laboratory par excellence*

Just as my favourite research subjects *R. marginata and R. cyathiformis* reside on the campus, so do their most important predatory wasps, *Vespa tropica and Vespa affinis*. These are remarkably large and complex wasp societies building multistoried paper nests. I had a memorable and dangerous experience collecting one of their large nests built on a tree and hanging precariously in front of the nursery. Incidentally, the wire mesh of the Vespiary is designed to keep the predatory wasps out while letting *Ropalidia* through. More recently, I had the great pleasure of teaching organismal biology to the first semester undergraduate students of the Institute for six years. All the practicals for the students utilised the biodiversity on the campus. One of their main projects and perhaps the most interesting one was the 'ant walk' during which they learned how to sample ants and compute and explain their levels of diversity and abundance.

I have had the privilege of living on the campus for most of my life, first in the student hostel blocks D-09 and N-17, then in the Kaveri married students' apartment, followed by staff faculty quarters D-240, E-35 and DQ-18. I have not been away from the campus for more than three months at a time since I joined the Institute in 1974, or indeed from Bangalore since I moved here in 1963. I cannot imagine a better place to raise a family – my son Vikram grew up with the biodiversity of the campus as part of his family, becoming an avid birdwatcher and publishing scientific papers on the birds of the campus [https://gadagkar.zuckermaninstitute.columbia.edu/publications] even before he graduated from high school, which was also on the campus. He now studies how the brains of birds help them to learn their species-specific songs.

Photo: Thresimamma Varghese

The entrance to Jubilee Gardens where a long-term study of the population dynamics of the ant Diacamma ceylonense was carried out

It surprises me that, barring a few of my colleagues from the Centre for Ecological Sciences who conduct small parts of their research on the campus, many more of us do not take advantage of the animal and plant life on campus for our research and teaching. It bothers me that most people do not even appreciate the uniqueness of our campus – their ignorance is so great that they think that our campus needs re-branding. They fail to appreciate that a rich biodiversity is the brand of our campus, that has been bequeathed to us over millions of years of evolution and by the foresight of JN Tata and the Wodeyars and sustained by the wisdom of our directors such as CV Raman, Satish Dhawan and CNR Rao. If we cannot pursue modern biology on a campus that is home to over 112 species of ants, 25 species of bees, 50 species of wasps, 140 species of butterflies, 110 species of birds, 17 species of snakes, 20 species of dragonflies and damselflies, 60 species of spiders, and 112 species of trees, something must be wrong with us, and/or with modern biology.

I wonder if anyone else has been so blessed as to have their personal and professional lives so intimately linked to the magnificent campus of this hallowed institution. Fifty years of worship at 'Tata's Temple of Science' – I cannot imagine a better life.

Raghavendra Gadagkar is a DST Year of Science Chair Professor at the Centre for Ecological Sciences and also an alumnus of IISc (ragh@iisc.ac.in). You can find more information about his research at http://ces.iisc.ac.in/hpg/ragh and https://www.researchgate.net/profile/Raghavendra_Gadagkar

The campus as a classroom

- Abhijeet Bayani

Photo: Lakshya Chauhan

Abhijeet Bayani taking photos of a Russell's viper near Jubilee Gardens

Using IISc's biodiversity for undergraduate education

"How many of you noticed the beautiful, white-coloured, fragrant tree just outside the stairs that lead us here to the lecture hall?" I asked the first year UG students in my first class of organismal biology at IISc. Barely two or three uncertain hands were raised out of 120.

"Go see that tree. It is called *Murraya paniculata* in Latin," I said. "And remember, this is what I am going to make you all do in the course."

I told them that all my lab sessions, field experiments and one-to-one discussions will focus on making them more observant and curious about what we have around us. That I wanted them to pick up or photograph any curious object and bring them to me. That I was going to make them think

and ask crazy questions, and try to turn them into naturalists, at least initially. All of this was going to test their patience, I warned them. "Be ready to hear answers that may astonish or disappoint you. Be ready to conduct experiments where there is no definite end result," I said.

And in return, I got some smiling faces, perhaps thinking, "That's it? We are going to look at different species and report back? That's easy!" But others had faces that said, "This is ridiculous! There should be some complex experiments to make biology interesting."

I see such stunned faces every time I say this to a new batch of undergrad students. They watch documentaries, read research papers and textbooks, go for tuitions, attend lectures, scientific and public talks; participate in conferences, and often present at conferences. This gives them a preliminary idea about what research involves. But when it comes to conducting research on their own, they often struggle with two foundational questions: Where to begin? How to start?

I like to teach ecology in a rather simple manner. I let them go out of the classroom and ask them to explore on their own. I ask them to consider any species and ask any interesting question. I put forth just one condition that they should not read anything about it prior to this exercise. I've seen that they take random walks and come back asking where to start. And this is the point where I like to begin. By this time, students also realise that there is no fixed syllabus for the course and it is quite open-ended. This makes the course and my teaching rather unstructured but also, I hope, interesting.

I like to teach ecology in a rather simple manner. I let them go out of the classroom and ask them to explore on their own

For every biologist, the most fundamental quality is to be observant, and the habit of exploring nature nurtures that quality. I believe that every person is fundamentally fascinated by nature. Everyone has curious questions about a particular animal or plant: What is its name? How do I identify it? Where does it live? Is it a male or female? What does it eat? How does it eat?

Asking all these questions contributes to understanding the organism's natural history. I believe that everyone loves to do it. Some take it more seriously and scientifically, others treat it as a hobby. For me, it is both, and IISc provides that opportunity to a great extent. The campus has over 100 species of birds, 100 species of ants, 50 species of spiders, and a myriad of other invertebrates including beetles, bugs, wasps, dragonflies, flies, and more. With each species, I see a new undergraduate project. Ever since I joined IISc, I have been utilising this biodiversity to teach my students in various ways.

If students wish to know or understand how to estimate distribution of species, how one habitat is different from another, or what kind of sampling and field methods to follow, I use ants. Such experiments require collection of specimens, labelling and preservation and, at times, observing them *in situ*. The focal species should be visible enough, should not be scarce, and should be readily available. Collecting a few individuals should not disturb the species or break any environmental, biodiversity or wildlife law. Ants are ideal for this, and are abundant, with over 100 species on campus. Collecting one individual out of thousands of ants in a colony does not affect any behaviour or balance in the ecosystem as such. Ants are also easy to preserve and observe without needing much equipment. I've seen that after observing ants closely, students end up understanding beyond the layman's classification of ants i.e. 'black ants vs. red ants' or 'the ones that bite vs. the ones that do not'.

Photo: Abhijeet Bayani

Multitrophic interaction between crab spider, honey bee, grass and a parasitic fly, observed near the JN Tata statue

Some students then wish to understand how multiple species interact with each other. I ask them to start looking for spiders. I have documented about 60 species of spiders on the IISc campus. They are more diverse in terms of their body shape, habits and behaviour than ants. They are not as easy to find as ants, nor are they as abundant. Their diverse interactions with their prey, co-predators and competitors make them very interesting to study. Once, while teaching trophic interactions, I took students out in the field and we saw an amazing demonstration of multitrophic interactions on a single grass twig: a crab spider laying an ambush for an insect visitor (maybe coming for pollen) caught a honey bee which a fly then tried to eat parasitically.

My experience tells me that pulling students out of the controlled environment of labs makes them start thinking on their own. One student approached me and asked if she can study sexual selection in animals. She was curious to study the Indian peafowl, and had come up with some preliminary protocols and field methods independently. I asked her to go and find a place where a large number of peacocks can be seen. She went around Bangalore and found a place where, at a time, two or three can be seen. But this sample size was too small, so I introduced her to guppies. They are a sexually dimorphic abundant fish species found all over the campus. They are easy to maintain in the lab and observe, and useful for doing controlled experiments. She then decided to study them to learn more about their mating choices.

In another instance, inspired from my talk in the very first class, a few students brought lichen and moss samples from trees to observe under the microscope. They found a curious worm-like object which turned out to be a tardigrade – a hardy microscopic creature. The students were thrilled to learn that tardigrades can survive the effects of outer space, UV radiation, starvation and desiccation, and the fact that they can be found so easily on the IISc campus. They wanted to extract a few and maintain them in the labs. And so experiments began and they are still going on.

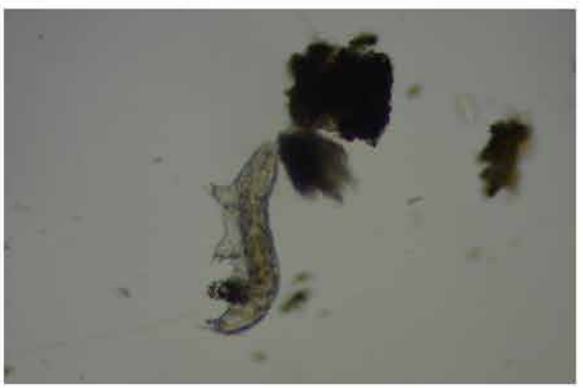


Image courtesy: Abhijeet Bayani

Image of tardigrade under microscope at 100X magnification

In all of the above cases, I did not suggest any research protocol to them, and rather asked them to develop it on their own. This exercise was needed as it gave them confidence to think independently, to design their own research methods and troubleshoot problems. This is what a researcher or a scientist is primarily required to do.

Training students to think on their own is crucial because while pursuing a research career, one has to come up with a question and design protocols for experiments, arrange for sampling, and so on.

Many research advisors have a system in which they give students an idea (or in fact a ready-made question), or ask them to start going through scientific literature and find out what the missing points – fashionably known as 'research gaps' – are, and start figuring out a question out of these. I must say that these are completely rational approaches. This also saves time and money. Even students find it very interesting in the beginning. But I see some shortfalls in this. By having a ready research question provided by the research advisor, students may end up doing what is interesting for the advisor, not for themselves. They may do what their supervisors say but not what they themselves would want to do.

Photo: Abhijeet Bayani

Preservation of insect specimen in Eucalyptus tree resin observed on the way to Jubilee Gardens

It should be noted that I said 'research advisor' and not 'PhD advisor'. I have noticed that this problem is equally prevalent among bachelor's and master's students who conduct research as part of their curriculum. There are only a handful of instances where students' interests and advisors' interests match. Training undergraduate and master's students to think on their own may also not be prioritised given the short duration of their programmes and the emphasis on imparting new skills or techniques rather than research. Having faced such situations during my undergrad years, I have realised the importance of teaching ecology differently to get students exposed to the fundamentals of research.

Today, students have unlimited access to knowledge. They are sometimes more adept at gathering facts than most of their teachers. The only thing that they lack is a systematic approach to using this information. I think teachers today should not try to compete with Google but rather try to train students to use the information they already have in more systematic and creative ways.

Abhijeet Bayani is an undergraduate instructor at IISc.

Campus life

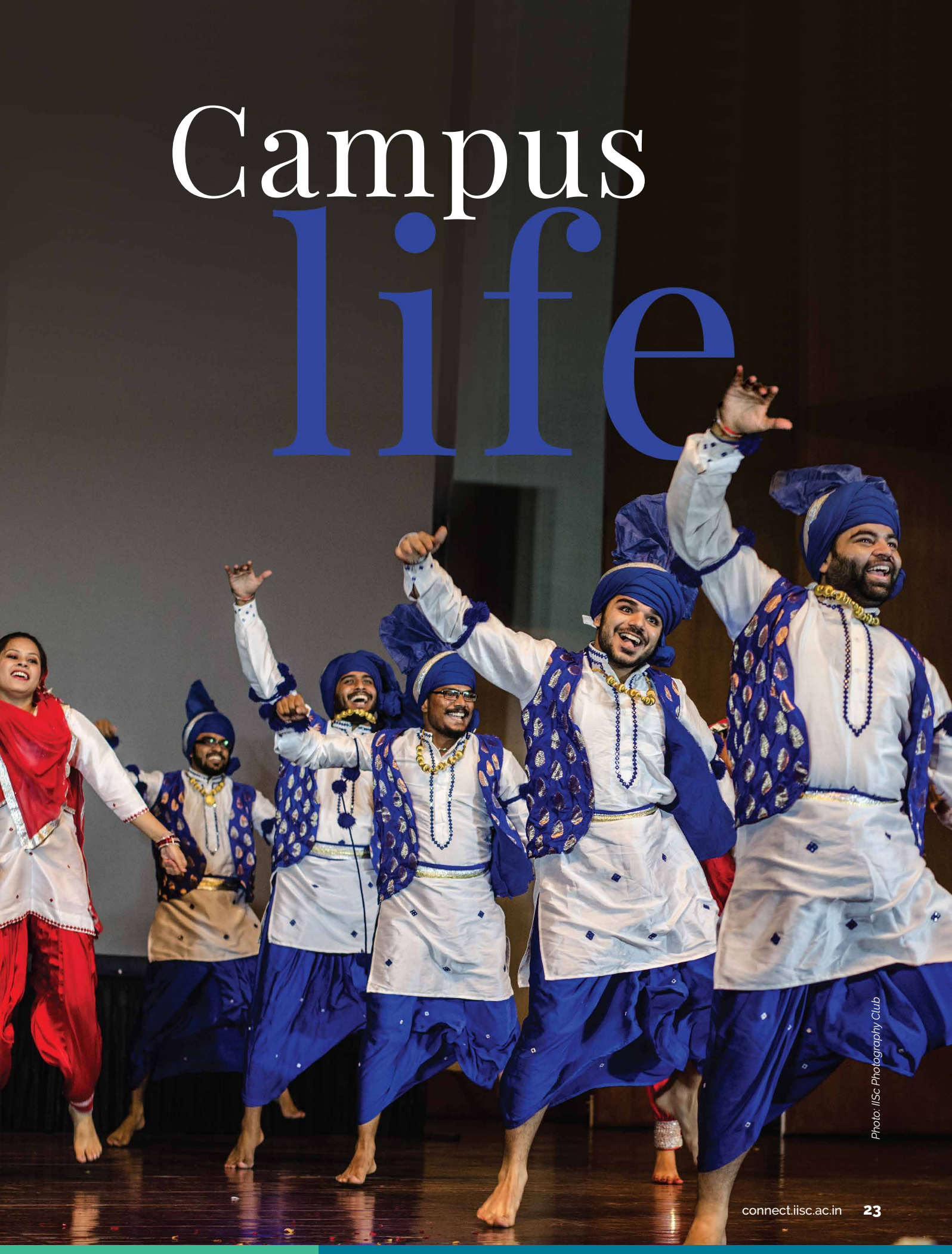


Photo: IISc Photography Club

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Photo: Chirantan Pramanik

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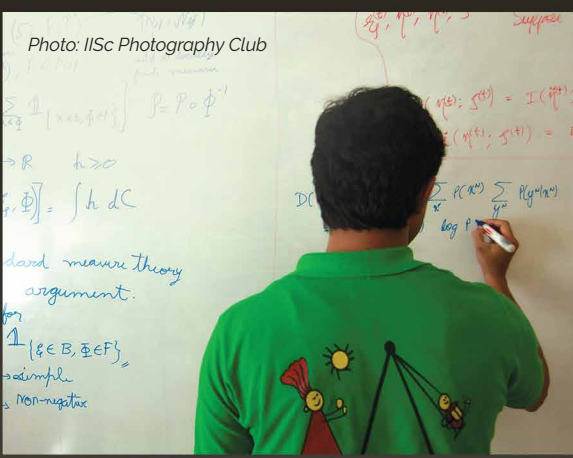


Photo: IISc Photography Club

Vikram Sarabhai's years at IISc

– Amrita Shah

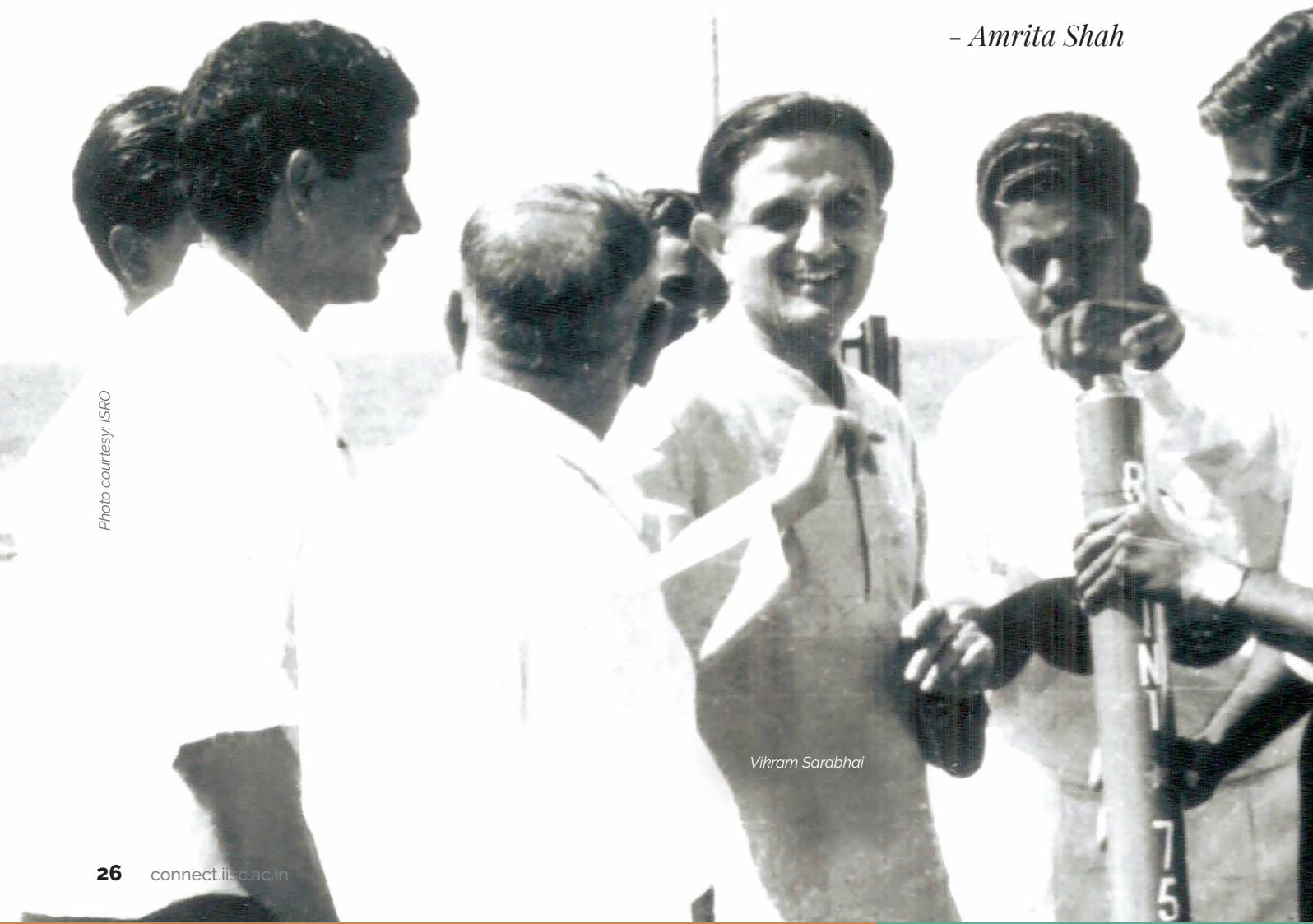


Photo courtesy: ISRO

Vikram Sarabhai

2019 is the birth centenary of Vikram Sarabhai, the founder of India's space programme, who was born in Ahmedabad on 12 August 1919. Sarabhai, pursuing his studies at Cambridge when WWII broke out, returned to India to work with CV Raman at IISc, where he also met Homi J Bhabha. In these excerpts from her book Vikram Sarabhai: A Life, *Amrita Shah recounts his time at the Institute.*

In September 1939, war broke out. Ambalal was frantic with worry. He insisted both brothers come home immediately. It was some months into the war, however, that Vikram actually made his way back to India. The interruption in his studies was a matter of concern. He had by then completed his undergraduate studies in physics and mathematics. He made inquiries with the authorities at Cambridge about the possibility of continuing his work back home and was informed that he could work on his postgraduate research in India as long as it was under the supervision of CV Raman. So, in 1940, Vikram, armed with a tripos in the natural sciences, returned to India and headed for the Indian Institute of Science in Bangalore. [...]

It is likely that Raman received Vikram with a certain degree of warmth. He knew the Sarabhais well; Ambalal had written to him, requesting him to take his son on as a student. He was also responsible for nudging Vikram towards the area of research in which he was to work for the rest of his life.

The area in broad terms was cosmic rays, the penetrating radiations coming from outer space, the existence of which was suggested by CTR Wilson, best known as the inventor of the cloud chamber in 1911. [...]

Robert Millikan, an American scientist and winner of the Nobel Prize in 1923 for his work on the electron charge, was the man who had actually coined the term 'cosmic rays'. In 1937, he had come to India to acquire data for his world survey of cosmic ray intensity, during which time he visited Raman. In 1940, he came again to carry out stratospheric balloon ascents.

In his PhD thesis, Vikram points out that most cosmic ray research at the time was being carried out in laboratories in the temperate region; South India, on the other hand, located right on the path of the magnetic equator, was of particular significance for cosmic ray investigations. The conjunction of these facts, amply demonstrated by Millikan's visits, possibly led Raman to suggest, as Vikram goes on to claim, "the initiation of experimental research in this field at Bangalore." "It was hoped at first," Vikram adds, "to make a more detailed high-altitude survey at various latitudes in India in order to supplement Professor Millikan's results, but wartime difficulties in the procuring of the necessary balloons and other radio apparatus prevented embarking on this."

The apparatus Vikram picked instead was the Geiger counter.. [...] Vikram's early experiments led to his first paper 'The Time Distribution of Cosmic Rays' which he presented to the Indian Academy of Sciences in 1942. Introducing him, Raman said, "Young Vikram Sarabhai has been brought up with a silver spoon in his mouth. He has started to do original experiments and is presenting his first paper to a scientific audience. I have great faith in him – that he will contribute much to India and to the growth of science in our country."

Whether this speech reflected Raman's genuine belief in Vikram's abilities or whether the hyperbole had more to do with the family's track record is not known. Vikram for his part had genuine regard for his supervisor. A few years later, when Raman wanted to break away from the IISc and form his own Raman Institute, it was Vikram who put him in touch with Ahmedabad-based industrialists and helped him collect a tidy capital. [...]

A relationship he formed with another formidable name in Indian science at the IISc was to be an even more significant part of his life. Homi Bhabha, the man who was to found India's atomic energy programme and loom like a Colossus over Indian science until his death in the mid-1960s, had gone to Cambridge a decade before Vikram. [...] He had been holidaying in India when the war broke out. The IISc had offered him a readership which he had accepted. [...] It was an extraordinary circumstance then that brought these two gifted individuals together. In time, the intriguing similarities and the differences of their approach would become clear; they would also develop a close professional rapport of great significance for the country's technological development. As young men in Bangalore, however, there were other, more superficial common factors to draw them to each other's company.

Photo courtesy: ISRO

In the first place, both were men of means. Bhabha's grandfather had been an inspector general of education in the state of Mysore but he was related through his aunt to the Bombay-based industrial family, the Tatas, that rivalled the Sarabhais in wealth. Both hailed from western India, an anomaly at a time when most scientists tended to come from the south or the east. They were sophisticated, though Bhabha was the more westernised of the two. They were good looking – Bhabha with his dark, brooding mien and Vikram with his delicate features and complexion so translucent that Ramaseshan was moved to describe it as *paal vazhiarathu*, meaning a baby's skin with the appearance of milk flowing below the surface. Both men also had passions outside science and a taste for the good life.

Many evenings, after work, they would head off to the posh West End Hotel, to meet with friends, mainly local, self-styled intellectuals, one of whom was an attractive Sri Lankan woman called Anil D'Silva. These apparently playboy-type excursions scandalised their co-students who were mostly middle-class, conservative Tamil Brahmins. Ramaseshan recalls wryly, "We used to look at them with envy."

Money certainly gave Vikram an enviable lifestyle. Not for him the cramped quarters of a student hostel. Even at twenty-one he had fine taste and found for himself a house with a view on a leafy slope in the northern part of the city called Malleswaram. The veteran Congress leader S Nijalingappa is rumoured to have lived for a while in this house which was called *Premalaya*. In the little house with its stone floor and sharp-angled rooms, Vikram set up home supervised by his devoted man Friday, Lala Inkayya.

Sometimes, when he was not meeting Bhabha and the others, Vikram would wander down the road from *Premalaya* to the Vedanta College run by the Ramakrishna Mission. He would seek out the priest there and chat with him about Hindu philosophy. These conversations clearly had an impact on him, for he was to refer to them in a public lecture in 1962, describing how "struck" he had been "by the great concern of ancient Indian philosophers with questions about the nature of knowledge, of the role of the observer and of the qualitative recognition of aspects of relativity." [...]

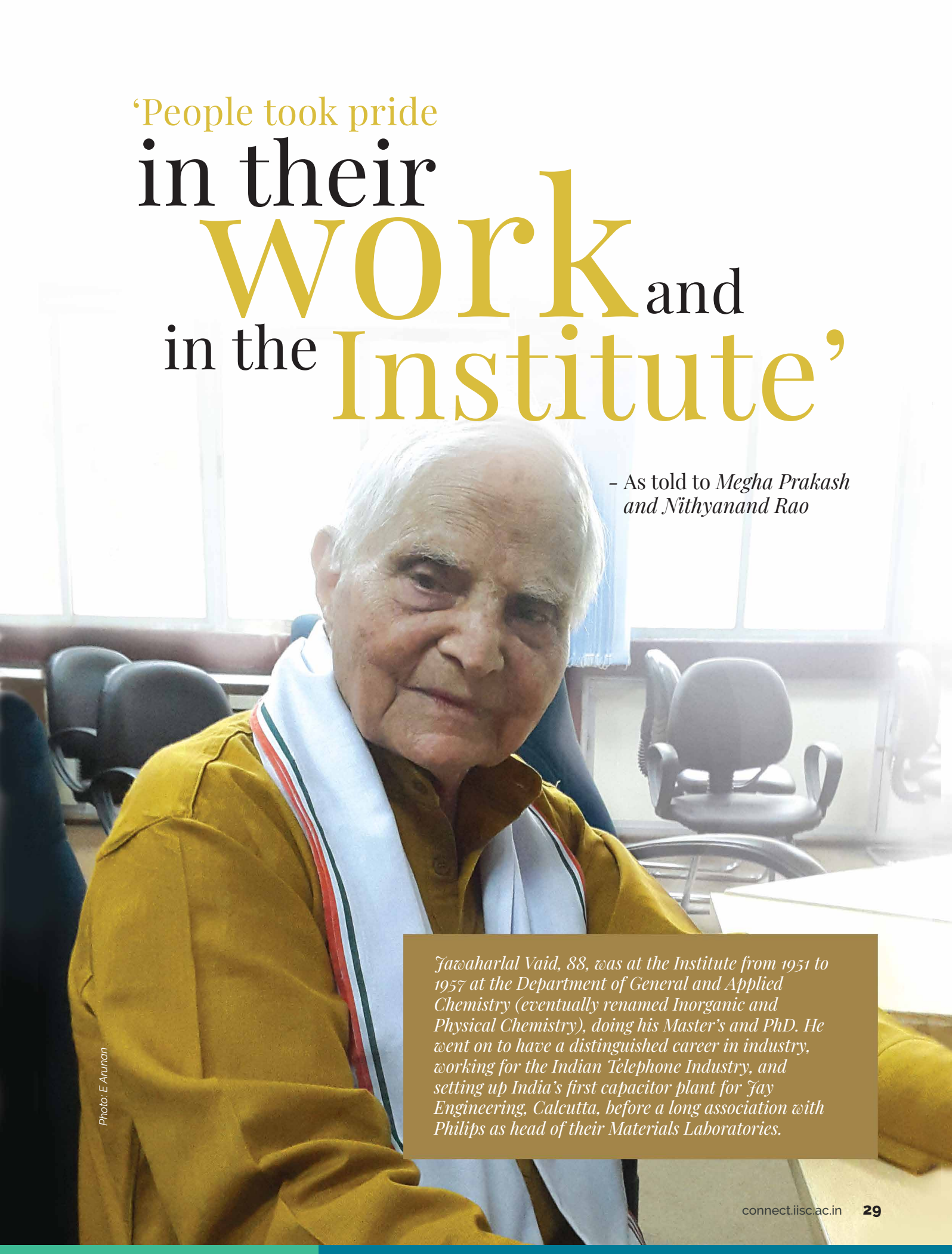
Vikram worked hard on his research in Bangalore. Bruno Rossi, a pioneer in X-ray astronomy and space plasma physics, to whose laboratory at the Massachusetts Institute of Technology (MIT) Vikram was later to go every year, would maintain that Vikram had "an almost uncanny capability to absorb and store in his mind a vast amount of experimental and theoretical data. Having done that, and guided by what I am tempted to call an artistic intuition, he would then proceed to arrange these data into a self-consistent picture, bringing out hidden regularities and relationships; a picture which, through the years, would progressively evolve and become more precise.... For him, scientific research was an act of love towards nature."

Excerpted with permission from Penguin Random House India

Amrita Shah is a journalist and was a visiting faculty at the Centre for Contemporary Studies (now the Centre for Society and Policy).

‘People took pride in their work and in the Institute’

– As told to *Megha Prakash and Nithyanand Rao*



Jawaharlal Vaid, 88, was at the Institute from 1951 to 1957 at the Department of General and Applied Chemistry (eventually renamed Inorganic and Physical Chemistry), doing his Master’s and PhD. He went on to have a distinguished career in industry, working for the Indian Telephone Industry, and setting up India’s first capacitor plant for Jay Engineering, Calcutta, before a long association with Philips as head of their Materials Laboratories.

Photo: E Arunan

Punjab and the Partition

I grew up in Kot Kapura, near Firozpur in Punjab. Ours was a big family – we were nine siblings, and I was the third child – but with small means. We had enough to eat, and that's all. But we enjoyed our childhood thoroughly. We went to the local municipal school, walking 3 miles everyday. The lingua franca in school was Urdu, and so my first language is Urdu, even though this was a Sikh school. We even used to wear a turban to school. I was the shortest in my class, throughout my school years. And I always felt that something was wrong with me because other people were taller, stronger. Fortunately, I had a teacher in the 9th standard, who taught science and math, Master Munshiram, who told me: "You should be better than everybody else in studies. That is the only way you can lift yourself." I took his advice and topped my matriculation exams in 1945.

Then I joined the Dayanand Anglo-Vedic College in Lahore, where my elder brother, Hiralal, had completed his Master's from. I remember very well the ninth day of August in 1947 – half the city was burning and people were on the streets, but even then, examinations were going on. After the last exam of my intermediate [equivalent to today's 12th standard] that day, I somehow walked to the railway station and took the first train home. That was the last day I was in Lahore.

Like me, there must have been thousands of other boys and girls who had given their exams and then moved from one side of the border to the other after Partition. We had no idea when and how we would know our examination results. We had lost all hope. Then, one day, after about eight months, I got a printed postcard with my results, saying I had passed with distinction. Just a printed postcard with a signature, that was my certificate. I don't know how they found my address, but it was a godsend. *Salaam* to those educationists in Lahore who sent the results of the students who had migrated to this side, to East Punjab University, Solan. Children's careers were important to them, despite the Partition and all that happened.

Learning Chemistry

My brother, Hiralal, was in the UK at the time. He had gone there in 1946 for a doctorate in chemistry under a government scheme that sent students abroad for training. I sent him a letter, and he replied saying I should do an honours course in physics if I can.

Photo courtesy: Minnie Vaid

Jawaharlal Vaid with his mother and siblings

This was around May 1948. My father told me that I should leave immediately for Delhi. I was 17 years old – I didn't know where to go, where to study, or what to study. I went to Delhi, with only a tin box and bedding. Upon arriving at Delhi University, I was told that the barracks behind the University housed the Punjab University Honours School for chemistry and physics.

But it was too late to get admission for physics that year. As I sat disheartened in the long veranda of the military barrack, a Sikh gentleman walked past me. So vividly I still remember – he was wearing white clothes, white turban, white sandals, and had a white beard. He came back and asked me in Punjabi who I was. I told him my story. It turned out that he was Principal Niranjan Singh, and he had been the head of the chemistry honours school in Lahore and had taught my elder brother there. He said he could get me admission in chemistry, and I followed him.

The hostel was in the barracks, a dormitory. We had to use public toilets and bathe under a public tap, and eat whatever we could afford from the street. Our classes were held in the afternoon, after Delhi University's classes were over and the lecture hall was free. But we never felt alone because all of us were in the same boat. Later, because of the inadequate infrastructure and facilities, we were shifted to Government College, Hoshiarpur, and finished our honours course there.

To Bangalore

I completed my BSc (Hons) in 1951. My elder brother, who had just returned after his PhD, was among the first scientists appointed at the National Chemical Laboratory (NCL), Pune. I decided to visit him. For a few days, I stayed with him in the NCL hostel and enrolled for a Master's at Pune University. Here, I met SK Kulkarni Jatkar, a retired professor from IISc. One day, he called me to his office and, after asking me what I was doing there, advised me to apply to the Indian Institute of Science (IISc) in Bangalore. When I told him that I had already applied but hadn't received a response, he immediately tore a paper from his notepad and wrote to Prof KR Krishnaswami, then the head of the Department of General and Applied Chemistry [now known as Inorganic and Physical Chemistry], asking him to take me as a student.

I was amazed at how a professor unknown to me wrote to someone in Bangalore to help me. He didn't ask me anything, he just saw a boy struggling hard, and said "Go this way". I will remember him and the sardarji till the end of my days. With just Rs 22 in my pocket – out of which Rs 7 I spent on the train ticket – and my tin box and bedding, I arrived in Bangalore. This was 1951, June or July. Prof Krishnaswami sent me to the hostel, where Mr Patham was the warden. For the first time in my life I had a room to myself. And I could have all four meals in the mess for Rs 32 a month. It was like *jannat*, to have such an organised hostel life and meals.

> *For the first time in my life I had a room to myself*

Krishnaswami gave me 45 rupees a month as scholarship. I don't know where he got it from, I never questioned him and he never told me. Later I received Rs 100 a month as a junior scholarship from the Government of India, and then a senior scholarship of Rs 200.

Academics at the Institute

There were very few occasions when we met Krishnaswami. He suggested that I work under the guidance of Dr TL Ramachar, in Electrochemistry. The Department also had the Inorganic section headed by CC Patel, and the Physical Chemistry section headed by MR Aswathanarayana Rao. Dr Ramachar was a person of very few words, a simple person. He used to come in the morning at about 9.30 am and exactly at 5 pm he would take his umbrella and leave.

For my Master's thesis with Ramachar, completed in 1953, I worked on non-cyanide baths that used pyrophosphates for electroplating instead of the cyanide baths which are toxic and dangerous. I was Ramachar's first doctoral student and for my PhD thesis, I studied tin-based alloy deposition in various systems. In all my stay at IISc, Dr Ramachar was my guide, but I also treat as my guru Dr Aswathanarayana Rao. Whenever I was in Bangalore later on, I always went to meet him. There was such a bonding with him. He was humorous, and he had such a voice that you could hear him from the other end of the Department.

The Department had some 12 staff members, eight or nine lab boys and typists, and 13 or 14 students. All the labs worked till midnight. Nobody told us to work like that; it was our urge. The spirit, of the professors also, was that you are working on a time-bound problem and you should finish on time. When you needed guidance, it was given, but otherwise you were expected to be on your own. You had to have the habit of independent working. You had to search the literature yourself in the library. If your research wasn't progressing for a while, you could go on vacation, or go outside campus for a few days, and come back with your mind refreshed. The professors even gave us the freedom to not attend classes. They would ask those not interested to please feel free to leave.

People took pride in their work and in the Institute. The joy of being in the Institute is something which is missing today, even though it has more people now. You are in the highest learning centre in India, and you should be proud of it.

It was an unwritten tradition that you stopped working at 4.30 pm and went for your evening tiffin, and then to the library or to play sports at the Gymkhana. There was no football or cricket at the time at IISc; we had tennis, table tennis, hockey and billiards. Then you would take your bath, have meals and go back to the lab.

> *You are in the highest learning centre in India, and you should be proud of it*

The Director MS Thacker and Prof Brahm Prakash [Metallurgy] used to come occasionally to mix with the students at the Gymkhana. EG Ramachandran [Asst Prof, Metallurgy] would come to play regularly.

He was a good athlete; he could match Satish Dhawan in tennis. I remember that Satish was a dashing, tall and handsome young man, a good athlete, and every girl at IISc had her eyes on the bachelor – they used to spy on him. Then he married Nalini Nirody, who was a beautiful and gracious lady. They were a lovely couple and she became the centre of attention for boys whenever she visited the Gymkhana! She was very friendly and everyone was enamoured of her.

crockery outside the mess and declared that the invited guests will be served on banana leaves. Then, a lady from the Dorabji Tata Trust learned about this incident, and through her we were able to get brand new crockery.

We used to celebrate Diwali and Holi without any barriers between students from different regions or between the staff, students and faculty. We even used to go to our professors' homes for sweets on these occasions.

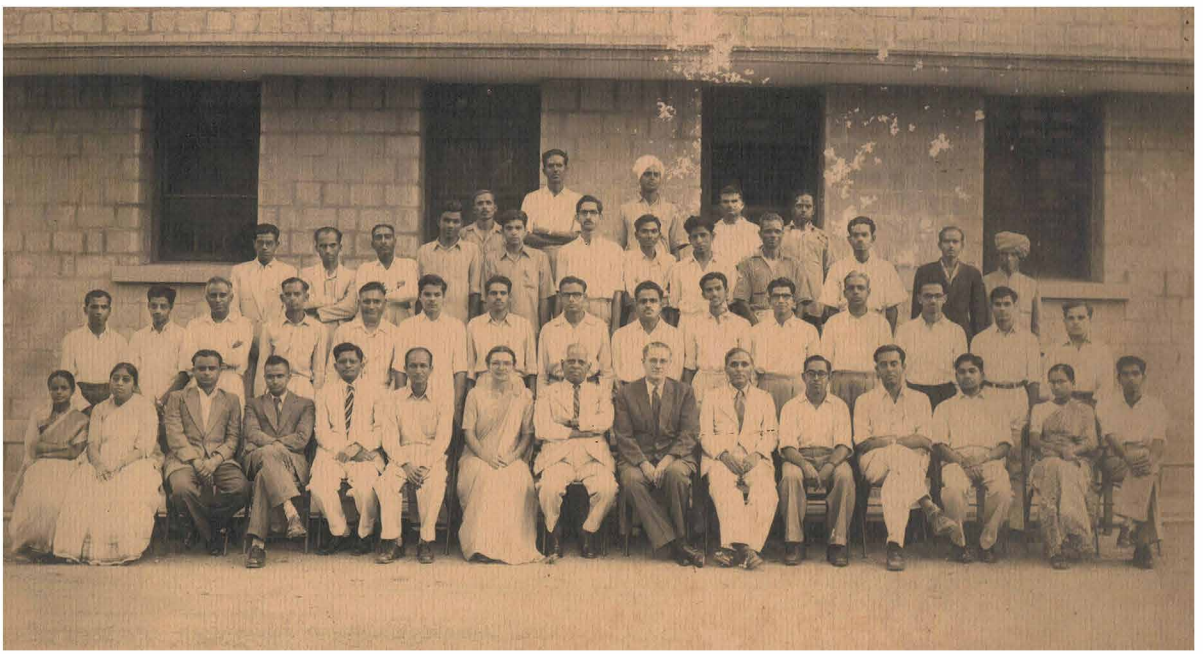


Photo: IISc Archives

Members of the Department of General and Applied Chemistry, 1950s. Jawaharlal Vaid is standing in the second row, first from the right.

Student Life at the Institute

I remember that mess presidents were served food on a reserved table, unlike other students. I was elected as the mess president for one term. During that time, the Institute had just welcomed summer students and, once, a group of five or six students came in shouting, dressed in their night pyjamas. I told the mess attendant to tell them to maintain discipline, but these students yelled back. So I asked them to leave the mess premises immediately. They went to the Registrar to complain, but he asked them to leave the Institute instead. This was the kind of discipline and tradition at the Institute.

I remember another incident during my tenure. We were organising a dinner for Founder's Day. A few days before the feast, we found that the crockery was chipped and required replacement. A budget proposal was sent to the Acting Director, Dr Sreenivasan. He refused. So we dumped the old

Working in the Industry

After my PhD, I was selected as a chemist at the Indian Telephone Industry (ITI), Bangalore, even though they were looking for someone with 10 years' experience in the metal finishing industry, aged not less than 35, to replace their chief chemist who had left. The General Manager of ITI at the time was Mr NK Sengupta, who became one of my mentors.

On my first day, I met the plant manager and he asked me to measure the diameter of a brass rod. I took 42 seconds; he took 17 seconds. It's the first lesson I learned about industry – speed is the name of the game. We can always do things better, faster and cheaper, and I have said this in so many seminars and management meetings.

I had joined ITI on the condition that there would be no one above me, so I left the job when their

former chief chemist returned. The confidence to do this came from the training I got in the Institute. I then joined the Central Electro Chemical Research Institute (CECRI) of the Council of Scientific and Industrial Research (CSIR) in Karaikudi [in Tamil Nadu]. This was on the advice of Prof MS Thacker, former Director of IISc, whom I met in New Delhi where he was the Director-General of CSIR.

Photo courtesy: Minnie Vaid

Vaid in his youth

I joined CECRI as Junior Scientific Officer. Soon, I got a message from NK Sengupta. I went to meet him and he told me that the National Physical Laboratory (NPL), Delhi, had developed a process for making silver-mica capacitors indigenously in India. The capacitors were thus far being imported from the UK. He wanted me to go to NPL and find out if it's worthwhile to manufacture them for ITI or not. I knew nothing about the damn thing and he was saying let's put up a plant!

I went to meet Dr TV Ramamurthy at NPL, who headed their research on electronic materials and is known as the father of the Indian electronics component industry. He said, "Don't feel nervous." I said I will never feel nervous. At the most I will fail and then I will go back and do something else. This was the Institute talking: a never-say-die attitude. I spent a month at the Institute library learning about these capacitors. In a few months, a pilot plant was established in the backyard of NPL with the help of Dr Ramamurthy and some people from ITI. But it took the life out of me.

We moved the plant back to ITI, Bangalore, but I decided to leave. I was about to join as Lecturer in the Department of Electrochemistry at IIT Bombay, when I got a telegram from one TR Gupta, General Manager of Jay Engineering, Calcutta, [now Kolkata] requesting me to meet him. He had also enclosed an air ticket. Gupta ji had a proposal. His company, under the Usha brand, made 50 to 70 thousand fans per month. But every fan needs a capacitor, and they imported these from Nichicon in Kyoto, Japan, the world's leading capacitor manufacturer. There was no capacitor plant in India at all. Gupta proposed that we start manufacturing capacitors here and then others could buy from us.

I went to meet him, and it turned out that Dr Ramamurthy had suggested my name. They sent me to Kyoto to work with the Japanese for a few months. Then we established a plant with Japanese help, and this was how India Capacitors Pvt Ltd was set up. By the end of 1959 we were making up to 70,000 paper capacitors for the fan industry. Philips was our sole buyer and, after six years with Jay Engineering, I joined Philips as head of their Materials Laboratories. My association with Philips lasted 25 years before I retired.

During my time in Japan, I had observed how the electronics industry had worked together to standardise the components and materials they used. This ensured inter-usability across the industry and brought down the cost of production. Prof Ramamurthy encouraged me to do the same in India and I was associated with the Indian Standards Institution for many years as a chair of various committees tasked with standardisation, to bring our standards in line with those of the International Electrotechnical Commission. This work was close to my heart. I was also made a Fellow of the Institution of Engineers (India), though I was not an engineer.

The world is large, and you need confidence in yourself, which the Institute teaches you. Throughout my career, the moral strength came from the Institute – that if you're right, fight for it. I'm grateful to my teachers at the Institute. And my biggest bow is to the house of Tatas that created an institute with such facilities, where someone like me could come and study.

Megha Prakash is a freelance journalist

Beating the jam

– *Ranjini Raghunath*

Using technology to tackle India's terrible traffic

Last summer, the image of a software engineer riding a horse to protest against Bangalore's notorious traffic jams went viral on social media. "Bengaluru is overcrowded and too many vehicles on the road lead to traffic jams every day," he was quoted as saying. "In fact, I learnt horse riding because of the traffic headache."

Internet memes and hand-wringing aside, little has been done to systematically address the city's traffic troubles in the past few decades. The 90s' IT boom transformed this quiet retirement town into a bustling metropolis. Since then, the city's population growth has far outstripped its infrastructure development, with its narrow and pothole-riddled roads struggling to contain the increasing number of privately-owned vehicles. The resulting traffic snarls are costing the city a staggering $5.9 billion annually, according to a 2018 Boston Consulting Group report.

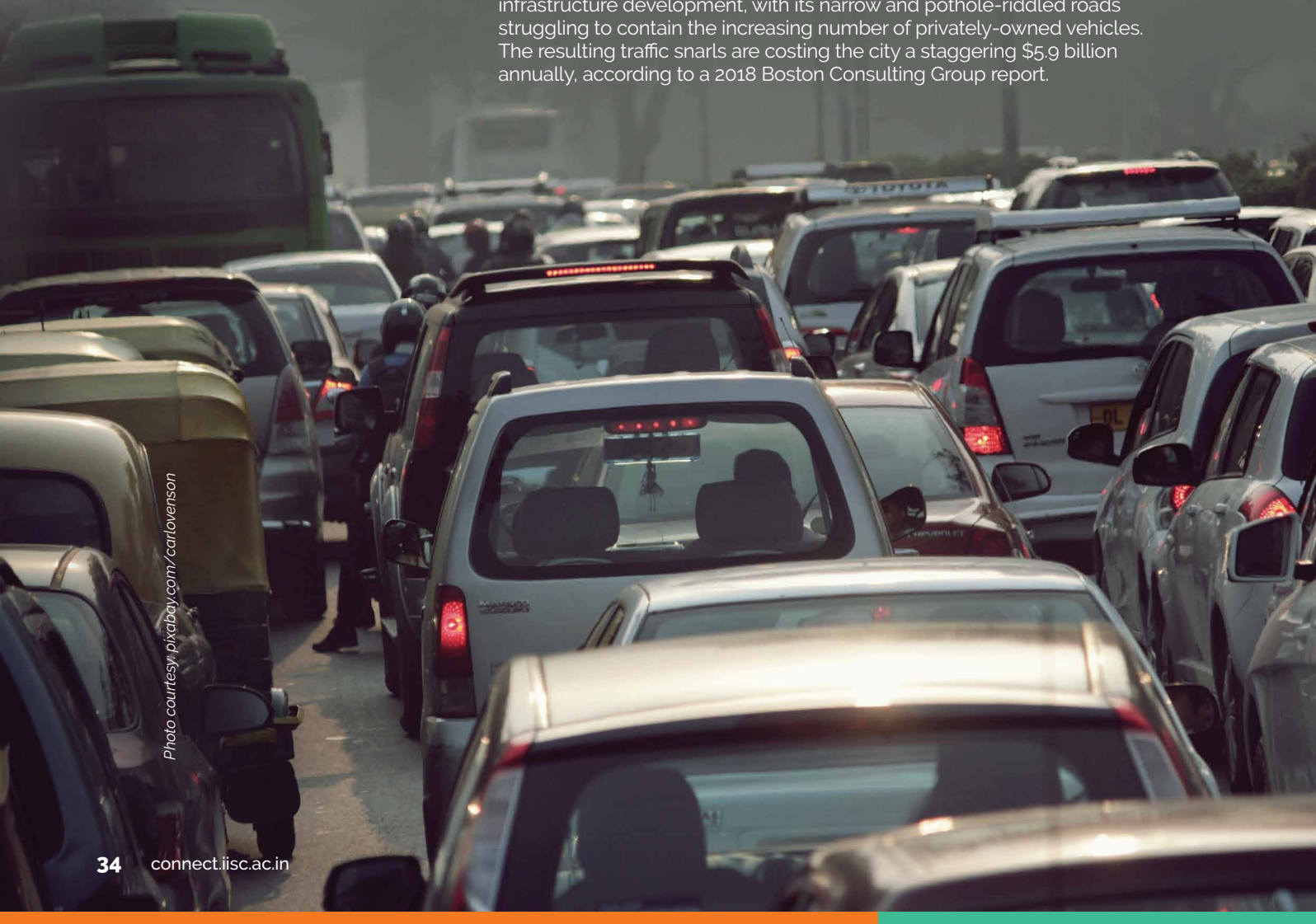


Photo courtesy: pixabay.com/carlovenson

One way to reduce congestion – and related problems such as emissions and accidents – is to revive the city's public transportation systems, says Abdul Rawoof Pinjari, Chair of the Centre for infrastructure, Sustainable Transportation and Urban Planning (CiSTUP).

> *One way to reduce congestion – and related problems such as emissions and accidents – is to revive the city's public transportation systems, says Abdul Rawoof Pinjari*

CiSTUP was set up at IISc during its centenary to work closely with government agencies on transportation and urban planning issues. In recent years, the Centre, along with researchers at the Department of Civil Engineering, has largely focused on figuring out ways to boost public transit systems.

One of their current projects, for example, involves using the power of the Internet of Things (IoT) to improve first- and last-mile connectivity. In recent years, app-based services such as Ola and Uber have exploded in popularity. IISc researchers are trying to see if these services can be synced with the movement of buses and metro trains to pick commuters from bus stops or train stations and drop them off at their final destinations. They are developing algorithms and models that use GPS data to track buses in real-time and help service providers decide how many autos or cars they would need to provide, when and where.

"We want to see if there is a win-win for both transit agencies and on-demand mobility services. If the model is successful, it will increase ridership and reduce congestion," says Pinjari.

Image: Sangram Nirmale

Envisioned interactions and data flows for real-time reliability and last-mile connectivity in public transit systems

He and his colleagues are also trying to address the problem of bus bunching, in which a delay by one causes two or three on the same route to arrive together, adding to crowding and reducing commuters' confidence in the system. Working with the Centre for Development of Advanced Computing (C-DAC) and IIT Madras, they are building an app that would display "reliable" bus routes to users, and indicate how crowded an upcoming bus might be, based on ticket sales data.

"Providing this information will help balance loads. People would start to shift from more crowded to less crowded routes," says Tarun Rambha, Assistant Professor at the Department of Civil Engineering and a co-investigator on the project. Transit authorities will also be notified when bus bunching happens and asked to hold buses at one of the transit hubs for a specific duration to break the bunching and get schedules back on track.

Public transport systems also struggle with irregular driver behaviour. Researchers from CiSTUP and the Robert Bosch Centre for Cyber-Physical Systems (RBCCPS) at IISc have teamed up with a deep-tech startup called Netradyne Technology India Private Limited to fit buses with devices that can track and infer drivers' behaviour.

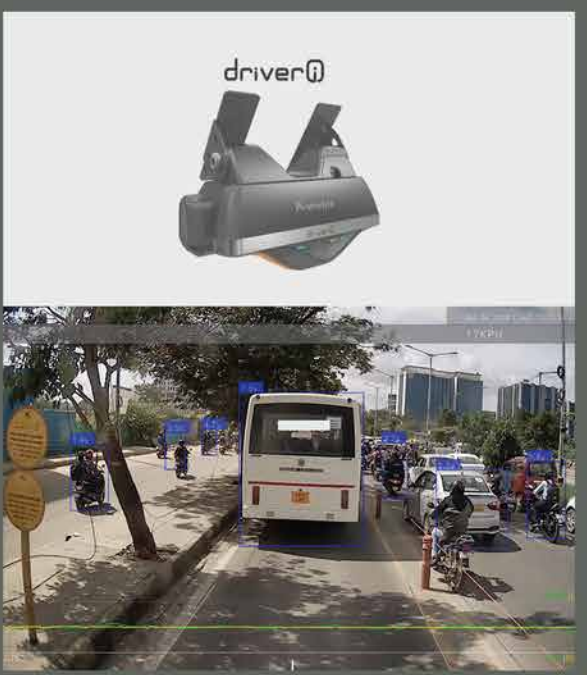


Photo courtesy: Netradyne and CiSTUP/RBCCPS

A device being deployed on buses to track driver behaviour

These devices, which have four cameras, processors, accelerometers and gyroscopes, use artificial intelligence and machine learning to trigger automated alerts to drivers and fleet managers in case of speeding, sudden braking, tailgating or

similar events, with video evidence. The devices are being deployed on 40 buses that ply on the new Bus Priority Lane in the Outer Ring Road between Silk Board and Byappanahalli, one of the most congested routes in the city. The Bengaluru Metropolitan Transport Corporation (BMTC) also hopes to use these devices to watch for other vehicles that may misuse this lane, says C Shikha, its Managing Director.

"In such schemes, the critical issue is enforcement. We have to ensure that other vehicles don't enter this lane," says Shikha. "When we were grappling with this problem, CiSTUP came up with the innovative solution of installing these cameras on the buses." Although installed for real-time alerts and driver behaviour studies, Shikha says that the cameras could, for example, automatically capture the licence plates of violators and send them to the Bengaluru Traffic Police.

Simulating a city

When such pilot projects show promise at the route or zone level, the next step is to scale it up to the city. However, rolling out a new traffic policy can have ramifications across the entire transportation network. Researchers need to first develop city-scale simulation models to test the impact of new measures before they are launched.

But modelling Indian traffic isn't easy, according to Ashish Verma, Associate Professor at the Department of Civil Engineering.

In the US, cars make up the bulk of road traffic and follow lane discipline. Whereas Indian roads are a chaotic jumble of buses, cars and two-wheelers that don't stick to lanes but squeeze into whatever gaps they can find.

> *Indian roads are a chaotic jumble of buses, cars and two-wheelers that don't stick to lanes but squeeze into whatever gaps they can find*

Verma's lab has been trying to develop basic models and modify existing theories to suit India's "heterogenous, disordered" traffic. In 2018, they published a modified version of a well-established signal delay model by introducing a new queuing behaviour that takes into account this gap-filling attitude. Using this, they were able to propose more effective timings for three separate intersections in Bangalore.

Verma's lab also spent four years developing a city-scale travel demand model for the whole Bangalore Metropolitan Region (BMR), as part of an Indo-Norwegian project called CLIMATRANS. They used this model to come up with a slew of bundled policy interventions that would reduce congestion and emissions. A comprehensive report published by them is now being referred to extensively by the Karnataka government and different transit agencies to chalk out their plans.

Building these models typically requires extensive data collection. In collaboration with the Electronic City Industrial Township Authority (ELCITA), CiSTUP researchers have been using CCTV cameras, computer vision algorithms and traffic counting equipment to capture the movement of vehicles in Electronic City Phase I. Surveys have also been carried out among employees at various IT companies to gauge traveller behaviour and choice of modes and routes.

Combining these two sets of data has helped build a virtual replica of Electronic City's traffic network that can be used by ELCITA to run some *what-if* scenarios. "For example, when the metro rail network is expanded to Electronic City, how will the travel patterns change? Will congestion reduce; by how much? These models are sensitive to such changes in the system, and can predict what will happen to various travel indicators," says Pinjari.

The model showed, for example, that installing traffic signals at some junctions would cut down overall travel time by 20-25 percent, says Ranju Mohan, Consultant Scientist at CiSTUP. It also showed that real-time adjustment of signals would be more effective than fixed timings. Based on this suggestion, ELCITA has now partnered with Siemens to use Google Maps data to dynamically adjust their signal timings at 13 junctions.

Outdated solutions

Technological advances may have boosted traffic management, but there are several cultural and political barriers that also need to be overcome.

While cities around the world are looking at beefing up cycling and walking infrastructure, reclaiming public spaces, and improving public transport corridors, Indian urban planners are still stuck on outdated solutions such as building flyovers and widening roads, says Verma, who frequently interacts with policymakers and the public.

He cites the examples of the controversial steel flyover and elevated corridor projects that were recently proposed by the Karnataka government. His team analysed the impact of these projects and

published reports showing that congestion would only worsen. "We gave these to the concerned agencies who mooted those projects and also debated them in public forums. People filed Public Interest Litigations with our reports. Eventually, both projects were shelved," he says.

Photo: Kishore Raju/Tejasvi Surya media team

Ashish Verma sharing a copy of the CLIMATRANS report with Bangalore South MP Tejasvi Surya during a discussion on ways to mitigate traffic congestion

Another flaw is that traffic signals – which contribute greatly to travel delays – are still manually handled by the police, instead of automated systems. "The constables are on the ground...standing at a junction and pressing a button," says Verma. The effect that their individual decisions can have on subsequent junctions is often ignored, he says.

The transportation governance structure in Indian cities is also fractured. Many major cities abroad have a unified, central authority – Transport for London, for example – that brings all of the city's modes of transportation under one umbrella. "Whereas, here we have 10-15 different agencies handling transportation within a city," says Verma. Although a central Bangalore Metropolitan Land Transport Authority was set up in 2007, it has long been defunct, and plans to revive it are still on paper.

These governance gaps can especially affect the flow of data between agencies, a factor that is crucial for the transformation of today's metropolises into smart cities of the future.

A data-driven future

When the Smart Cities Mission was launched in India in 2015, it ushered in hope that governments would finally start recognising the value of the data collected by their departments. A key expectation was that cities would use cutting-edge IoT technologies to analyse all this data, and make "smart" decisions on improving their infrastructure and services. On the heels of this launch, researchers at RBCCPS began evaluating what kind of IoT technologies would help.

"We found that the biggest challenge is not the technology itself for extracting data," says Bharadwaj Amrutur, Chair, RBCCPS. "The problem is getting access to the data, having the right people look at the data and do something with it."

For example, an app could theoretically crunch data on GPS locations, camera feeds from inside buses and ticket sales, and tell the user how crowded an upcoming bus is. But in reality, there are several obstacles. The data may be in silos, with different agencies who may not share them easily. Even if they are shared, they may be unusable because they are not readily available in a format that can be fed into the app or understood by another person or agency. And cities are talking about integrating data not just within one sector such as transportation, but across sectors: water, power, infrastructure and more.

This realisation led RBCCPS to come up with a proposal for the Indian Urban Data Exchange (IUDX), under the aegis of the Ministry of Housing and Urban Affairs. IUDX is an open source software platform that would provide standardised protocols and templates for how data should be described, stored and retrieved in a way that can be used by everyone: entrepreneurs, industries, academic researchers, policymakers and citizens.

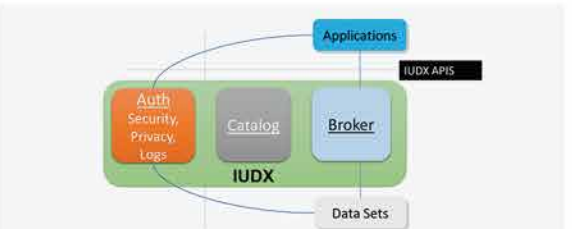


Image: RBCCPS

IUDX: An open source software platform for data exchange

"Think of it as the grammar with which you can describe the format of the data," says Amrutur. IUDX will provide standardised Application Programming Interfaces (APIs) – protocols that allow software programs to talk to each other – as well as mechanisms for controlled sharing of data. "With this framework in place, hopefully the data from all sources will be made available through what we are calling an urban data exchange for every city," he says. This can eventually be scaled up to enable data sharing between various cities.

As with traffic management, cultural concerns also need to be addressed here. "Traditionally, we are not a data-driven society," says Amrutur. "They [stakeholders] have the data, but are either apathetic to it, or don't know how to use it for their operations." This is where institutes such as IISc can pitch in, he says, by helping to analyse the data, offering courses and training programmes, and advising on policy making.

In the end, no single initiative can act as a silver bullet, Pinjari points out. "Each will have a delta improvement," he says. "All the deltas together will lead to greater improvement."

When Raman brought Born to Bangalore

– *Karthik Ramaswamy*

11 December 2019 marks the birth anniversary of Max Born, who came to IISc on CV Raman's invitation

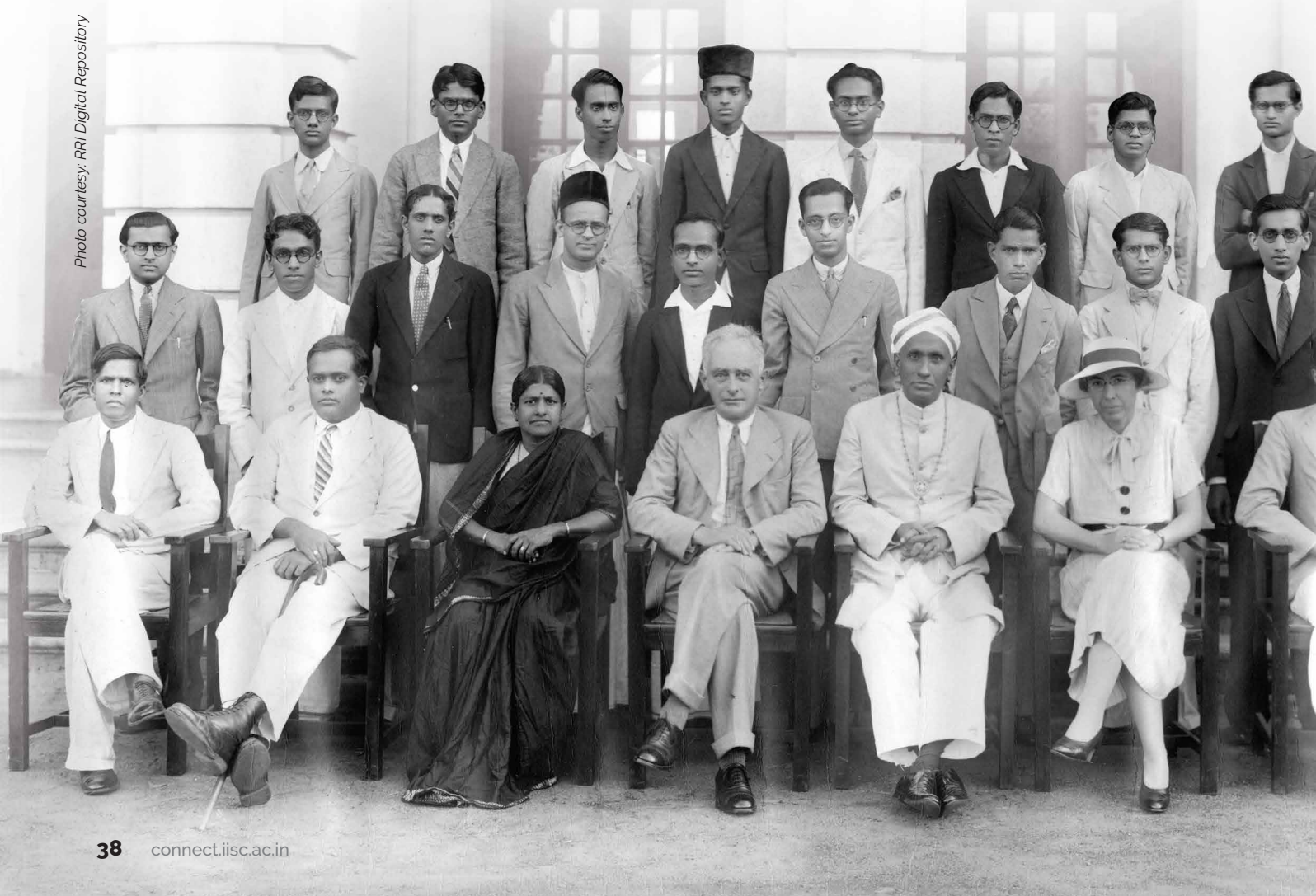
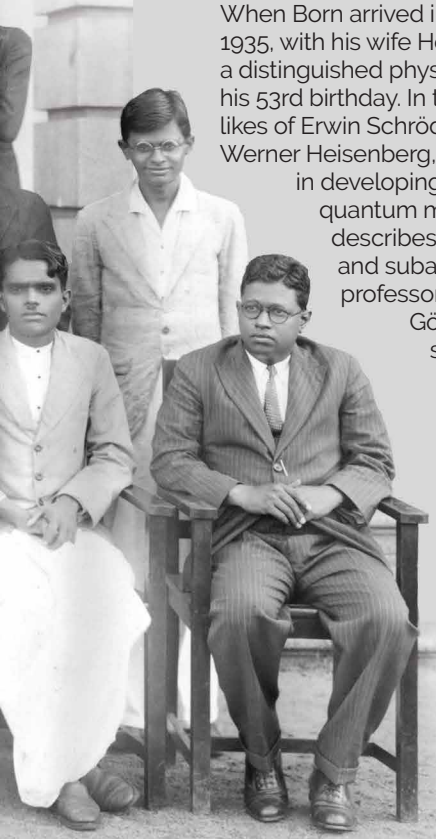


Photo courtesy: RRI Digital Repository

The Mysterious Number 137 was the title of a lecture that Max Born delivered to the South Indian Science Association in Bangalore on 7 November 1935. Called the fine structure constant α, 137 is a dimensionless entity (its value is actually its reciprocal), calculated using the charge of an electron, Planck's constant and the speed of light. Since the early 1900s, some physicists have suggested that this number could be at the heart of a Grand Unified Theory because it combines electromagnetism, gravity and quantum mechanics.

The talk was among over 30 lectures that Born gave, both within and outside the Institute, in his capacity as a Reader in Theoretical Physics at IISc, a position he held for six months. The Institute's 1935-36 Annual Report states that his presence provided *great stimulus* to the work in the Physics Department, which had just been established by IISc's Director CV Raman. The report adds that besides giving lucid lectures, Born continued his own investigations and directed theoretical physics research in the department. But during this period, a political drama, in which Born inadvertently became an actor, was also being played out – one that determined not just his future at IISc but also that of Raman and the direction of research at India's best known science institution.

When Born arrived in IISc on 28 September 1935, with his wife Hedwig (Hedi), he was already a distinguished physicist who was closing in on his 53rd birthday. In the 1920s, along with the likes of Erwin Schrödinger, James Franck, and Werner Heisenberg, he had been instrumental in developing the foundations of quantum mechanics, the theory that describes nature at the scale of atoms and subatomic particles. As a professor at the University of Göttingen, he mentored several physicists, including Enrico Fermi, Robert Oppenheimer and Pascual Jordan – besides his assistant Heisenberg – making the German university one of the most important centres for physics in the world.



Max Born (fourth from left) with Lokasundari Ammal (third from left), CV Raman (fifth from left) and Hedi Born (sixth from left) at IISc. Also seen are Raman's students

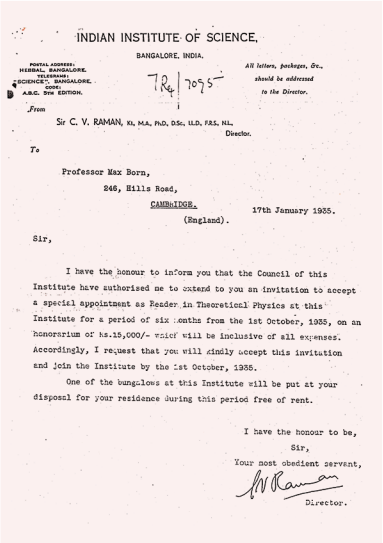
But not long after, Born's life – both professional and personal – came to a crossroads. In 1928, he had been nominated by Albert Einstein for the Nobel Prize in Physics (Einstein himself had a strained relationship with quantum mechanics. Annoyed with its probabilistic nature, he famously declared in a letter to Born that "God does not play dice with the universe"). The Nobel Prize Committee, however, did not deem Born's work worthy of the honour, even though Heisenberg received the Prize in 1932 and Schrödinger the following year (Born eventually won the Prize in 1954). But, by the early 1930s, being overlooked for the award was not what was uppermost on his mind.

Adolf Hitler became Chancellor of Germany on 30 January 1933. "Then one evil event followed the other," writes Born in his autobiography *My Life: Recollections of a Nobel Laureate*. On 25 April, he was suspended from his job because of his Jewish heritage. In the coming months, he was also to lose his doctorate, professorship, property, and citizenship. When he was suspended, Born's first thought was about the effect it would have on the research at Göttingen. "All I had built up in Göttingen, during twelve years' hard work, was shattered. It seemed to me like the end of the world," he writes. His next thought was the safety of his family. "I went for a walk in the woods, brooding on how to save my family," he adds. He realised that they – Max, Hedi, and their daughters Irene and Gritli – had to leave their homeland. In early May, they fled Germany by train and made their way to northern Italy.

The family then moved to Cambridge, UK, where Born had been offered a temporary lecturership position. During his time there, he received a letter from India. It was from Raman. The Indian physicist had, with the help of KS Krishnan, discovered what came to be known as the Raman Effect. The discovery, for which Raman was knighted in 1929 and won the Nobel Prize in 1930, provided further evidence for the quantum nature of light.

In the letter, Raman asked Born if he could recommend names of "young and efficient" theoretical physicists who might be interested in working in IISc. The latter responded by saying that even if he did, he could not persuade any of them to go to Bangalore without knowing much about the place. Then Raman wrote back asking Born if he himself could come to IISc for six months to "have a look at the place." Born was inclined to make the move since his Cambridge appointment was going to end soon. He consulted with Hedi, who readily agreed to join him. At Cambridge, she had no friends, felt cut off from her roots, and was overworked, according to Born. Once Born said yes, it did not take Raman long to convince the Governing Council of IISc to create a temporary position of Reader in Theoretical Physics. For his services, Born would receive an honorarium of Rs 15,000 for a period of six months, more than what he was getting paid at Cambridge.

Image courtesy: IISc Archives



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TR4/7095

All letters, packages, &c., should be addressed to the Director.

From

Sir C. V. RAMAN, Kt., M.A., PH.D., D.Sc., LL.D., F.R.S., N.L.
Director.

To

Professor Max Born,
246, Hills Road,
CAMBRIDGE.
(England).

17th January 1935.

Sir,

I have the honour to inform you that the Council of this Institute have authorised me to extend to you an invitation to accept a special appointment as Reader in Theoretical Physics at this Institute for a period of six months from the 1st October, 1935, on an honorarium of Rs.15,000/- which will be inclusive of all expenses. Accordingly, I request that you will kindly accept this invitation and join the Institute by the 1st October, 1935.

One of the bungalows at this Institute will be put at your disposal for your residence during this period free of rent.

I have the honour to be,
Sir,
Your most obedient servant,
C V Raman
Director.

Letter of appointment as Reader in Theoretical Physics from CV Raman to Max Born

The Borns arranged for their children to be sent to live with families of friends and set off for India on the steamer *Staffordshire*. They arrived in Cochin (now Kochi), where they spent a day, and travelled to Bangalore from there. At IISc, they were received by Raman's wife Lokasundari Ammal, who took them to a two-storey bungalow, which was to be their home for the next few months. "We had a large garden with beautiful trees and flowers," writes Born, "and two tennis courts which were screened off by marvellous bougainvillea shrubs. The Raman family lived in a similar house just across the road."

The Borns did not get to meet Raman for the first few days. And when they did, they were fascinated by his appearance and talk. To Hedi, Raman in his Indian dress and turban looked like a prince from the *Arabian Nights*.

During their stay, the Borns played tennis and socialised, mostly with Indians. They also travelled to Bombay, Agra, Nilgiris, and Mysore for the annual Dasara festivities. Hedi, in particular, seemed to be enjoying herself in India, in stark contrast to her time in Cambridge. This in spite of two major illnesses, including a nasty sunstroke which kept her in bed in a dark room for weeks together.

Born had mixed feelings about India. Though the stay was pleasant, he was disconcerted by certain aspects of life here: the poverty, the gulf that divided Indians and the British, the opulence of the Maharajas, and the caste system.

In Bangalore, Born also got to meet Mysore's Dewan Mirza Ismail, whom he came to admire. "He was a Mohemmedan while the majority of the inhabitants of Mysore were Hindu. But this seemed to cause no friction," he writes. When Ismail asked Born whether he knew any good architects to work for Mysore State, Born suggested the name of his nephew Otto Koenigsberger, who had also fled Germany. Koenigsberger eventually became the State Architect of Mysore, designing and building several prominent buildings in Bangalore, including in IISc.

On the academic front, Born spent a considerable amount of his time preparing for and giving lectures. Even though he and Raman often had "violent" discussions on modern theoretical physics, they got along well. Raman was keen to create a permanent chair for the German in the Institute. When he asked Born about whether he would be willing to stay on in Bangalore, Born – and Hedi – were open to the idea. Two search committees were set up, one in Bangalore (led by Raman), and the other in London (led by the physicist Ernest Rutherford). This seemed a mere formality – both committees were in favour of offering the position to Born.

However, Raman also had to seek the approval of the Senate – the faculty body – and the Council. With some persuasion and questionable tactics, he was able to convince them to create a Professorship in Mathematical Physics at IISc (Born writes that Raman later informed him that he intentionally sent invites to his "enemies" on the Council late so that they would not show up).

> *I was so shaken that when I returned to Hedi, I simply cried," Born writes*

It was during the Senate meeting that Born first got a whiff of the ugly spat between Raman and IISc's establishment. At the meeting, Kenneth Aston, an Englishman recently hired as a professor in the Electrical Technology Department, attacked not just Raman but also Born. "The English Professor Aston went up and spoke in a most unpleasant way against Raman's motion, declaring that a second-rank foreigner driven out from his own country was not good enough for them. This was particularly disappointing since we had been kind to the Astons, as I mentioned before [they stayed as guests with the Borns when they arrived until their bungalow was ready]. I was so shaken that when I returned to Hedi, I simply cried," Born writes.

In 1933, when Raman became Director of IISc 24 years after it was founded, it still had only four departments: General Chemistry, Organic Chemistry, Biochemistry and Electrical Technology. And research was skewed heavily towards industrial applications. Among his main tasks as Director was to establish a physics department, a recommendation that had been made by two government-appointed review committees, the Pope Committee in 1921 and the Sewell Committee in 1931.

Once the department was set up, Raman – its only faculty member – initiated investigations in key areas of theoretical and experimental physics with his students, leading to several publications of high quality in a short period of time. But Raman realised that in order for him to make Bangalore a world-class centre for physics, it would need world-class physicists. He was particularly keen that IISc become a hub for atomic physics.

Raman's tenure as Director coincided with the rise of the Nazis in Germany. Several physicists of Jewish heritage were being forced out of their country. Raman believed that he might be able to convince some of them to come to IISc. "[After setting up new lines of research], he then identified gaps in knowledge in India and adopted a strategy of trying to recruit to the Institute faculty from among the reputed scientists who were fleeing from the tyranny of Hitler," says S Ramaseshan, Raman's nephew and former Director of IISc, in a profile of his uncle in *Current Science*.

It was then that Raman invited Born to IISc. Later he also wrote to a few other Jewish scientists, including Schrödinger, who, according to Ramaseshan, wrote back saying that Raman's offer arrived a bit too late as he had just accepted an offer from the School for Theoretical Physics in Dublin, Ireland. He adds that Schrödinger also expressed his regret that he could not settle in the land of the Upanishads.

Raman's effort to bring international scientists to IISc was part of an ambitious project to make IISc be counted among the best in Asia, if not the world. "In walks a spirited giant who finds this set-up all wrong. His mind is full of visions of Cambridge and Caltech, and he wants to recreate their atmosphere in his backyard," writes G Venkataraman, a condensed matter physicist and science historian, in his book *Journey into Light: Life and Science of CV Raman*.

But it did not take long for Raman's grand plans to be thwarted.

Opposition to Raman began with his attempt to speed things up at the "sleepy place where little work was done by a number of well-paid people," as Born describes IISc. Raman's enthusiasm to change the work culture at IISc was perceived as criticism of the establishment. But there were other reasons for the growing animosity between him and some faculty members as well as the Council.

Raman wanted the work in physical chemistry (he called it chemical physics), then being undertaken in the General Chemistry Department, to be conducted under his watchful eyes in the new Physics Department. The move upset HE Watson, a professor in the General Chemistry Department, who resigned in protest. Born suspected that there was more to this resignation than his resentment of an administrative decision. "Watson's friends and he himself may have expected that he was to be the new Director after Sir Martin [Forster] retired. Certainly Watson did not like to continue under an Indian Director. I was told this by some of Watson's English friends," recounts Born in a letter to Rutherford written after he left Bangalore and returned to the UK.

Photo courtesy: Indian Academy of Sciences

Max Born (second from right) with CV Raman (third from right) and Mysore's Dewan Mirza Ismail (fourth from right) at the Indian Academy of Sciences down the road from IISc

In the early 1930s, IISc's finances were not in great shape – the Mysore State had reduced its annual contribution from Rs 50,000 to Rs 30,000. But Raman, given his ambitious goals for the Physics Department, wanted more money, more than the capital grant of Rs 1 lakh (and the recurring sum of Rs 25,000) allocated by the Institute. "He therefore re-apportioned the budget to aid the fledgling Physics Department, an act which invited charges of embezzlement!" Venkataraman writes.

The situation was precipitated by Raman's apparent lack of administrative tact – a flaw in his character that even his most ardent cheerleaders find hard to defend. "Raman's ebullience and sharp tongue, his pride and prejudice, not infrequently surfaced to such levels that open mindedness and the future of the Institute had to take a backseat," Subbarayappa concedes in his book *In Pursuit of Excellence: A History of the Indian Institute of Science*. "Raman went in there like a bull in a china shop," writes Ramaseshan.

It was under these circumstances that Raman was working towards creating a permanent professorship for Born, a move that was not popular among some faculty members. The Born episode brought things to a boil, notes Venkataraman, leading to games of one-upmanship between Raman and the Council.

In the letter to Rutherford, Born writes that he did not see the unprecedented verbal attack on Raman and him at the Senate meeting as an isolated incident. He was convinced that the Council appointed Kenneth Aston as a professor to stir trouble and weaken Raman.

Amidst rising tensions, the Government in January 1936 appointed another review committee, headed by James Irvine, Principal and Vice Chancellor of the University of St Andrews, UK. Its mandate was to look into the working of the Institute and to make recommendations on how it could fulfil the purpose for which it was set up, while taking into account its financial resources.

Some historians have suggested that the real reason the committee was instituted was to clip Raman's wings and undo his controversial decisions. Born concurred. He writes that Raman's enemies in the Council had made up their mind to get rid of him. "It was evident to me from the beginning that they had received instructions beforehand."

The Irvine Report was submitted in late March that year. Among its many suggestions included the appointment of a Registrar, thus creating a parallel power structure in IISc. It also blamed Raman for the faulty use of Institute funds. While appreciating the work done in physics, the report expressed concern that the "centre of gravity" had shifted from chemistry to pure physics. It believed that modern mathematical physics "has little contact with industry, and in this respect cannot compete with Chemistry as a subject likely to be of service to India."

On the issue of Max Born, the report said that though "the presence of an eminent mathematician such as Dr Born would have a stimulating effect on the activities of the Department of Physics," the recently-approved position of Professor of Mathematical Physics should be abolished. The Committee justified the suggestion on the basis of the prevailing fiscal condition of the Institute.

The recommendations of the report were discussed at length at an extraordinary meeting of the Council in June 1936. At the meeting, a memorandum was also circulated by Raman critiquing many of its suggestions. But a majority of the members present were in favour of accepting them.

"Meanwhile, the opposition to Raman had been gathering momentum," Subbrayappa writes. He was becoming increasingly isolated. Born, who left India at the end of his six-month appointment, pleaded with Rutherford to intervene and "save Raman from a precipitous fall," Subbarayappa adds. However, Rutherford's attempted intervention had little impact on the Council. Eventually on 19 July the following year, Raman was forced to resign as Director but continued as a professor and the Head of the Physics Department until he retired in 1948.

Born and Raman remained friendly for a few years after the former left IISc. Raman even invited Born to become an Honorary Fellow of the Indian Academy of Sciences, which he founded. But their relationship soured in later years, thanks to an intellectual dispute that had its origins in Born's lectures in Bangalore. In IISc, Born devoted a few of his talks to the theory of lattice dynamics – the theory of how atoms in crystalline solids stick to each other and vibrate. But Raman felt that the theory did not explain the experimental observations he had made in his lab.

But their relationship soured in later years, thanks to an intellectual dispute that had its origins in Born's lectures in Bangalore

During the ensuing debate, which went on for many years, most theoretical physicists threw their weight behind Born, who had become the Tait Professor of Natural Philosophy at the University of Edinburgh in the UK. In 1947, Born's student Helen Smith's experiments also supported his ideas (though research in the 1950s and early 1960s showed that Raman was partly right). Raman seemed to take it personally.

The Borns met the Ramans twice after they left India. The first was at Bordeaux in France for the 25th anniversary of the discovery of the Raman Effect. At the reception, they greeted each other cordially, according to Born. But for the rest of the congress, Raman "was nervous, excitable and aggressive." The second time they met was at one of the Lindau meetings of Nobel Laureates in Germany. Again, Raman greeted them cordially, but the next day his attitude changed, writes Born. "He must have suddenly remembered that I was his 'enemy'."

Born and Hedi were especially disappointed that the controversy affected their relationship with Lokasundari. "Hedi and I regret all this and particularly the split between us and Lady Raman, whom we loved dearly," he laments.

Nonetheless, Born continued to remain an admirer of Raman's devotion to research and the risks he was willing to take for Indian science. "It makes me sad to think that by inviting me to India and trying to keep me there permanently he has brought himself into a precarious situation, and had to give up this leading position at the [Indian] Institute of Science."

The many avatars of the *Journal of the Indian Institute of Science*

– TN Guru Row

Looking back at over 100 years of its publication

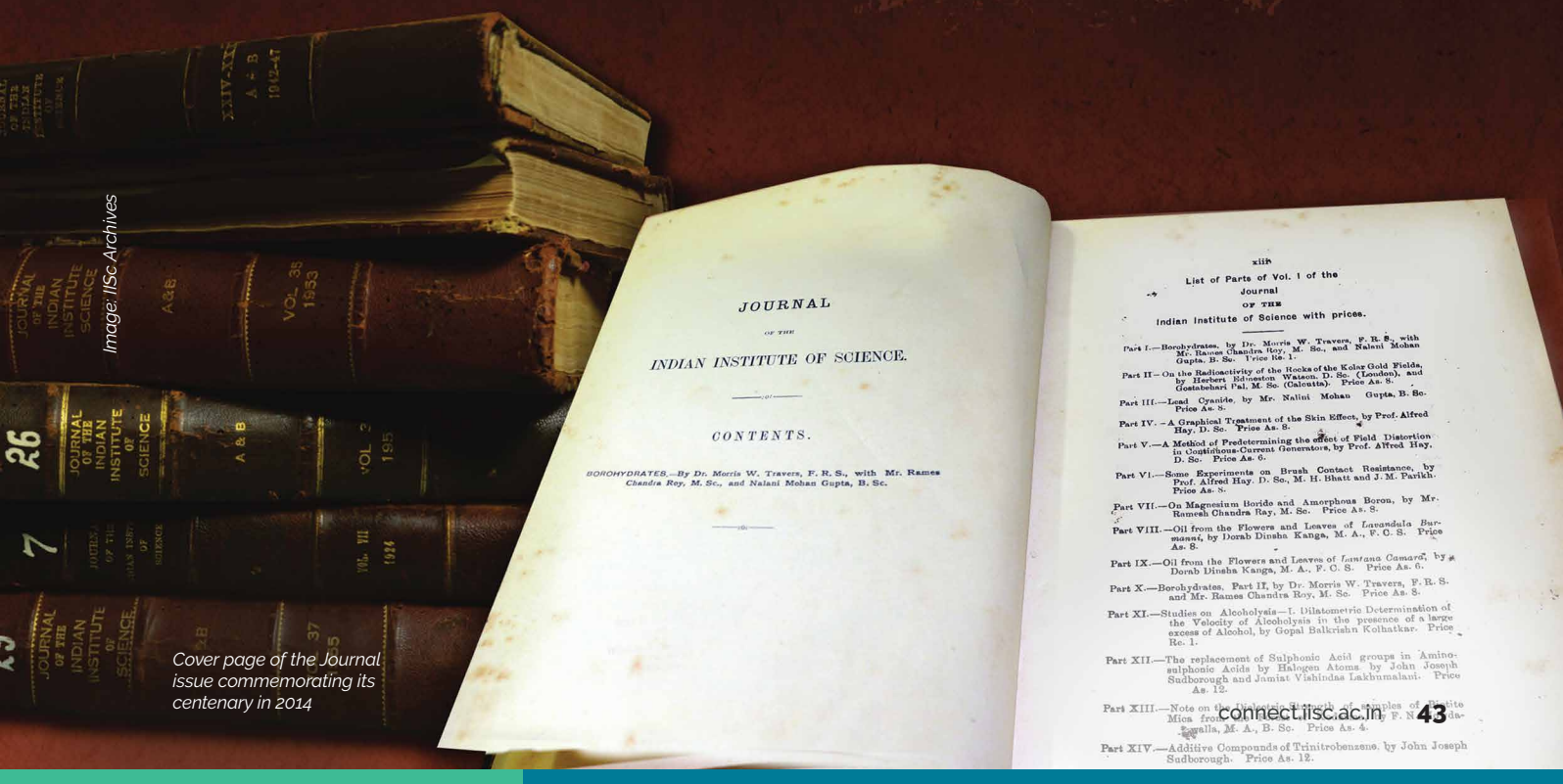


Image: IISc Archives

Cover page of the Journal issue commemorating its centenary in 2014

I once asked the students at one of my lectures whether they had heard of the *Journal of the Indian Institute of Science*. The response I received was depressing, particularly because I happened to be the *Journal's* Editor at the time. Except for a few hands that hesitatingly went up in a class of over 70 students, it was clear that none had had a look at the *Journal*. I soon found out that many faculty members too were unaware of the *Journal's* existence, even though it has a citation index that is respectable among current Indian journals and is also on *Web of Science* with an impact factor of 1.8.

The *Journal of the Indian Institute of Science* is today a review journal, a one-of-its-kind in India. An enthusiastic editorial board with GK Ananthasuresh (Professor of Mechanical Engineering at IISc) at the helm is actively pursuing its publication activities and I am informed that the articles for the next couple of years of the *Journal* (Volumes 100 and 101) are already lined up.

Image: IISc Archives

The cover page of an issue of the Journal during its lean "yellow" period

But the *Journal* had a very different avatar when it began 105 years ago. When IISc was established over a century ago, its Council felt that the Institute should publish its own journal. In fact, at its meeting on 19 January 1914, the Council sanctioned an initial grant of Rs 1,000 (a very generous amount in those days!) to start the *Journal*, with a mandate to publish "scientific and technical" articles. The first set of 10 articles initially submitted to the Council cost 403 rupees, 13 annas and 3 paise to print. The first volume of the *Journal* containing 21 articles was published during the years 1914-1918. The first article in this volume, entitled "Borohydrates" was authored by Morris W Travers (the first Director of IISc), Rames Chandra Roy and Nalini Mohan Gupta. Volume 2, published over the next three years, contained 15 papers; volumes 3 and 4 contained 9 and 16 articles, respectively. Since 1922, each year saw the publication of a single volume. In the early years of the *Journal*, the Director of the Institute served as the Chairman of its editorial board. Given IISc's British connections, they adopted the policies of the Royal Society's journals, with Section A of the *Journal* dedicated to chemistry and Section B meant for electrical engineering, as these were the two departments with which the Institute began functioning.

However, this ambitious project did not take off as expected as the researchers of our Institute felt that publishing in journals already established elsewhere would bring them more recognition (I must say that this attitude is still dominant among our current day researchers as well, resulting in the lack of interest in publishing in Indian journals). Following a lean period, in 1937, a dedicated editorial board was set up to revamp the *Journal's* functioning. During this period, faculty members of the Institute were encouraged to publish in the *Journal* and this resulted in a resurgence in its activity with 26 publications appearing in its next volume in 1938. Nevertheless, it is noteworthy that stalwarts like Sir CV Raman (the first Indian Director of the Institute from 1933 to 1937) were not in the habit of submitting their articles to the *Journal* and the reason is still elusive! In fact, Raman established the Indian Academy of Sciences, started several journals under its auspices, and published extensively in them. The *Journal* meanwhile, did not get due attention.

Researchers of our Institute felt that publishing in journals already established elsewhere would bring them more recognition

The Bangalore Press was involved in the *Journal's* publication during the 1930s and '40s, and the Institute's library was in charge of it from 1951 to 2007. In 1971, GN Ramachandran became the *Journal's* Editor with TKS Iyengar, the Institute's Librarian, as the Associate Editor. In 1974, Iyengar was appointed as the Executive Editor. Subsequently, several eminent researchers from the Institute donned the mantle of the Editor – N Mukunda, S Soundaranayagam, M Vijayan, SS Krishnamurthy and MS Shaila – while librarians NM Malwad and S Venkadesan served as Executive Editors. I must note here the contributions of K Srinivasa Rao, who served as an Assistant Editor for several years, doing literally everything from copyediting to producing the final print form of all the articles.

In this period, the *Journal* started including synopses of the PhD theses submitted by the students to the Institute and these turned out to be the major content of the volumes published. The *Journal* lost its identity as a consequence and went through a lean "yellow" period (yellow being the colour of the cover page during this time). During 1978-1992, the *Journal* went through many changes based on suggestions from the Director and the editorial board members. It became a monthly journal and, starting from 1978, each issue had a theme. In 1992, the *Journal* became a bi-monthly.

In 2003, LM Patnaik, then a professor in the Department of Computer Science and Automation, took over as the Editor, and he formed a new editorial board which apart from publishing the *Journal* online stopped publishing

thesis synopses and made fresh efforts towards publishing peer-reviewed articles from the members of the Institute. I had the privilege of serving as a member of this editorial board and, with enormous efforts, we managed to publish a reasonable number of articles from the Institute faculty. The cover design as well as the layout of the *Journal* were redone, and the quality of the printing improved, too. However, very soon the initial excitement from the Institute's faculty diminished and it became very hard to get a sufficient number of papers to keep the quarterly publication of the *Journal* going.

At this juncture, in 2007, P Balaram, the then Director of the Institute, called a meeting of the editorial board and, after detailed discussions, suggested closing down the *Journal*. Even though Patnaik was to retire that year, the editorial board members were reluctant to stop a nearly 100-year-old journal. After several hours of deliberation, Balaram came up with the idea of remaking the Journal into its current avatar of a review journal. Such a review journal serves the important purpose of publishing reviews of selected research areas in a way accessible to researchers from different disciplines. A useful feature of these review articles are short explanatory notes, appearing in the margins, of terms that might be widely known to researchers within a particular field but not to those in other fields. The authors of review articles use their judgment to identify such terms and provide short explanations.

In 2008, a new committee was set up with myself as the Editor, and the *Journal* was moved to the Archives Cell, which was renamed the Archives and Publications Cell (now the Office of Communications). IIScPress was established as an entity within the Archives and Publications Cell, bringing all the Institute's publications under a single umbrella. In these changes, the efforts of AG Menon, the first Chair of the Archives and Publications Cell, were very helpful. After Srinivasa Rao's retirement, Kavitha Harish has been handling the publishing of the *Journal* as its Editorial Assistant since 2008.

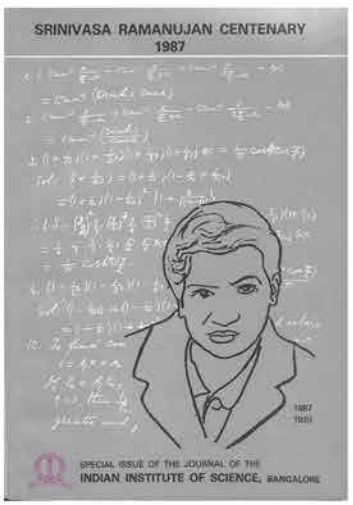


Image: IISc Archives

Cover page of the Journal's special issue commemorating Srinivasa Ramanujan's birth centenary in 1987

Over the years, there have been a few special issues of the *Journal* published to commemorate important occasions. Thus, a special issue was published during the Golden Jubilee year of the Institute in 1959; one to commemorate the birth centenary of the mathematician Srinivasa Ramanujan in 1987 which carried, among other things, handwritten content from Ramanujan's notebook put together by KG Ramanathan; and one in 1988 to commemorate the birth centenary of CV Raman.

A special issue of the *Journal* commemorated the Institute's centenary year in 2009. It carried 100 landmark papers published by IISc researchers over the years in various other journals. In 2014, another special issue commemorated the centenary of the *Journal*, carrying selected original papers published in it over its first fifty years, from 1914 to 1964. These papers were selected for their historical as well as current scientific value.

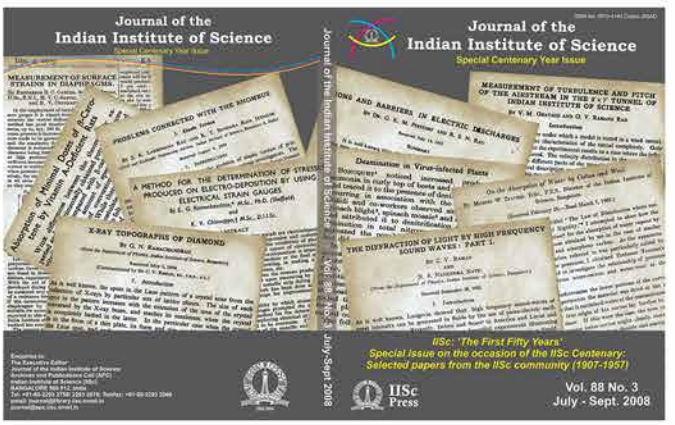


Image: IISc Archives

Cover page of the Journal issue commemorating the Institute's centenary

Starting from 2017, the *Journal* entered a co-publishing arrangement with SpringerNature for an initial period of three years, facilitating its greater global reach. A new committee headed by GK Ananthasuresh as the Editor was set up in 2018 and, for the first time in the history of the *Journal*, its editorial board has members from outside the Institute. In 2020, the 100th volume of the *Journal* will be published, with the first issue on hydrogen bonding, being guest edited by E Arunan of the Department of Inorganic and Physical Chemistry. This is a fortunate coincidence, for 2020 will also mark 100 years of hydrogen bonding. May the *Journal* continue to be published for the next 100 years!

With inputs from Kavitha Harish

TN Guru Row is an Honorary Professor at the Solid State and Structural Chemistry Unit, and was the Editor of the Journal of the Indian Institute of Science *from 2008 to 2018.*

The Birth of Wipro's Computer Systems Business

– Rohini Krishnamurthy

Photo courtesy: Wipro

Wipro's Series-86

WIPRO

IISc's role in helping Wipro launch its minicomputers in 1981

As one of India's leading technology companies, Wipro is today largely known for its Information Technology (IT), engineering, and consulting services. But what brought Wipro into the IT industry was its computer systems business in the 1980s. The origins of the company's most flourishing business in the 1980s and 1990s can be traced back to IISc's Digital Systems Lab at the School of Automation (now the Department of Computer Science and Automation or CSA).

"This really was the birth of our IT business – what is now the globally successful business by which Wipro is most known across the world. So, it would be quite accurate to say that the Wipro IT business was born in IISc," said Azim H Premji, the Founder Chairman of Wipro Limited, while addressing those gathered at IISc's convocation ceremony held in September 2019.

"Approaching IISc was a natural choice because they had the required expertise," says Sridhar Mitta, who joined Wipro in 1980 as Research & Development manager. This collaboration helped Wipro launch their minicomputers in India in 1981. These computers were used primarily by the industry and the research community.

> *"It would be quite accurate to say that the Wipro IT business was born in IISc"*

Before Wipro, IBM and other multinational companies (MNCs) were meeting the computing needs of Indian consumers. But in 1974, IBM found itself in a quandary when the Indian government passed the Foreign Exchange Regulation Act, capping the expansion of MNCs. The next three years were a trying time for many MNCs doing business in India. In 1977, the newly elected government under Morarji Desai began promoting indigenous industries, forcing IBM to exit operations.

There was also a change in how computers were developed all over the world. "From the expensive vertically integrated systems where computer vendors had to develop components – such as CPU, memory, and the operating system – by themselves, the world was moving towards more open and cheaper, horizontally integrated systems. Customers or vendors could buy, integrate sub-systems and peripherals from different vendors," explains Mitta.

Following these developments intently in the late 1970s was Wipro, which was until then in the business of producing vegetable and refined oils. The company decided to fill the void in the computer systems business by cashing in on IISc's expertise. IISc, around the same time, was keen on boosting collaboration with industry through its consultancy arm, the Centre for Scientific and Industrial Consultancy (CSIC).

To formalise the partnership, Wipro awarded a consultancy project to IISc through CSIC, by signing an agreement in July 1979. In a letter dated 5 October 1979, IISc's Registrar wrote to Ashok Narasimhan, General Manager of Finance & Planning, Wipro, stating: "The Indian Institute of Science has undertaken a project for the design and development of microprocessor-based minicomputer systems for M/S Wipro Products Limited, Bombay. It is envisaged that the design and production knowhow would be transferred to M/S Wipro Products Limited, in another fifteen months. Preliminary work on the project has been carried out during the past four months." The value of the consulting project was approximately Rs 14 lakh. The start-up named its business Wipro Information Technology Limited and became a subsidiary of Wipro Products Limited.

"The Institute constituted a committee to advise us on what computer we should make," said Premji. "This consulting project involved surveying the literature on computers being made all over the world. And it was also a platform for technical discussions, conceptualisation, and design review between Wipro's R&D team and IISc."

Photo courtesy: Wipro

Sridhar Mitta (facing the camera) in discussion with colleagues at Wipro

NJ Rao, who was heading the Digital Systems lab at the time, had a strong foothold in a technology that was beginning to revolutionise the field of computers – microprocessors. Acting as the brain of the computer, these compact electronic circuits have become ubiquitous today, present in everything from computers and phones to cars and trains. Microprocessors replaced an older technology called vacuum tubes. Computers built using vacuum tubes were not suitable for widespread use due to their size. The first digital computer developed in 1946, ENIAC, used 18,000 vacuum tubes, and it stood 10 feet tall, weighed over 3 tonnes, and filled a 1,500-square-foot room. Machines that used vacuum tubes also required massive amounts of power and were prone to failure as the tubes burned out frequently. With the advent of microprocessors, computers could become smaller, faster, and more reliable. Given this changed scenario, Mitta says, the Indian government under Moraji Desai issued a directive asking Indian companies to develop minicomputers with microprocessors.

IISc had researchers with other expertise relevant to computers too, such as systems design, in both hardware and software. They worked at the Centre for Electronics Design and Technology (CEDT), an Indo-Swiss collaboration founded to make students industry-ready. The Centre offered practical courses in building microprocessor-based systems, recalls Y Narahari, who was a BE student at IISc at the time and is currently the Chair, Division of EECS, IISc. Two faculty members from CEDT, Serge Boada and HS Jamadagni, were already working on 16-bit microprocessors, which were much faster than 8-bit ones.

Minicomputers in-the-making

Wipro had another reason to look for support from IISc. According to Rao, in 1979, Intel released its Microprocessor Development System, a tool to help students and engineers familiarise themselves with its newly launched 8086 microprocessor and help develop microprocessor subsystems. "It would have been really difficult for a company to import the Intel Microprocessor Development System," he says. "So IISc procured it. This was used by the CSA faculty and students, and the Wipro team."

The Wipro team worked out of the Digital Systems Lab, setting the stage for close interactions between academia and industry. Several discussions, deliberations and experiments later, the team drew up plans for the architecture of its minicomputer: microprocessors, system buses that connect various components, operating system and computer housing. The consultancy project lasted for over a year, after which, the start-up, Wipro Information Technology Limited, shifted to its first office at 45, Dickenson Road, Bangalore.

Photo: IISc PRO

Azim Premji at IISc's Convocation on 12 September 2019

In 1981, Wipro launched its first minicomputer named Wipro Series-86, which, according to Rao, was the best minicomputer architecture developed indigenously in India at that time. Powered by the Intel 8086 microprocessor and Intel Multibus, the operating system was licenced from the US-based Sentinel Computer Corporation. A CEDT team, headed by Kishore Babu, designed and built the computer housing.

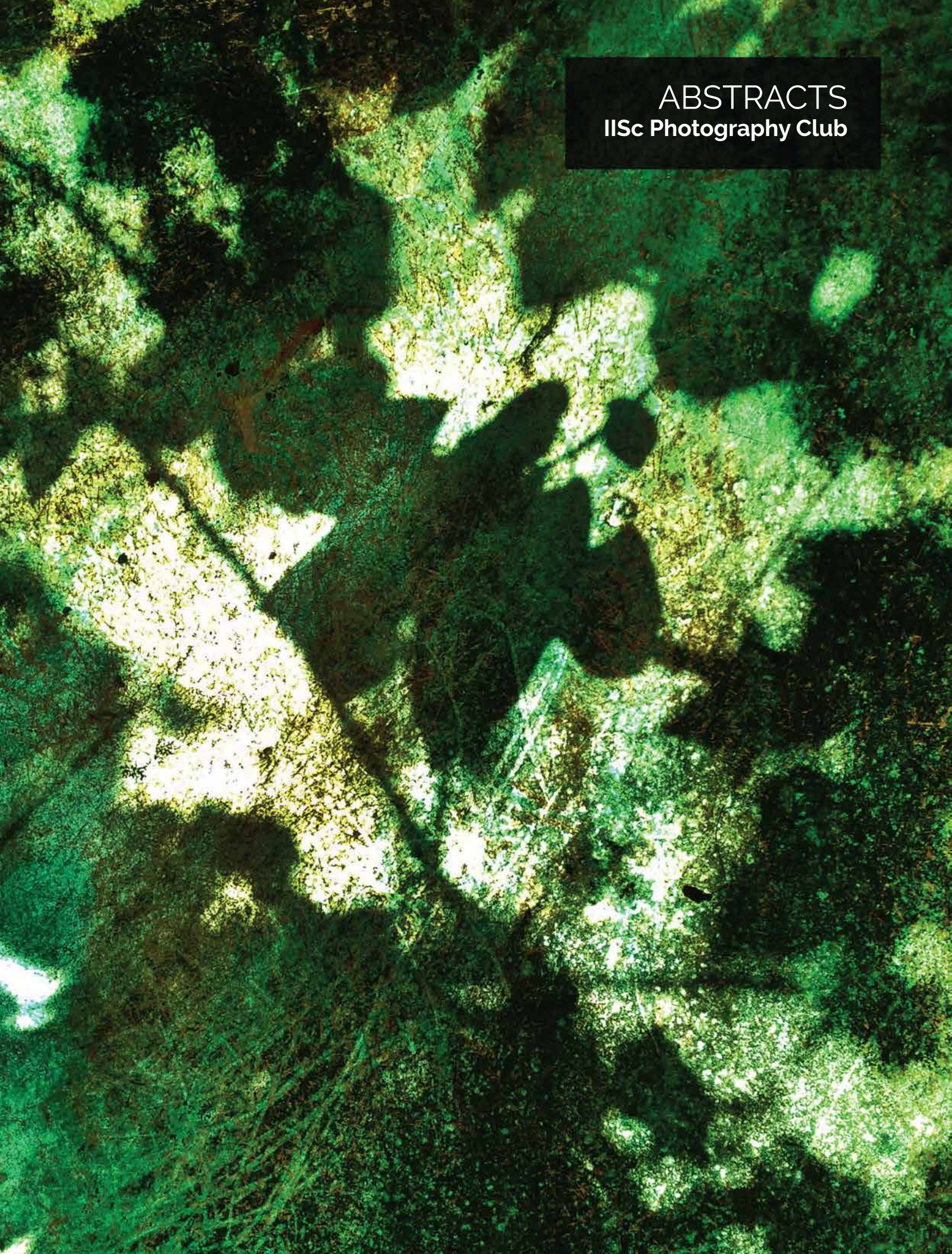
With this, Wipro's computer systems business took off in the Indian market. Their first-year revenue was Rs 2 crore, according to Mitta. "The chosen architecture proved to be so robust," Rao adds, "that it served Wipro for the next three generations, with Series 286 and Series 386."

This collaboration benefitted IISc as well. Narahari remembers that a member from the Digital Systems Lab named Victor Jayakaran was hired by Wipro as one of their first employees. "Out of the first few employees of Wipro, several were trained in this lab," he says. "IISc students were given an opportunity to work for a start-up like Wipro." Many IISc alumni joined Wipro during its first two years: Vallab Kulkarni, Srikant Seshadri, Anand Talwai, Anujan, Varma, and Ravi Bail. Narahari himself had been offered a position in Wipro in early 1982 but he chose to join the ME program in the School of Automation. And, as Premji observed, Wipro, with its 40-year-old association with IISc, continues to recruit from IISc and do "collaborative projects at the cutting edge of technology."

> *More recently, IISc and Wipro have come together for a project titled Wipro-IISc Research Innovation Network*

Though the project with IISc drew to a close, the collaboration continued over the years. More recently, IISc and Wipro have come together for a project titled Wipro-IISc Research Innovation Network (WIRIN). "It is a big programme, where teams from IISc and Wipro have started working on autonomous systems, artificial intelligence and robotics," says Narahari. They will be working on building 'driverless cars' and India's first indigenous 'Metal 3D Printing Machine', according to Premji. The project also includes funding PhD students and setting up of the Autonomous Systems and Robotics Lab at IISc. Wipro is funding this initiative in a major way, adds Narahari. "It's a multi-year program, we have just completed one year."

"We must encourage and foster collaboration across different sectors," said Premji in his convocation address, "across education and research institutions, industry, civil society and government."



ABSTRACTS

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