ISSN 2454-6232

CONNECT

WITH THE INDIAN INSTITUTE OF SCIENCE

Open Day
IISc's science carnival

Department of Mathematics
Bridging the sciences

Early Research on Lac
A prized commodity

May 2016
Volume 3 • Issue 2

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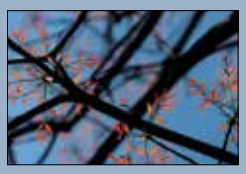
Front Cover: Open Day activity (IISc Photography Club)



Front Inside Cover: Foliage (IISc Photography Club)

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Photography: IISc Photography Club (unless otherwise mentioned)

Published by

IISc Press

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QUICK LINK **apc.iisc.ernet.in/newsletter**

Design: SaiMaa | Printer: Sri Sudhindra Offset Process

FROM THE CONNECT TEAM

Greetings!

Until the advent of vinyl in the 1950s, gramophone records were made from shellac—the processed form of lac—a resinous substance produced by a group of sap-sucking insects. In India, lac has been harvested for centuries, but its economic importance surged in the early 20th century when its versatility became evident to British industry. Soon lac was a sought-after raw material. And like many other raw materials that powered Britain's industrial might, this too had to be sourced from its colonies, particularly India, the principal producer of lac in the world.

Realizing the importance of lac research, the British government tapped into the existing expertise in chemistry in the Indian Institute of Science ('IISc' or 'Institute' from here on) to study lac and its products. And new researchers, including biologists, were hired to investigate this prized commodity. The story of lac research in IISc has been pieced together by Megha Prakash and Manu Rajan in this issue.

Also in this issue, Nithyanand Rao throws light on the Department of Mathematics at IISc. Conventionally, mathematics has been divided into pure and applied mathematics. They even have their own scholarly societies. However, this distinction is often superficial. Many fields of pure mathematics had their origins in solving practical problems. And pure mathematics keeps finding new applications. For instance, number theory ("Thank God that number theory is unsullied by any application," the American mathematician, Leonard Eugene Dickson, is supposed to have said) is today integral to cryptography and encryption.

When it was established in 1956, the Department of Mathematics at IISc was called the Department of Applied Mathematics. But over the years, it has freed itself from the shackles of having to do research mainly to support science and engineering studies in the Institute. As its current Chair, Gadadhar Misra, says, "…we live happily without having any biases about what sort of mathematics should be done."

In March this year, IISc celebrated its Open Day. We have a report from the ground by Sudhi Oberoi, who tells us about the activities that were on display at this year's event, fast becoming the Institute's most important outreach initiative. She also informs us about what goes into planning for an event of this magnitude.

This issue has much more for the reader to reflect on, including insights into journalism, provided by veteran broadcaster, Mark Tully, in an interview with Nithyanand Rao and Karthik Ramaswamy.

Happy reading!

In This Issue...

SCIENCE FOR ALL

IISc's annual outreach event—Open Day—showcases cutting edge research in the Institute and educates visitors about fundamental concepts in science and engineering

Courtesy: SP ARUN'S LAB

Using an optical illusion to demonstrate how the brain perceives the size of an object

✍ **SUDHI OBEROI**

"I love mathematics," an excited Anamika Dubey declares as she attempts to solve a puzzle in a classroom in the Department of Mathematics at IISc. The fourth standard student from Kendriya Vidyalaya – AFS Yelahanka, who wants to become a police officer when she grows up, was on campus with her father on the occasion of IISc's annual Open Day on 5 March this year.

Anamika was one of the thousands of visitors who thronged the campus on this day, along with other school and college students, teachers, parents, science enthusiasts, media personnel and more. They participated in scientific demonstrations, talks, seminars, movie screenings, discussions, and other activities organized as part of the event. The many food joints that were specially set up on the occasion were an added attraction. According to the Public Relations Officer (PRO) of IISc, N Krishnamurthy, around 20,000 people visited the Institute on Open Day this year, a jump of more than 50 percent compared to last year.

Open Day is organized to showcase research in the Institute and communicate important concepts in science and engineering to the general public. Its origins can be traced to a report of a Review Committee headed by JC Ghosh, a former Director of IISc. The report, tabled in 1956, suggested that "the Institute should have an open week before the annual meeting of the Court, during which the Institute may be visited, both by members of the Court and the general public." The suggestion found support from JRD Tata, then President of the Court of IISc.

Thousands of school children thronged IISc

Open Day is organized to showcase research in the Institute and communicate important concepts in science and engineering to the general public

Based on the suggession, the first Annual Week was organized in March 1957. In the years that followed, Open Days were spread over two or three days. However, this practice was discontinued and an Open Day was organized intermittently. More recently, it has become a regular feature in the Institute's calendar. The day-long science carnival is held on (or close to) 3 March, the birth anniversary of JN Tata, the founder of the Institute.

Planning

The task of organizing this event rests on the broad shoulders of an Open Day Committee, comprising all the Divisional Chairs, the PRO and Chairpersons of all the departments.

The planning starts as early as January every year when the date for the event is decided. The Committee then requests the various departments to put together a list of activities that they would like to showcase and provide it with an estimate of the cost of each activity. It also asks the departments to identify volunteers for manning the help desks to be set up around the campus. Based on this input, the Committee finalizes the activities and allocates the required funds.

Even as the activities are put together, the Committee focuses on advertising Open Day to the public, particularly in schools and colleges. It also works towards ensuring adequate security for the event.

"It is always challenging to organize a big event like the Open Day," says Krishnamurthy. "But we now follow a set protocol which makes it easier. We also have efficient staff who help prepare for it," he adds.

KG HARIDASAN

One of the many help desks that were set up around the campus

"It is always challenging to organise a big event like the Open Day"

Activities

As in previous years, this year's Open Day too sought to mix fun and science in equal measure. Some took the hands-on approach to a new level: visitors themselves became subjects in experiments. For instance, this approach was used in the 'Incredible Shrink Machine', an experiment designed by students from the Centre for Neuroscience, one which used an optical illusion (see photograph on Page 4) to explain how the brain perceives the size of an object.

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Solving a puzzle

Other departments, such as Mathematics, came up with their own ways to engage visitors. Besides a treasure hunt, it also had a collection of puzzles. These puzzles, of varying levels of complexity, were based on real-life

Aeroshow, one of the more popular events

experiences that people could relate to. Vignesh AN, a Master's student who helped design a few of these puzzles, claims that some of the solutions surprised even mathematicians. "It is amazing to see some people design unconventional techniques to solve a puzzle," he tells CONNECT. The prizes for the winners included books related to mathematics and famous mathematicians.

Though there are new activities every year, some like the Aeroshow, organized by the Department of Aerospace Engineering, have proven to be so popular that they have become regular features on Open Day. Aero enthusiasts from different flying clubs were also invited to showcase their models. Among them was Sandeep, a school student, who made his own plane from scratch. "It feels awesome to demonstrate my model here," Sandeep says.

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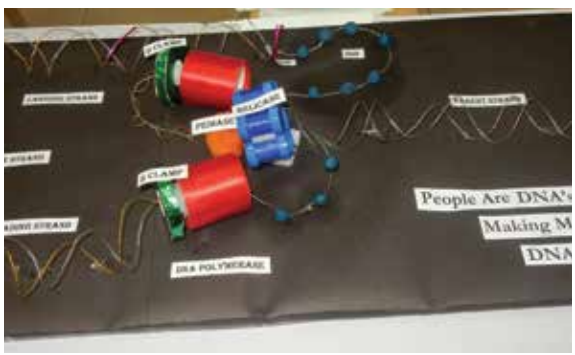
Painting workshop

But Open Day at IISc is not all about science. One such pleasant diversion from science was a stall set up by a non-governmental organization SEVITA, on invitation from the Centre for Product Design and Manufacturing. SEVITA organized a painting workshop to make visitors aware of India's traditional art forms, many of which are dying. Elated on being invited to conduct the workshop, Devaki Rao, the founder trustee of the NGO says, "We would like to make this a regular feature here at IISc. It is a great place to find people with lot of energy and talent."



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Demonstrating DNA replication and repair

The driving force behind Open Day's diverse activities is the student community. It is the students who decide on the learning goals, plan and design the exhibits, and communicate the underlying science to visitors. S Amitash, a PhD student from the Department of Biochemistry, explained to CONNECT why he enjoyed the experience. "It helps me evolve as a researcher. The main essence of science is to communicate what we are doing in the lab. Otherwise there's no use [of doing science]", he asserts. He and his lab-mates showcased a model that depicts DNA replication; he also explained to visitors the repair mechanisms found in animal cells to fix errors that sometimes arise during the replication process.

"It helps me evolve as a researcher"

For their part, visitors have the opportunity to see science in action, learn scientific concepts, and appreciate the diversity of research pursued in IISc. The experience also motivates many youngsters to consider a career in science and engineering. And for some, it provides greater clarity on what they want to do with their lives. For instance, Martin Jose, a class IX student from St Joseph's Boys High School, was certain that he would become a doctor before he came to Open Day, but not what he would specialize in. He now aspires to become a neurologist after watching a live demonstration of brain activity using EEG (Electroencephalogram) at the Centre for Neuroscience.

New Challenges

Ironically, the success of Open Day has led to some new logistical challenges in recent years. One such issue the Institute has been grappling with is the management and disposal of waste produced due to the large number of people who visit the campus on this day. The responsibility of dealing with this problem was shouldered by members of IISc Family and Friends and Solid Waste Management Initiative of IISc (SWaMII) this year. Colour coded bins were placed all over the campus to facilitate waste segregation. Volunteers at the help desks guided visitors on proper disposal of trash. Food vendors were encouraged to use recyclable materials. "We know Bangalore has a huge waste disposal problem and want to contribute our bit to mitigate it. We are very happy to see that it has worked," says Kavitha Harish, a member of IFF. "A good job was done to segregate waste and we should keep up this discipline at all times," adds Vikram Jayaram, the Chair of the Open Day Committee and also the Chair of the Division of Mechanical Sciences.

"We know Bangalore has a huge waste disposal problem and want to contribute our bit to mitigate it"

KG HARIDASAN

Increasing traffic has become a challenge

Another consequence of the large crowds on Open Day is significant increase in the number of motorized vehicles in the campus. This year even saw the odd traffic jam, an unprecedented sight in IISc. Though a shuttle bus service was arranged to ferry visitors, it was not sufficient, according to Jayaram. He, however, believes that the traffic situation will improve next year when the Committee plans to set up parking lots at the various entrances and arrange more frequent shuttles within campus.

With an increase in the number of departments and a consequential upsurge in the number of activities on Open Day, visitors find it difficult to cover all of them on a single day. "I went crazy in the Biological Sciences building. It had so many exciting displays. But I was not able to go through all of them as there were very long queues and I was afraid that I might miss the Aeroshow!" exclaims Anant Caprihan, a class V student. Caprihan's views are shared by many others, including Vinay Dubey, Anamika's father, who suggests that the Institute should consider throwing open its gates to visitors for an entire week instead.

(*The author acknowledges the help of the following: Sowmithri Ranganathan and Manu Rajan for sourcing and researching archival material, and Karthik Ramaswamy and Nithyanand Rao for reporting on some of the Open Day activities*)

CLASS OF 2016: FULFILLING THE PROMISE

As they depart from the nest that has nurtured them for the last four years, CONNECT ***takes a closer look at where students from the second batch of the BSc (Research) course are headed***

ANSHUMAN SWAIN

✍ **SUBHAYAN SAHU**

Come September, Suhas Mahesh, currently a senior undergraduate (UG) student in IISc, will be joining Oxford University for his PhD in condensed matter physics, with the prestigious Rhodes Scholarship under his belt. Only the third Rhodes Scholar in the Institute's 107-year-old history, Suhas, who will graduate later this summer, is part of the second batch of IISc's four-year Bachelor of Science (Research) programme which started in 2011. Until then, IISc, India's premier research institution, had focused exclusively on postgraduate education.

Focus on Research

Not surprizingly, a majority of the students graduating this year intend to pursue a career in research. "Like most of my batch mates, I joined IISc with an interest in research [and] the biggest benefit of being a UG student at IISc is the postgraduate nature of the Institute," says Suhas. Balaji Jagirdar, Professor, Inorganic

and Physical Chemistry, and one of the two Associate Deans of the UG Programme, concurs with this view. "Students joining this Institute experience all the research activities that go on here and the path for the students to go into a career in research is well laid out," he adds.

The course work emphasizes hands-on research in world-class laboratories, ensuring that these young minds appreciate the rigors and joys of doing science. Experiments in laboratories compliment lectures taught by faculty members who are among the best researchers in their respective fields. At the end of their first year, students major in any one of the following subjects: Biology, Chemistry, Environmental Science, Materials, Mathematics or Physics. In their final semester, students also do a research project with one of the several faculty members of the Institute. This emphasis on research cannot be overstated, feels Kishalay De, a fourth year Physics major, who is going to Caltech for a PhD in astrophysics.

Broadening Horizons

As part of their curriculum, students are also expected to take courses in engineering and the humanities. The engineering courses allow them to explore the real-life applications of the basic sciences, while the humanities courses give them an opportunity to understand the social context in which science is done. The interdisciplinary nature of the curriculum has been recognized and appreciated by the students. Harsha Gumani, a graduating Biology major, who has received the sought-after Wellcome Trust Fellowship for her graduate studies, says, "My chosen area of research is neuroscience, a field which is interdisciplinary by itself [and] having both biological and mathematical training is useful for doing this science."

Climbing the Research Ladder

De and Gumani along with many other fourth year students have already bagged offers from some of the best universities in the world, including Caltech, MIT, Harvard, Cornell, Yale, Berkeley, Princeton, University College London, Max Planck Institutes and Oxford. Though going abroad to pursue graduate studies is a popular option, a few students are considering doing their PhDs in India. In the past, most Indian universities required a Master's degree for admission into a PhD programme. "However that situation is changing," clarifies PS Anil Kumar, also an Associate Dean and Associate Professor, Department of Physics. He adds that opportunities for research for UG students, both within and outside India, will increase in the near future. He says, "More universities are taking note of the UG programme in IISc, and hence the placement scenario is only going to improve with time."

"More universities are taking note of the UG programme in IISc, and hence the placement scenario is only going to improve with time"

Staying Home for Another Year

But not all students who wish to pursue research are leaving the Institute. At least not yet. After four years of study, IISc's UG students have the option of staying back for a fifth year to earn a Master's degree at the Institute itself, an option that a number of graduating students are planning to exercise. According to Anil Kumar, this gives students an opportunity to investigate their final year research project

more deeply and also to explore other avenues that may lie ahead of them. The precedent to continue at IISc for another year was set by the batch of 2011, when 47 out of the 83 enrolled students opted to get a Master's degree at IISc. For instance, Pranav Mundada, decided, in his final semester, that he wanted to work in a new field, and therefore stayed back. This year, he will be going to Princeton University for a PhD to "try to make a fault tolerant quantum computer."

Changing Tracks

At least three of them from this cohort of graduating students are planning to study economics in graduate school, a subject that they did not major in. Sabareesh Ramachandran, a Mathematics major, is one of them. He is headed to the London School of Economics for a Master's in Economics, armed with a Commonwealth Fellowship. "I intend to work in public policy or developmental economics. I think the [Humanities] course on governance made me look at this career option more seriously. I find in economics a nice avenue to work on pertinent social issues while also using the analytical abilities that we developed in our maths courses," he says.

Acing Entrance Exams

Another indicator of the quality of the UG programme is how well IISc's students have been doing in the national-level entrance exams for graduate programmes. This year, Tapan Goel, a Physics major, has stood first in CSIR NET Physics; Ullas Chembazhi, majoring in Biology, has got the first rank in GATE Biotechnology and Nidhin Kurian, a Materials major, has topped the GATE Materials exam. Many of the top rankers in these entrance exams have also received offers for PhD and Master's programmes in foreign schools.

Exploring Other Options

Though the UG programme is designed to help young students become researchers, it also provides students with the skills required to go into the private sector. For instance, Abhinav Jain, who graduated last year, is a financial analyst in Ernst and Young. He believes that though taking up a job immediately after graduation is not yet a popular choice, there are ample opportunities in the corporate world for IISc's UG students. This year saw Fortune 500 companies like Goldman Sachs, Capital One and Walmart coming to IISc, specifically looking to recruit UG students. One such recruit is Sameer Shah, a fifth year student majoring in Mathematics, who was hired by Walmart as a data analyst.

Environment of Excellence

As the programme gets older by a year, UG students at IISc, enriched by its environment of excellence in research and pedagogy, have more than just lived up to the faith imposed on them by the Institute. Their stories of success are testament to the quality of education they have received. Suhas, who is also a connoisseur of classical languages, ends with an old Sanskrit adage:

santah sadābhigantavyā yadi nopadiśantyapi |
yāstu svairakathāstesām upadeśā bhavanti tāh ||

"Keep the company of the wise, even if they aren't teaching lessons.
For whatever they tell in passing, they turn out to be lessons."

ON CAMPUS

In conversation with guests of the Institute

MARESI NERAD: EQUIPPING YOUNG RESEARCHERS WITH PROFESSIONAL SKILLS

✍ **MEGHA PRAKASH**

CONNECT

Maresi Nerad is a professor of higher education and the founding Director of the Center for Innovation and Research in Graduate Education (CIRGE) at the University of Washington in Seattle, USA. In January 2016, Nerad spent a month as a Visiting Professor at the DST Centre for Policy Research in IISc. During her visit, she conducted a workshop for graduate students. She also gave a lecture on 'Issues in Doctoral Education and Innovation Policies: Looking Beyond One's National Horizon' at the Centre for Contemporary Studies. After the workshop, she spoke to CONNECT *about CIRGE's activities, the need to equip researchers with professional skills, the role of mentorship and other issues concerning higher education.*

Q Tell us about CIRGE and its activities.

The Centre, set up in 2002, focuses on doctoral education with three emphases: PhD career path studies, international research synthesis workshops, and evaluations (formative and summative) of theme-based, interdisciplinary, flagship doctoral programmes in the US and Europe.

So far, CIRGE has undertaken three National PhD Career Path Studies. The studies surveyed PhD recipients five to ten years after they completed their doctorates. These surveys inquired about the retrospective assessment of their doctoral studies, the career paths from the time they completed their degrees to the time of survey completion, as well as on their satisfaction with their current employment. In order to understand better the reasons behind career decisions of the surveyed men and women PhDs, these surveys tracked not only the career path, but also the 'family path', that is the career of the spouse, the birth and age of children, and the need to take care of parents.

An interesting result that emerged from these surveys was that a majority (two-thirds) of

women in the United States with a PhD had a partner who also had a PhD, or a medical or law degree. But only about a quarter of the men had a partner who had invested in education as much as they had.

Further analyses of the survey data addressed questions such as the importance of acquiring competencies in professional skills, teaching, time management, grant writing, working effectively in interdisciplinary teams, knowing how to manage budgets and people. In short, it sought to understand professional competencies beyond the knowledge of the subject and research methodologies. We found that doctoral students who had done workshops that addressed these issues took a shorter time to graduate. Our studies also inquired whether working as a postdoctoral fellow in a more reputed laboratory upped one's career prospects.

"We found that doctoral students who had done workshops that addressed these issues took a shorter time to graduate"

The international research synthesis workshops address the interests of many countries around the world in doctoral education in light of national innovation policies. In these week-long workshops, funded by the National Science Foundation (NSF) and co-sponsored by the host country of the workshop location, CIRGE brings together experts in doctoral education from different countries. We have published two books on doctoral education that resulted from these conferences: *Towards a Global PhD* (2007) and *Globalization and its Impact on the Quality of Doctoral Education* (2014). And a third book on *Intellectual Risk-taking in Doctoral Education*, is in progress. These workshops also help us understand the issues and challenges in doctoral education within different national higher education systems.

The third focus of CIRGE activities supports the process of innovative doctoral programmes while they unfold and provides 'in time' feedback to the faculty who run these special programmes.

Q You conducted a workshop for doctoral students here at IISc as well. Can you tell us more about these workshops? How do the participants benefit from them?

The goals of these doctoral student workshops are to make the students aware that today an independent researcher needs to have more competencies than the traditional academic skills, to better comprehend the student-advisor relationship and to learn to present one's dissertation in a limited time (say in 5 minutes) to people outside one's field without using disciplinary jargon. I often employ "role-playing" in these workshops to facilitate a better understanding of the delicate advisor-advisee relationship. Globalization has only accentuated the need for the development of more professional skills beyond the pure academic skills. Many countries—Australia, New Zealand and those in Europe—have been organizing professional skills workshops for their doctoral students as a means of improving career preparation.

Q During the workshop you emphasized "professional feedback". Why is this important?

We learn more when we receive feedback on our work from colleagues in a professional way. By this I can learn what was good and what we can improve upon, and receive concrete suggestions on how to do this. In conferences that I have attended, I have noticed students become startled or baffled when posed with queries after presentation of their papers, and they struggle to answer them. This may well be because the question is not well understood or the feedback is discouraging. Students need to learn to stay calm, listen, and ask if they do not understand the comments. They also need to learn how to become a supportive colleague by providing feedback that is constructive with concrete suggestions and do so also by pointing out the positive aspects. This makes the presenters more comfortable. The same applies to any work environment where collaboration and discussion is involved. One of the objectives of my workshops is to train students to appreciate the contribution of co-workers with positive feedback and also point out ways and means of improvement.

Q What are your views on the two different kinds of doctoral degrees—industrial and research—awarded in some universities nowadays?

What does an industrial doctorate mean in India? If this means professional doctorates, such as a doctorate in nursing, social work, audiology, or physical therapy, then I am familiar with this degree. In the US, professional associations of these fields have been pushed for higher social recognition that resulted in the conceptualization of such a degree. They are different from a research doctorate in that there is no original research involved. Rather than generating original research, the focus is on applying and using knowledge in different contexts. I think both these types of doctorates are desirable and have their place in society.

Q How important is it to have a mentor in academics?

Though we do learn from experience and often by ourselves, I believe a mentor can be extremely beneficial. A mentor need not be just the dissertation advisor; he or she can be from another area or discipline or even from another institution. A mentor taking the mentee under his or her wing, so to speak, helps the protégé to set goals and standards, protects the protégé from others in a way that allows room for risk and failure, and facilitates successful entrance into academic and professional circles.

"Though we do learn from experience and often by ourselves, I believe a mentor can be extremely beneficial"

Q Did you have a mentor?

Yes. While in Germany, a professor in sociology was my mentor. I continued consulting with her, even while pursuing my doctoral studies in the US. And at the University of California (UC) Berkeley, the Dean of the Graduate Division, also a nuclear chemist, sponsored me professionally, made me aware of mistakes before they saw the light of the day, taught me how natural and social scientists complemented each other and how to successfully design policies

for graduate and postgraduate education in a given environment. I felt protected and guided in the early days of my career, and thus I would call him a mentor who also happened to be my boss.

Q When and how did you get interested in higher education?

When I was 17, I spent the senior year in an American high school under the American Field Surveys programme. This exposed me to different cultures and kindled in me an interest in international education. In Germany, I opted to study political science and physical education. After college, I spent two years as a high school teacher. I became interested in organizational change and university education after realizing that my university education contributed little to prepare me in my role as high school teacher. I wanted to change this. I decided to undertake doctoral study in the field of higher education to understand how change in organizations comes about. I then moved to UC Berkeley to pursue my interest in higher education because Germany then did not offer a degree in the field of higher education.

"I became interested in organizational change and university education after realizing that my university education contributed little to prepare me in my role as high school teacher"

Q Does culture impact education?

Of course culture impacts education. Every student studying for some time in a different country will notice cultural differences and even talk about culture shock that extends to educational settings. In doctoral education, we find different advising cultures in different countries. In the US, the faculty-student relationship tends to be less formal than in Europe or Asia. In Japan and China, for example, the advisor is more a parent and is treated with great respect. Given the increasing mobility of researchers, we would be wise to include intercultural awareness in training the next generation of researchers.

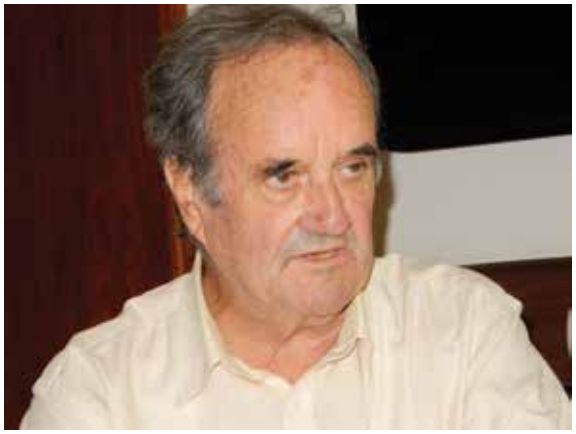
Q What else can be done to improve the quality of higher education?

Training in research has to begin early—right at the undergraduate level. Undergraduate students could be introduced to small research projects. There is a pressing need to develop critical thinking skills. There is also a need to train students in the art of asking the right kind of questions, and not blindly accept whatever is stated by the instructor. This is how independent thinking can be developed. The "flipped classroom" concept that turns the traditional classroom on its head is already gaining ground in many universities. In this model, instructional content is delivered in a video online. Students listen to the lectures online before they come to the class. In the classroom, the instructor uses the time to involve students in active discussions and hands-on exercises.

Workshop participants

MARK TULLY: BBC'S VOICE OF INDIA

✍ **NITHYANAND RAO** AND **KARTHIK RAMASWAMY**



CONNECT

Born in 1935, Mark Tully, who spent the first 10 years of his life in India, was sent to England to further his education. After his schooling, he read History and Theology at Cambridge and considered becoming a priest in the Church of England. He abandoned this idea in favour of pursuing a career in journalism. He joined the BBC in 1964 and moved to Delhi as its India Correspondent the following year.

Tully was associated with the BBC for over three decades, both as a reporter as well as its Bureau Chief in Delhi. For his contributions, he was made an Officer of the British Empire in 1985 and knighted in 2002. The Indian Government (which had barred him from entering India during the Emergency) awarded him the Padma Shri in 1992 and the Padma Bhushan in 2005.

Tully was in IISc in January to give a talk organized by the Undergraduate Programme and the Centre for Contemporary Studies. When CONNECT *caught up with him at the Institute's Guest House, he had been deprived of a good night's sleep, thanks to a flight delay. He greeted us cheerfully, but made sure that he conveyed his dislike for airlines and airports, a dislike matched only by his passion for the Indian Railways. These were among the many subjects he discussed in an interview with* CONNECT. *Here are excerpts from the conversation:*

Q How independent do you think the Indian media is?

I think the Indian media is independent of the government. As with any media in a democracy, there may be some newspapers or TV channels which are pro-government and some which are anti-government. But usually their identity is fairly well-known. In fact, I think in the fifty-odd years since I've known this country, the media has actually become more independent and less dependent on government information sources. Of course, the major exception was the Emergency—I don't think the media covered itself in great glory during the Emergency.

But I would like to point out the government policy towards radio, where people are still not allowed to broadcast independent news and current affairs. This is a grave infraction because radio is a very important medium, particularly in a country like India where large numbers of people still don't have televisions.

Q You've worked mainly in radio. What's unique about radio journalism?

Radio broadcasting differs from print journalism for many reasons. One very obvious reason is that you have to be precise and quite simple. With TV, you have pictures to help; so writing isn't as absolutely crucial.

I like radio because it makes me exercise my writing skills. I like it because I love listening to radio. I think one of the greatest pleasures you can have in life is, for instance, listening to a drama on radio. It's similar to perhaps how your mother used to read to you when you were young.

I think that radio has three great advantages which make it continually popular. You can listen to it while you're doing other things. That's why breakfast radio is so popular in Britain. It's a medium that leaves room for your imagination and therefore it's highly personal. And the third factor is its intimacy. I was once speaking in a cathedral in Britain, and quite a lot of people came. I said that I don't know why so many people had come because I'm just a journalist. At the end of it, an elderly lady came up to me and said, "You asked why I had come. I came because I think of you as my friend." This is a unique quality of radio—that of intimacy. With good radio, you as a broadcaster should be able to give many people the impression that you're talking directly to them.

That's why I think it's a very important, and a very popular, medium.

"This is a unique quality of radio—that of intimacy. With good radio, you as a broadcaster should be able to give many people the impression that you're talking directly to them"

Q Every media organization needs financial backing, either from the government, politicians, business houses or philanthropists. How does it survive the scourge of the agendas of the financial stakeholders, whoever they may be?

Well, what you said is not absolutely true—you have papers like *The Guardian* in the UK and *The Tribune* in India, which are run by trusts. Secondly, you have, in many democracies, organizations like the BBC which are not run by the government.

The BBC, though a public broadcaster, has always maintained, and fought for, its independence from the [British] government. In my experience of working at the BBC, I remember many occasions when the BBC came under pressure from the [British] government and resisted that pressure. I remember covering the anti-[Zulfikar Ali] Bhutto movement; I was called in by the British High Commissioner in Pakistan and told that Mr. Bhutto did not like me and it would be a good idea if I left the country. So I said to him, "Well, that means I've got to stay here for two more weeks," when in fact I was hoping to go back to India.

But this independence depends very much on the proprietor. If you have a proprietor like Mr. [Rupert] Murdoch, then your policy is dictated for you and you cannot escape from that. Then you have to do your journalism within those limitations. But it is important to realize that the public knows about that. Nobody in Britain has any doubts about where the political support for *The Sun* or *The Times* lies. I think that is a very important thing to remember about this question that you posed.

Q Do you think a public broadcaster like the BBC is still relevant and required? In the Indian context, do you think Doordarshan and the All India Radio do a reasonable job?

I think government broadcasters like AIR and Doordarshan have limited impact because

everyone knows that they are the voice of the *sarkar*. One of the reasons why the BBC was very influential in the 1960s, 70s and 80s was because the only other available broadcasters from within India, both on radio and TV, were the government ones and everyone knew that they carried government news. Therefore, people turned to the BBC. So I think that governments which rely on government media too much are making a mistake and are underestimating their audience.

"I think that governments which rely on government media too much are making a mistake and are underestimating their audience"

Q Do you recall any specific cases where you were put under pressure by the Indian government, other than during the Emergency?

During the Emergency, we were thrown out of the country. And we've been attacked often in the [Indian] Parliament.

There were complaints made quite often about specific TV films which were made. One example was a film about the cleaning of the Ganges when Rajiv Gandhi was the Prime Minister.

I always say about journalism: you can question the balance of the piece, and as a journalist you have to admit that you sometimes get things wrong. If you don't admit that, you're either a liar or an idiot—an idiot if you don't recognize it. But I can recall no real incident where we were put under pressure. Mind you, by this evening, I might have remembered. [Laughs]

Q As an editor, how do you decide what's newsworthy? How do you balance the need for reporting good news along with the "man bites dog" stories?

Well, this is an old question. At the BBC, I once worked on a programme called the *Good News* programme. We used to scour the world's papers for good news, and we got quite a lot of good news, but we didn't get very many listeners. So this is a problem. You're absolutely right that sensationalism is something which is sometimes quite difficult to avoid. But I think there's a way of balancing this to some extent by having thoughtful and in-depth articles rather than just news stories. In all journalism, balance is a very difficult thing to achieve.

"At the BBC, I once worked on a programme called the* Good News *programme. We used to scour the world's papers for good news, and we got quite a lot of good news, but we didn't get very many listeners"

Q You've been awarded the Padma Bhushan, you've been knighted, won several other awards. What do these awards mean to you?

Of course, it's a great honour. But I don't call myself Sir Mark Tully, although some people call me that. I certainly would not put Padma Bhushan on my card or anything like that. I wouldn't like to boast about them. At the same time, I don't want to diminish the importance of these awards, because other people have given them to me and it would be very ungenerous to say that it doesn't matter. But I'd also like to say that I hope they have not made me less accessible to people or turned my head.

DT MOURYA: DIRECTOR, NATIONAL INSTITUTE OF VIROLOGY

✍ MANBEENA CHAWLA

MANBEENA CHAWLA

Established in 1952, the National Institute of Virology (NIV) in Pune is one of the major institutes of the Indian Council of Medical Research (ICMR). It houses a BSL-4 (Biosafety Level 4) facility which allows researchers to work with pathogens that could cause severe to fatal diseases in humans, and for which vaccines or other treatments are not available.

NIV is headed by DT Mourya who took over as its Director in September 2011. In his illustrious career, he has received several honours, including the first Dr. T Ramachandra Rao ICMR Award in 1990 for his work in the field of medical entomology.

Mourya was in IISc on 11 April, 2016 to conduct a workshop titled Biorisk Preparedness in Laboratory Setting*, during which he gave several lectures. He took a few minutes off from his packed schedule to talk to* CONNECT.

Q As the Director of NIV, how do you decide on your priorities and agenda?

As the Director, I decide on priorities based on the mandate of the Institute, and also on the country's priorities. There are many emerging and re-emerging viral diseases spreading in our country. A large number of people are getting affected with morbidity and mortality, thereby affecting public health. Keeping these things in view, the agenda and priorities are decided by the Institute.

Q Do you miss active research?

In addition to all the administrative responsibilities, I am actively involved in scientific activities and I also have my own research projects. It is really tough to take time out for science, but somehow I try to manage to do it by working long hours. But the time I want to give to science has reduced because of so much administrative work, travel and meetings.

Q What measures are we taking to tackle the Zika virus, especially since there is now increased trade and travel between India and South America?

Firstly, we are making efforts for preparedness for Zika. If it comes to India, we want to make sure that we will be able to contain the disease.

We will also have to consider our research priorities. For instance, the Zika virus is a flavivirus similar to the dengue virus, but is unlike chikungunya, which is an alpha virus. So by taking such factors into consideration, it will help us understand aspects of its biology such as how it replicates. This will also help in the surveillance programme and in the detection of this virus in the vector.

Q In 2014, a study showed that the number of dengue cases were vastly under-reported in India. Why?

It is unfortunately very common in India, not just for dengue, but for other diseases as well. The problem is that good diagnostic tools are still not available, such as a good ELISA test [a test to determine the presence of antibodies generated within the patient's body in response to any infectious disease], so that proper IgM [Immunoglobulin M, the first and most common antibody to appear in response to an antigen] monitoring can be done. Thereby, we can understand the number of cases and the spread of the disease. Disease burden estimation is also necessary.

Q What is the status of polio in India? Has it been completely eradicated?

Type 2 polio virus has already been eradicated and now we are in what is called a "shift period". So in this shift period of 6 months, we have stopped administering children oral polio vaccinations. When this vaccination is given, it produces immunity in children, but also replicates in the body. And so it is released in the environment through excreta which has to be reduced. Vaccine-associated outbreaks have been known for a long time; so nobody wants to take that risk. Now, Inactivated Polio Vaccine [IPV] has been introduced, which will help wipe out this virus. The combined effect of IPV and oral vaccine can provide additional protection to the children. Very soon, possibly by 2017, we should be able to complete this task of eradication of the disease.

Q NIV is active in setting up field units in different parts of the country for studying viral diseases. How do you decide where they should come up?

Yes, we have opened 3 field stations now : one is in Bangalore itself, one is in Kerala, and third is in Gorakhpur [in Uttar Pradesh]. The country is vast and we need to understand disease scenarios from a regional perspective. A disease may be different in Himachal Pradesh as compared to Karnataka. ICMR has taken initiative to establish Virus Research Diagnostic Laboratories [VRDLs] in all states to address the issue of viral infections.

Q What will be your priorities in the coming years?

There are two main priorities. The first is in the area of respiratory infections as they spread very fast. Many emerging infections like H1N1 spread through the respiratory mode. Besides this, many people are not even aware of diseases being caused by RSV [Respiratory Syncytial Virus]. We now know that about 10% of people suffering from influenza are infected because of RSV. The second priority is viral hemorrhagic fever. We also want to focus on immune therapeutics because there are many viral diseases for which anti-virals and vaccines are not available.

Q You are here to conduct a workshop on safe laboratory practices. Tell us more about it.

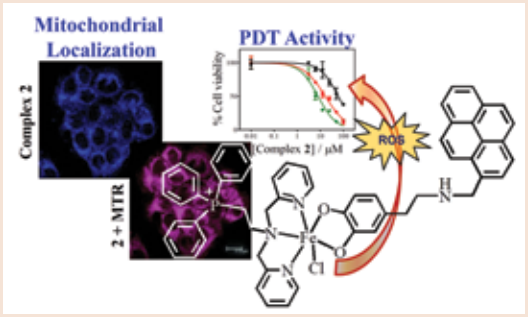
One thing that I have realised in my 15 year-career in biocontainment is that there are a lot of lacunae when it comes to following safety protocols in laboratories working on pathogens. We plan to create and enhance knowledge, as well as increase awareness about this simple, yet important responsibility in all important institutes working on infectious agents. So we are conducting 1-5 days workshops on basic safety protocols in institutes across the country.

HOT OFF THE PRESS

Recent research highlights from IISc

✍ Compiled by **NITHYANAND RAO** from press releases written by the **SCIENCE MEDIA CENTER***

CANCER BIOLOGY



Courtesy: UTTARA BASU

Light-activated iron compounds to fight cancer

Researchers from the Department of Inorganic and Physical Chemistry and the Department of Molecular Reproduction, Development and Genetics have discovered that a class of inorganic iron compounds called iron (III) catecholates can be used to kill cancerous cells.

These compounds are activated when irradiated with red light. On being administered to a cancer cell, they attack its mitochondria—the organelle which produces energy—thus killing the cell. This method avoids the problems of skin sensitivity caused by organic drugs. It is also extremely selective because it is activated only by light.

The team now aims to investigate the action of this anti-cancer drug in animal models.

Published in: *European Journal of Inorganic Chemistry*
Read more at: http://dx.doi.org/10.1002/ejic.201501105

METEOROLOGY

An improved rainfall detection model

Detection of rainfall over land using satellite images is tricky, since the microwave radiation from land heated by the Sun obscures the radiation from rain clouds. The variation in land cover poses another hurdle.

Now, researchers from the Department of Civil Engineering have developed a new model for detecting rainfall. The team tested their model on satellite data from the basin area of the river Mahanadi and compared the results with actual rainfall data for select events from ground-based sources. The model detected rainfall in 95% of the case study events.

Published in: *Hydrological Sciences Journal*
Read more at: http://dx.doi.org/10.1080/02626667.2015.1133908

BIOMIMETICS

How termites fortify their mounds

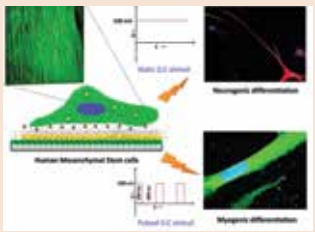
Researchers from the Centre for Ecological Sciences and the Department of Civil Engineering have discovered how *Odontotermes obesus*, a fungus-growing termite, alters the physical and mechanical properties of the soil in order to make the mounds strong and stable.

They compared the soil in termite mounds to the surrounding soil, and found that the soil particles in the mound were smaller. Besides, through a process called "biocementation", the termites strengthened the soil tenfold. It involves making little boluses of soil using their own secretions. Biocementation also makes the mound less susceptible to erosion and collapse.

Published in: *Environmental Geotechnics*
Read more at: http://dx.doi.org/10.1680/jenge.15.00036

* Science Media Center is a joint initiative of IISc and Gubbi Labs

TISSUE ENGINEERING



Courtesy: GREESHMA THRIVIKRAMAN and BIKRAMJIT BASU

Stem cells for the heart and the brain

Studying stem cells has become a popular area of research in recent years because of its enormous potential in treating tissue damage.

Researchers from the Department of Chemical Engineering and the Materials Research Centre took a step in fulfilling this potential when they used a pulsed current to induce stem cells to transform into heart cells, and a direct current to transform them into nerve cells. In both cases, the current was transmitted using gold nanoparticles, which through "electroactuation" exerted mechanical forces on the stem cells. This technique could be used to differentiate stem cells for tissue engineering and regenerative medicine.

Published in: *Biomaterials*
Read more at: http://dx.doi.org/10.1016/j.biomaterials.2015.10.078

PHYTOMEDICINE

Garlic-artemisinin combination effective against malaria

Artemisinin, the discovery of which won the 2015 Nobel Prize in Physiology or Medicine, is widely used to treat *Plasmodium falciparum*, the most lethal form of malaria. However, the parasite is increasingly becoming resistant to artemisinin, especially in parts of Asia. The WHO, therefore, recommends using artemisinin in combination with other drugs.

Researchers from the Department of Biochemistry and the University of Birmingham have found that a garlic concentrate along with arteether, a semi-synthetic derivative of artemisinin, is an effective combination to combat malaria caused by *Plasmodium berghei*, a mouse analogue of *Plasmodium falciparum*. The combination therapy worked successfully, while either drug on its own did not. What's more, the mice did not suffer a relapse.

The researchers are now studying the mechanism of garlic's anti-malarial action.

Published in: *Biochemistry and Biophysics Reports*
Read more at: http://dx.doi.org/10.1016/j.bbrep.2016.01.015

INFECTIOUS DISEASE

A new TB vaccine candidate

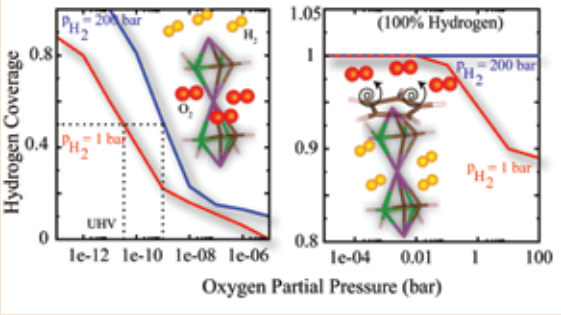
Researchers from the Department of Microbiology and Cell Biology, collaborating with those from other institutions in India, have identified a new candidate vaccine for tuberculosis.

The researchers recruited groups of healthy volunteers who have a latent TB infection—the bacterium *Mycobacterium tuberculosis* being present in a dormant state—and those with active TB. They treated blood samples of both groups with various peptides which are smaller parts of Rv1860, a protein secreted by the TB pathogen. This was found to stimulate $CD8^+$ T cells, which are involved in the human body's immune response. This effect of Rv1860 was significantly greater in the volunteers who had latent infection compared to those who had the active disease.

The researchers next aim to validate the results with larger study groups.

Published in: *Clinical and Vaccine Immunology*
Read more at: http://dx.doi.org/10.1128/CVI.00554-15

ALTERNATIVE ENERGY



Courtesy: RAFIA AHMAD and ABHISHEK KUMAR SINGH

Storing hydrogen more efficiently

One of the major challenges in using hydrogen as a fuel is finding a way to store it efficiently. A material that has a carbon base with metal atoms "decorated" on it does store hydrogen, but not as much as it theoretically could. This is because oxygen atoms too get adsorbed by the metal atoms.

Now, researchers at the Materials Research Centre have come up with a way to enhance hydrogen adsorption by "capping" the metal atoms with molecules called arenes. This alters the electronic structure of the metal atoms in such a way that the interaction with oxygen atoms is selectively blocked.

This solution could also be applied elsewhere, such as in gas sensing and catalytic systems.

Published in: *International Journal of Hydrogen Energy*
Read more at: http://dx.doi.org/10.1016/j.ijhydene.2016.02.081

COMPUTATIONAL CHEMISTRY

A tool to compute hydrogen bonds

A hydrogen bond is one in which a hydrogen atom of one molecule is attracted to an electronegative atom—such as a nitrogen or oxygen atom—of another molecule. Hydrogen bonds are abundant in nature, playing an important role in determining the shapes and functions of biomolecules, including DNA and proteins.

A team at the Department of Computational and Data Sciences has developed a Hydrogen Bonds Computing Server (HBCS, http:// bioserver1.physics.iisc.ernet.in/hbcs/) which computes various properties of the hydrogen bonds in a given molecule, and also the estimated error in these calculations. For this, HBCS uses a repository of standard information about the 3D structures of various biological macromolecules. Users can also input information about any other molecule whose hydrogen bond properties they wish to compute.

Published in: *Journal of Applied Crystallography*
Read more at: http://dx.doi.org/10.1107/S1600576716002041

MOLECULAR BIOPHYSICS

Protein structure from sequence

Researchers at the Molecular Biophysics Unit have developed a method called "saturation suppressor mutagenesis" to predict which amino acids in a protein lie close to each other. This is important for predicting the structure and, therefore, the function, of a protein from its specific sequence of amino acids. Traditional methods require high-quality protein crystals, which may not always be available.

Suppressor mutations, which preserve protein function, happen when mutations in one amino acid are compensated for by mutations in amino acids close by. A comprehensive procedure to identify suppressors has now been devised. This was achieved by creating an inactivating mutation in a protein and then systematically searching for suppressors. Using mutations in several places, the researchers were able to piece together proximity information for multiple pairs of amino acids.

Published in: *eLife*
Read more at: http://dx.doi.org/10.7554/eLife.09532

DISPATCHES FROM THE LAB

In this section, we shine the spotlight on researchers from IISc who are making a splash in their fields of research

✍ BASED ON INPUTS FROM THE **FEATURED RESEARCHERS**

A CHOCKALINGAM (PROFESSOR, DEPARTMENT OF ELECTRICAL COMMUNICATION ENGINEERING) AND B SUNDAR RAJAN (PROFESSOR, DEPARTMENT OF ELECTRICAL COMMUNICATION ENGINEERING)

MANOJ SUDHAKARAN

RESEARCH IN LARGE-SCALE MIMO SYSTEMS

Multi-antenna wireless communication has become immensely popular because of its unique advantage of achieving increased data rate (without increasing bandwidth) and link reliability. Large-scale multiple-input multiple-output (MIMO) systems with tens to hundreds of antennas are being considered for 5G wireless standards. Chockalingam and Sundar Rajan's

labs have made pioneering contributions in the area of large-scale MIMO systems (now popularly called *Massive MIMO systems*). They have developed near-optimal low-complexity receiver algorithms that broke the optimum receiver complexity barrier encountered in large dimensions. These algorithms are rooted in artificial intelligence and machine learning, algorithms based on local search and meta heuristics (tabu search, for example), belief propagation/message passing and Monte Carlo sampling methods. Ingenious ideas in these proposed algorithms with carefully balanced performance and complexity were instrumental in the success of these algorithms for signal detection in large-scale MIMO systems. This collaborative research by these two electronics communication engineers resulted in the early development of the field of large-scale MIMO systems. They also have several US patents granted in this area.

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More recently, recognizing the value and importance of translating their research output into practice, Chockalingam and Sundar Rajan, jointly with DRDO and partners from industry, have developed a large-scale MIMO system that uses 16 transmit antennas and 20 receive antennas in the 2.5 GHz band. The basic design and implementation approach for this system are based on their patents on large-scale MIMO.

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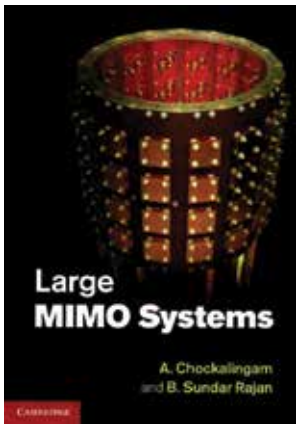
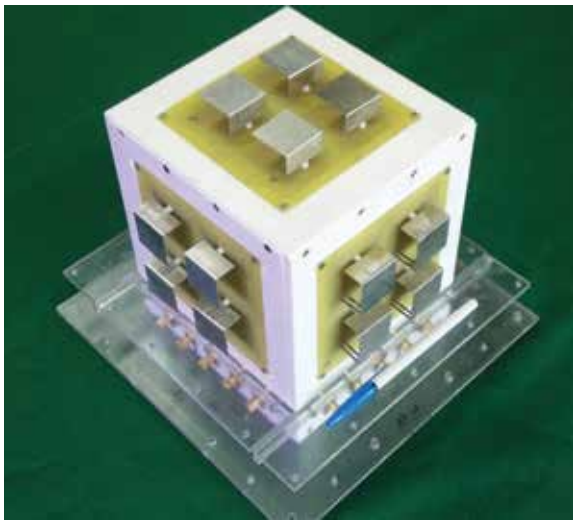
Chockalingam and Sundar Rajan have also authored a book titled *Large MIMO Systems*, published by Cambridge University Press in 2014. It is the first book to take an in-depth look into large MIMO systems with tens to hundreds of antennas. A Chinese edition of this book is being planned by the publisher.



Courtesy: CHOCKALINGAM AND SUNDAR RAJAN

Their book on the subject



Courtesy: CHOCKALINGAM AND SUNDAR RAJAN

A 20-Antenna MIMO Cube

GAUTAM DESIRAJU (PROFESSOR, SOLID STATE AND STRUCTURAL CHEMISTRY UNIT)

KG HARIDASAN

PIONEER IN CRYSTAL ENGINEERING

Gautam Radhakrishna Desiraju—one of India's most eminent chemists—joined IISc in 2009 after 30 years at the University of Hyderabad. It was he who, in his 1989 book, coined the term "crystal engineering", which he defined as "the understanding of intermolecular interactions in the context of crystal packing and using it to design new solids with desired physical and chemical properties". He is also associated with terms such as "weak hydrogen bond" and "supramolecular synthon", now an integral part of a crystallographer's lexicon, and is one of the most highly cited Indian scientists. He was president of the International Union of Crystallography from 2011 to 2014 and is currently a member of the editorial advisory boards of *Angewandte Chemie*, *Journal of the American Chemical Society* and *Chemical Communications*.

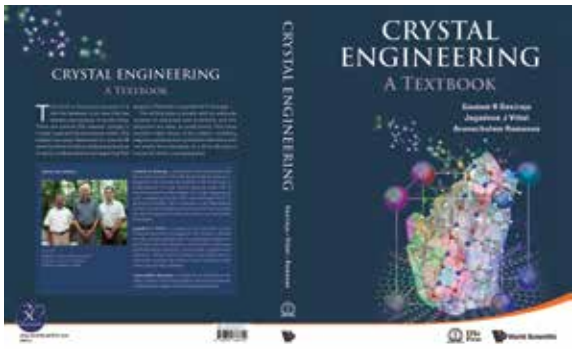
In their research, Desiraju's group uses a technique called nanoindentation, in collaboration with U Ramamurty of the Department of Materials Engineering, to understand the mechanical behaviour of organic crystals and to correlate it with the properties of the molecules in these crystals. With this tool, they have studied the properties of the active pharmaceutical ingredient (API) felodipine and also engineered the hardness

of an important API, omeprazole. Recently, they have also identified the structural features that enable organic crystals such as N-benzylideneaniline to be highly flexible.

Using nanoindentation, Desiraju's group has studied the properties of the active pharmaceutical ingredient (API) felodipine and also engineered the hardness of an important API, omeprazole.

Desiraju's research team has established for the first time dual mechanical properties in an organic crystal, namely pressure-induced elastic mechanical bending and temperature-induced crystal splitting. A combinatorial crystal synthesis approach has been explored to design ternary—three component—molecular solids that constitute the crystal structure landscape. This concept of a supramolecular combinatorial library can be profitably extended to the crystallization process, with supramolecular synthons being the constituents of such a library.

Desiraju's lab has also successfully improved the physical and chemical properties of the diuretic drug hydrochlorothiazide using various other compounds with which it can form crystals.



Courtesy: GAUTAM DESIRAJU

Front and back cover pages of Desiraju's textbook co-authored by Jagadese Vittal and Arunachalam Ramanan

Desiraju with his team

DEPARTMENT OF MATHEMATICS: BRIDGING THE SCIENCES

A closer look at contributions of researchers who seek to connect various scientific disciplines through a common language

CONNECT

✍ **NITHYANAND RAO**

Founded in 1956 as the Department of Applied Mathematics by PL Bhatnagar, an eminent mathematician, the initial mandate of the Department was to provide mathematical training to students in the science and engineering programmes of the Institute. It took its current name in 1989 during CNR Rao's tenure as the Director of IISc, a period that Gadadhar Misra, the current head of the Department, believes led to a reinvigoration. "He tried to put the Department on a footing equal to that of any other maths department in the country," he says.

The name change reflected an expansion in the research interests of the Department, which was earlier focused on areas considered as applied mathematics, such as the kinetic theory of gases and fluid mechanics, areas that Bhatnagar was active in. But this is not the case today. "Unlike many other institutes, we live happily without having any biases about what

sort of mathematics should be done," adds Misra.

Research

The research interests of faculty members in the Department are diverse. Traditionally, the different areas of research in mathematics fall within its "three pillars": algebra, analysis, and geometry. These are, however, more than just branches—they are also ways of thinking that permeate across the myriad avenues of research that mathematicians pursue.

Broadly speaking, algebra is the study of operations that one can carry out on mathematical objects. The algebra that one learns in high-school might appear, superficially, to be the manipulation of symbols with the aim of solving various kinds of equations. But trying to solve equations has, over the centuries, often been fertile ground for creating new mathematics. Structures, or sets of elements which have common properties and upon which one can define certain operations, that emerged from trying to solve equations later became objects of study. The study of such structures, and operations on them, is what is today called algebra. Faculty members of the Department who do research in algebra are Dilip Patil and Pooja Singla.

Such abstraction—developing a theory rather than techniques to solve individual problems—is what gives mathematics its power. "When you see abstraction, you may not see any applications directly. But abstraction really makes mathematics more applicable," says AK Nandakumaran, a professor in the Department.

"When you see abstraction, you may not see any applications directly. But abstraction really makes mathematics more applicable"

Analysis, another major branch, is the study of mathematical functions and how they change. The beginnings of analysis may also be found in high-school mathematics curriculum in the form of calculus. Central to analysis is the concept of the limit of an infinite sequence or of the sum of an infinite series—a quantity that will not be exceeded, yet one that can never be reached no matter how many terms one considers. An example is the sequence of numbers 0.9, 0.99, 0.999, and so on, which approaches, but never reaches, unity. The techniques of analysis applied to the abstract algebraic structures yield various avenues of research, pursued by Gadadhar Misra and Tirthankar Bhattacharya.

A major topic in analysis is the study of partial differential equations (PDEs), which are used to model many natural phenomena. Nandakumaran studies PDEs, especially those that arise in applications such as medical imaging. Often, solutions for these equations cannot be found in the form of exact formulae, which is where numerical analysis comes in, the idea being to develop algorithms that can give approximate but reliable answers. Such techniques, some of which are employed by Thirupathi Gudi, do not merely generate numbers, but provide insight into the phenomenon being studied.

The study of real numbers themselves, often integers, is called number theory. This line of

research is pursued by Soumya Das. Historically, it was in trying to solve equations which had no solutions in the real numbers that the "imaginary" number—the "square root" of −1—was invented. This gave rise to complex numbers. The study of functions of one or more complex variables is, generally, what's called complex analysis, which is the research area of Gautam Bharali and Kaushal Verma.

The study of how a function can be expressed in terms of a set of more basic periodic functions is the subject of harmonic analysis. Faculty who study harmonic analysis include S Thangavelu and EK Narayanan. As such, it finds application in any area of science and engineering where signals need to be analysed.

Geometry, the third pillar of mathematics, is the study of shapes. Central to geometry are higher-dimensional generalizations of shapes called manifolds—the surface of a sphere or of an inflated bicycle tube are familiar examples. Modern geometry involves studying these shapes from different perspectives. One of them, algebraic geometry, is the study of manifolds that can be described using algebraic equations and studied using algebraic techniques. It is pursued in the Department by Abhishek Banerjee.

Another faculty member, Harish Seshadri, meanwhile, does differential geometry, which employs the methods of analysis in the study of geometric objects. An example of a problem in differential geometry would be to understand how heat flows from one part of a manifold to another, especially when there are multiple paths available.

Topology, by contrast, is the study, especially in higher dimensions, of distinct shapes that can be twisted and stretched but not torn or punctured. Therefore, apples are topologically the same as oranges because it is possible to deform one (in your imagination, at least) into the other. They are, however, distinct from, say, the rubber tube in a vehicle's tyre. The topologists in the Department include Basudeb Datta, Siddhartha Gadgil and Subhojoy Gupta.

The Department also has a strong group, comprising Arvind Ayyer, Mrinal Ghosh, Srikanth Iyer, and Manjunath Krishnapur, that works on probability theory and stochastic processes. Ayyer studies, among other things, Markov chains, which are models for systems that evolve randomly whose next state depends only on the current state; Ghosh investigates stochastic processes that have applications in financial markets and in other real-life systems; Iyer works on stochastic phenomena arising in wireless networks, financial instruments and their pricing, and interacting particle systems; and Krishnapur studies the theory of matrices whose elements are random variables.

G Rangarajan works on the applications of nonlinear dynamics in, for example, networks, time series of various phenomena, and biological processes.

Academics

The Department has 21 faculty members, which, Misra says, is smaller compared to other major mathematics centres in India and abroad. Yet, the Department has more than 50 students enrolled in the PhD and Integrated PhD programmes, with up to 15 new students enrolling every year.

Apart from the regular PhD and Integrated PhD programmes, the Department also hosts the PhD programme in Interdisciplinary Mathematical Sciences. "The fact that we have an Interdisciplinary PhD programme, housed particularly in our Department, is a matter of great pride," says Misra. As he puts it, it's ideal for a student, who, for instance, "has solved a lot of differential equations but wants to really see how the wings of a plane warp and influence motion in practice." This unique programme gives students the option of doing their PhD in an area of science that involves mathematical work. Students can choose from various interdisciplinary projects that are listed at the time of admission. They could, for example, choose supervisors from among those who are part of the DST Centre for Mathematical Biology, also hosted by the Mathematics Department, which brings together researchers from across IISc to work on problems in biology, amenable to mathematization.

"The fact that we have an Interdisciplinary PhD programme, housed particularly in our department, is a matter of great pride"

The Interdisciplinary PhD programme is a part of the IISc Mathematics Initiative (IMI). This initiative began in 2003 to encourage collaborative work between mathematicians and other researchers across departments in the Institute who used mathematics in their research areas. Although the programmes—workshops, conferences, short courses—focusing on various interdisciplinary topics were held at IISc, people from outside were encouraged to participate, says Nandakumaran, who was involved with IMI from the beginning. The aim, he says, was "to bring together all people interested in mathematics, who do mathematics, who apply mathematics... otherwise everybody works in isolation."

In 2012, DST expanded the scope of the programme, and it was renamed as the National Mathematics Initiative (NMI). While still coordinated by IISc, events are now held outside IISc too. "IISc continues to be the nodal agency but the programme now has a wider focus; it has spread out," says Misra. Rangarajan, under whose leadership IMI began, continues to be the Convener of NMI. Every year, a committee headed by Rangarajan, the Chairperson of the Division of Interdisciplinary Research, decides a "theme"—an interdisciplinary subject area to focus on. The current theme is game theory and optimization.

Courtesy: NMI

At IISc, NMI involves more than 35 faculty members from various departments. Researchers from leading institutions all over India, and abroad, also participate in this Initiative, along with resource persons from national laboratories and the industry—something unique in India. "Though individual interactions were there, NMI provided a structure to these interactions," says Nandakumaran.

All these activities are housed in an inviting two-storey building, its airy architecture reminding one of the all-encompassing nature of mathematics, and the welcoming façade putting its visitors—even those for whom mathematics may have been a forbidding subject in school—at ease.

HELLO!

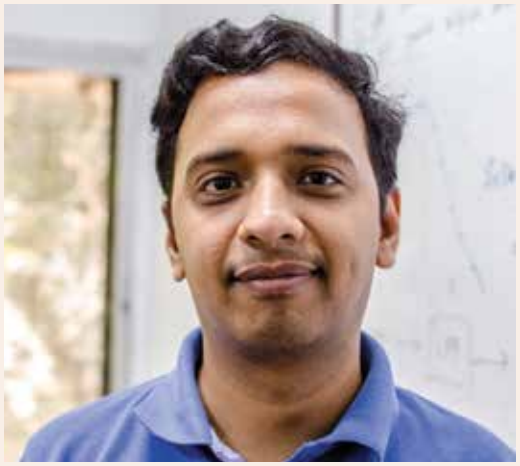
Meet new faculty members who have joined IISc

SRIRAM GANAPATHY (Assistant Professor, Department of Electrical Engineering) is from Thiruvananthapuram. He completed his PhD from Johns Hopkins University, USA, in modelling for audio and speech signals. After a stint as a Research Scientist at IBM TJ Watson Research Center, USA, where he worked on algorithms for dealing with highly noisy speech signals, he is now in IISc. Here he plans to pursue his research interests in signal processing, speech processing, machine learning and deep learning to extract information from speech and audio signals.

SARASIJ DAS (Assistant Professor, Department of Electrical Engineering) received his PhD from the University of Western Ontario, Canada. He pursued his postdoctoral work at the University of Ontario Institute of Technology, also in Canada. His research interests include smart grids, power system protection and monitoring, grid integration of renewable energy and power system data mining and analysis.

JYOTHSNA RANI KOMARAGIRI (Assistant Professor, Centre for High Energy Physics), originally from Hyderabad, did her PhD from the Tata Institute of Fundamental Research, Mumbai. Her research, done in collaboration with Fermilab, USA, was in the area of high energy physics. Komaragiri then did her postdoctoral studies at Simon Fraser University, Canada. At IISc, she is part of the newly formed Experimental High Energy Physics group.

ANAND SRIVASTAVA (Assistant Professor, Molecular Biophysics Unit) was born and raised in Patna, Bihar. He has an engineering degree from IIT-Kharagpur and a PhD from Ohio State University for his dissertation on glass transition temperature in thin films. He later joined the University of Chicago, USA, as a postdoctoral researcher to explore his interest in chemical-physics theory and molecular modeling. Now at IISc, Srivastava's primary interests are in the areas of mechanobiology and force-induced conformation changes in proteins.



RAJIV SOUNDARARAJAN (Assistant Professor, Department of Electrical Communication Engineering) did his Bachelor's degree from BITS Pilani and went on to get his Master's and doctoral degrees in Electrical and Computer Engineering from the University of Texas at Austin, USA. His work in IISc is in the area of image and video quality assessment. He is interested in predicting the quality of visual signals that would be in accordance with how humans perceive them, and also in information theory.

VIBHOR SINGH (Assistant Professor, Department of Physics) hails from Haridwar in Uttarakhand. He obtained his PhD from the Tata Institute of Fundamental Research, Mumbai, studying the condensed matter properties of atomically thin system graphene. His postdoctoral work at the Technical University of Delft, the Netherlands, was on developing new opto-mechanical platforms based on two dimensional materials and superconducting microwave cavities. At IISc, he plans to set up an experimental lab to probe the motion of nanoelectromechanical systems in the quantum limit and their applications in quantum information technology.

✍ Compiled by **MANU RAJAN** and **SUDHI OBEROI**

IN THE NEWS

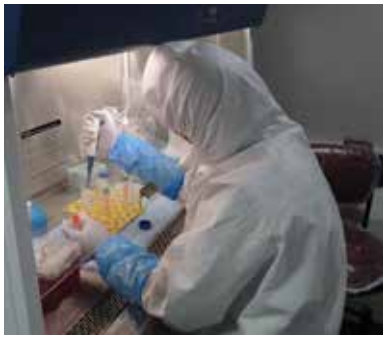
BOOST FOR INFECTIOUS DISEASE RESEARCH

✍ **SUDHI OBEROI**

Infosys Foundation has announced a financial grant to the Centre for Infectious Disease Research (CIDR) at IISc to help broaden its research and also provide additional infrastructural support to the Centre.

Infectious diseases like tuberculosis (TB), malaria, HIV/AIDS, hepatitis and more recently SARS, Ebola and Zika virus diseases are posing a threat to human health around the world. With human-induced changes to the environment and increased globalization, pathogens have become more likely to switch hosts and spread across traditional geographic barriers, causing not just more frequent disease outbreaks, but also epidemics. While some infectious diseases have been well researched and can be prevented, or cured, many others, particularly tropical diseases, have received far less attention. A major goal of CIDR, set up in 2013, is to help plug this gap and address questions in infectious disease research that are more relevant to countries like India.

Currently, CIDR consists of a central lab, a state-of-the-art bio containment space known as the Biosafety Level-3 (BSL-3) facility and office space for its researchers. In the past few months, the Centre has been looking to expand the scope of its research and improve its infrastructure, a point that was highlighted by G Padmanaban, a former Director of IISc and currently an Emeritus Professor at the Department of Biochemistry, during a session of the Global Alumni Meet of IISc in June 2015.



Courtesy: CIDR

Speaking to CONNECT, Dipankar Nandi, a professor at the Department of Biochemistry and Convenor of the committee that runs CIDR, said that Sudha Murthy (Chairperson, Infosys Foundation, and an alumnus of IISc), who was chairing this session, immediately offered to help CIDR in its plans for expansion.

In an interview to CONNECT, Murthy stressed upon the importance of advancing fundamental research in the area of infectious diseases and also developing new drugs and diagnostics.

The support from Infosys Foundation, which will be spread over five years, will help in building an annex to the Centre—this will house three laboratories and more office space. In addition, a small animal BSL-3 facility for research will be built. The research team at CIDR will also be expanded. It will recruit two Infosys Fellows who will conduct independent research. According to Nandi, some of the money from the Foundation will also be used to pursue another important goal of the Centre: translational research.

The Centre, which is already working with researchers from all over the Institute to ensure an interdisciplinary approach to studying infectious diseases, also plans to organize seminars to increase public awareness on the subject.

IISc AND GE INK AGREEMENT

✍ **RANJINI RAGHUNATH** (WITH INPUT FROM **Y NARAHARI**)

In December last year, IISc and GE India Technology Centre signed an agreement to formalize their collaborative efforts in many different areas of research. The MoU was signed by Registrar of IISc, V Rajarajan, and D Umamaheshwar, Executive Chief Consulting Engineer at GE Aviation, in the presence of Anurag Kumar, Director of IISc.

Over the past decade, IISc has been working on several collaborative research projects with GE India Technology Centre, GE's largest multidisciplinary R&D centre. To take this collaboration to the next level, Anurag Kumar and some of his senior faculty colleagues made a visit to their facility in Bangalore, the John F Welch Technology Centre, in April 2015. At this meeting, several broad areas such as energy, hybrid power, distributed control and optimization, big data analytics and Industrial Internet were identified for collaboration. In the following months, multiple workshops were organized in these focus areas involving IISc faculty members and GE researchers, paving the way for several joint project ideas in these research areas.

"This MoU will go a long way in fostering high impact collaborations and push the frontiers in exciting areas such as big data analytics, distributed optimization algorithms for hybrid energy systems, breakthrough new materials, and the Industrial Internet," said Y Narahari, Chairman, Division of Electrical Sciences at IISc. "We are looking forward to harnessing the synergy between academic creativity and industrial innovation."

GE, which has a presence in 175 countries, already has several such "umbrella" research agreements with leading universities worldwide. "At GE, we

RANJINI RAGHUNATH

believe in an open, collaborative approach to innovation. With the convergence of the physical and digital worlds and the ability to connect like never before, the premium and benefit on collaboration has never been greater. In India, we have a strategic vision to build long term relations with the premier institutes and IISc is one of the top institutes we want to collaborate with," said Umamaheshwar, speaking to CONNECT. "We have chosen IISc because of its reputation, talent, and high-end research capabilities." IISc and GE India Technology Centre have very similar multidisciplinary research interests, he added.

As part of the agreement, several high-impact projects in the identified areas will soon be launched under the aegis of IISc's Society for Innovation and Development. Many of these areas represent fields that GE is currently making strides and heavily investing in, apart from its core engineering focus, according to Umamaheshwar. "The talent and research infrastructure at IISc will be a great value-addition to GE, while IISc researchers will have an opportunity to leverage GE's expertise and industry insights," he said.

At the MoU signing, IISc and GE also inked an agreement to implement Corporate Social Responsibility (CSR) projects at IISc over the next three years.

CAMPUS CHRONICLES

DESIGNING FOR A CLEANER NATION

Courtesy: ORGANIZING COMMITTEE, REIMAGINE WASTE

Participants during the *Reimagine Waste* hackathon

Reimagine Waste, a "design hackathon", was organized at IISc by the Centre for Product Design and Manufacturing (CPDM), in association with the Centre for infrastructure, Sustainable Transport and Urban Planning (CiSTUP) and Waste Impact, an NGO. The event was spread across two weekends: 26-27 March and 2-3 April 2016. This hackathon was the first in a series of initiatives that aims to tackle the growing garbage problem, particularly acute in Bangalore.

Over 200 students from IISc and elsewhere participated in this hackathon. Day one saw an "Immersion" session in which the participants visited various facilities—dry waste collection centres, incinerators, and landfills—across Bangalore and its outskirts. Based on this first-hand knowledge, on day two, problem statements were proposed and participants were divided into teams, with each team tackling one problem. Each team also included at least one waste collector as the domain expert. On day three, the teams were provided with the raw materials, tools and machining facilities to "hack away" at the problem and come up with solutions within 24 hours. "In traditional workshops, participants only talk about what they've already done in their own silos—whereas here we're looking for creative solutions which impact the lives of waste collectors. We wanted the participants to have a much more interactive, engaging experience than just another knowledge sharing session," said Gayitri Handanahal of Waste Impact.

On the final day, the 12 finalists presented their solutions to a panel of judges comprising seasoned entrepreneurs, venture capitalists and domain experts. The teams were quizzed on various aspects of their proposed solutions, such as the viability and marketability of their ideas. The first prize was won by a team from Infosys, Nitte Meenakshi Institute of Technology and Alliance University, which built a system involving a smartphone app, a wireless weighing scale, and a "gamification" platform that would enable waste collectors to record data about the waste collected at the source.

The finalists have also been given an opportunity to refine their ideas and come up with marketable ventures within 45 days. "We would be happy even if one or two of these ideas become viable enterprises which make a real difference on the ground. In addition, the hackathon serves to sensitize participants to the problems of waste management in our city and how they can be part of the solution rather than just the problem," Manish Arora, a faculty member from CPDM and one of the brains behind this novel experiment, told CONNECT.

✍ **NAVIN S**

WiSER 2016

From left to right: Anurag Kumar (Director, IISc), Kiran Mazumdar Shaw (Chairperson and Director, Biocon Limited) and Sandhya Visweswariah (Professor, IISc) at WiSER 2016

"If I can get institutes to realize that something special needs to be done to encourage both young women students and faculty to prosper, then I would have achieved something," said Rohini Godbole (Professor, Centre for High Energy Physics, IISc), setting the tone for the first Women in Science, Engineering and Research (WiSER) conference. Organized by the IISc Families and Friends and the IISc Alumni Association on 2 April 2016 at the Institute, the event brought together women, and men, from industry and academia to discuss the obstacles that women researchers face.

In his introductory remarks, Anurag Kumar, Director, IISc, highlighted the crux of the problem, referred to as the "leaky pipeline" phenomenon: The number of women pursuing science drops dramatically as they climb career ladders (even though the percentage of girls in schools and colleges is increasing). This was followed by a keynote address by Kiran Mazumdar-Shaw, Chairperson and Managing Director, Biocon Limited. Mazumdar-Shaw shared experiences of the time when she was building her company, which, she said, made her more determined to create more opportunities for women in leadership roles.

In the general panel discussion, moderated by NDTV journalist Maya Sharma, the panel raised critical questions, including those related to the perception of women scientists and the importance of their inclusion in decision making processes. One of the panelists, Sandhya Visweswariah (Professor, Department of Molecular Reproduction, Development and Genetics, IISc), felt that the criteria for recognition in academia are tilted in favour of men.

A second panel discussion addressed, among other issues, the dilemma that women often face in trying to balance family life and work. During the discussion, Narayan Sundaram (Assistant Professor, Department of Civil Engineering, IISc) admitted that men were aware of the problems faced by women in various spheres of life, but often lacked the vocabulary to express their support. Usha Vijayraghavan (Professor, Department of Microbiology and Cell Biology, IISc) felt that the path is easier for the current generation than it was a few decades ago.

The final session featured roundtable discussions in which participants had to propose, and later discuss with the audience, practical solutions to address various issues such as gender harassment, women's health, and security. In conclusion, Vijayalakshmi Ravindranath (Professor, Centre for Neuroscience, IISc) echoed a widespread sentiment when she said that she hoped to see a day when there are no "women scientists" but just scientists who happened to be either women or men.

✍ **VRUSHAL PENDHARKAR**

A version of this article appeared in IndiaBioscience.org

THINK NANO

DEBADRITA PARIA

Rudra Pratap, Chairperson of CeNSE, interacting with a participant at Think Nano

The Centre for Nano Science and Engineering (CeNSE) organized a National Student Symposium, *Think Nano*, on 31 March and 1 April 2016. The event, being held for the first time, was co-sponsored by the Airbus group.

The idea behind conducting this event, said Rudra Pratap, Chairperson of CeNSE, was to spread awareness among undergraduate students about the research and career opportunities available in the field of nanoscience. As part of the symposium, faculty members at CeNSE hosted sessions highlighting their research. This included work on developing photonics on a chip—using photons rather than electrons to encode, transmit and process information—and that on micro and nano electromechanical systems, and microfluidics.

The symposium had sessions on commercial products that resulted from research at CeNSE—such as an air pollution monitoring system named Envirobat, a glucometer being commercialized by the start-up *PathShodh*, pressure sensors for Light Combat Aircraft and an advanced chemical vapour deposition reactor for manufacturing graphene. There was also a panel discussion involving CeNSE industry partners, including Unilever, KAS Technologies, Centum Electronics, and Analog Devices.

More than 180 undergraduate students from all over the country presented their research ideas in the form of posters. They also got an opportunity to visit various laboratories and the nano fabrication facility, and to interact with members of a panel of graduate students at CeNSE who shared their research experiences.

✍ **DEBADRITA PARIA**

STUDYING CELLS AS THEY FLOW

TARU VERMA / SYAMA SREEDHARAN

The "Build Your Own Flow Cytometer" session with William Telford

Flow cytometry is a technique in which a stream of single cells or particles is passed through an illumination point, and hit with coherent beams of laser light of specific wavelengths. The information that the scattered photons carry can be used to measure and analyze the physical and chemical properties of the cells or particles. This technology has found several applications, particularly in medical research.

To help students learn techniques of flow cytometry, the 17th Indo–US Cytometry Workshop on *Applications of Laser Flow Cytometry in Biomedical Research* was jointly organized by IISc, National Centre for Biological Sciences (NCBS) and the International Society for Advancement of Flow Cytometry, USA, between 14–18 March 2016. Students who participated in the event, held at IISc and NCBS, were selected from institutions across India.

The star attraction of the workshop was the "Build Your Own Flow Cytometer", a hands-on module conducted by William Telford of the National Institutes of Health, USA. The "workshop also saw many other renowned cytometrists including Awtar Krishan (University of Miami, USA), Zofia Maciorowski (Curie Institute, France), Sumeet Gujral (Tata Memorial Centre, Mumbai) and Vineeta Bal (National Institute of Immunology, New Delhi), deliver talks and conduct wet lab modules. Some of the modules were also taught by scientists working in industry, leading to a healthy interaction between researchers in academia and industry.

✍ **TARU VERMA** AND **SYAMA SREEDHARAN**

SOLID WASTE MANAGEMENT CONFERENCE

VINAY S

Almitra Patel and Tejaswini Ananth Kumar at MSWM 2016

A conference on *Municipal Solid Waste Management* (MSWM) was held at IISc on 23 and 24 February 2016. The event was jointly organized by the Energy and Wetlands Research Group (EWRG) at the Centre for Ecological Sciences, IISc, Students for Development, and the Karnataka Environment Research Foundation.

Speakers at the conference emphasized how individuals can make a difference by more responsible disposal of waste in their own homes, offices and organizations. One could, for instance, generate biogas from food waste instead of disposing it in bins. Composting in-house would also reduce the load on the Bruhat Bengaluru Mahanagara Palike (BBMP).

The conference emphasized the need to find scientific solutions for resource management and for waste disposal, especially in fast-growing cities like Bangalore. It also underlined the importance of inclusive solutions that address the livelihoods of the waste-pickers. Both the BBMP and various NGOs have been working in this direction.

The conference saw many presentations, including posters by students, research scholars and representatives of various companies and resident welfare associations. They covered topics ranging from data gathering initiatives related to waste management, disposal of construction and debris waste and challenges in dealing with various kinds of waste.

✍ **ELLEN BROCK**

EECS STUDENTS SYMPOSIUM 2016

ARIJIT MONDAL / HARIKIRAN

The poster session held during the EECS Symposium 2016

The *7th Joint EECS Research Students Symposium* was held on 28 and 29 April 2016 at IISc. Participating in the symposium were the Departments of Computational and Data Sciences (CDS), Computer Science and Automation (CSA), Electrical Communication Engineering (ECE), Electrical Engineering (EE), and Electronic Systems Engineering (ESE).

"The primary focus of the EECS symposium is to showcase the research work of final year students from these five departments," Dipanjan Gope, one of the members of the organizing committee from ECE, told CONNECT. Over 50 students, both PhD and Master's, made oral and poster presentations of their research work. The event, sponsored by GE, Bosch, and Flipkart, also provided a platform for industry to sample research from these departments at IISc.

The symposium featured four keynote speakers from outside IISc, including Shihab Shamma, University of Maryland—the first occupant of the K Vaidyanathan Distinguished Chair at IISc. Various faculty members from the participating departments also presented their research.

✍ **CRESSIDA HAMLET** AND **PRATEEKSHA VARSHNEY**

WORKSHOP ON BIOSAFETY IN LABS

PRASHANT SHUKLA

Pragya Yadav, Scientist, National Institute of Virology, demonstrating biosafety training protocols at the workshop

A workshop on *Biorisk Preparedness in Laboratory Setting*, organized by the National Institute of Virology (NIV), Pune, was held in IISc on 11 April 2016. The goal of the workshop, led by D T Mourya, Director, NIV, was to increase awareness about biosafety procedures and risk assessment in laboratories that handle infectious disease pathogens.

Infectious agents are grouped primarily into four categories based on the risk they pose to the individual working with them, and to the community at large. This translates to four biosafety levels (BSL-1, BSL-2, BSL-3 and BSL-4) that are prescribed for handling pathogens from these categories.

To highlight the importance of the mandatory training received by all laboratory personnel handling infectious agents in BSL-3 and BSL-4 facilities, Pragya Yadav, NIV, conducted a hands-on training session at the BSL-3 facility in the Centre for Infectious Disease Research (CIDR), IISc.

✍ **MANBEENA CHAWLA**

OTHER EVENTS

VIVEK VANAMANE

EntorQ 210, an award-winning concept scooter from TVS Motors, on display during the workshop

The Society of Indian Automobile Manufacturers (SIAM) organized a ***Design Workshop on Two-Wheeler Mobility*** (South Zone) at the Centre for Product Design and Manufacturing in IISc on 19-20 March 2016.

✍ **SALEEM AHMED**

MANDEENA CHAWLA / RICHA MISHRA

Amit Singh, Assistant Professor, Department of Microbiology and Cell Biology/Centre for Infectious Disease Research, IISc, speaking at the symposium

A symposium, sponsored by the Centre for Infectious Disease Research (CIDR), IISc, and the Infosys Foundation, titled ***Initiative for Infectious Disease and Immunology Research at IISc and Imperial College London (I for I5)***, was held on 9-10 March 2016.

✍ **MANBEENA CHAWLA**

Courtesy: NV VINITH KUMAR

Participants from the workshop relaxing over dinner

IISc and the Dakshin Foundation, Bangalore, jointly organized an Indo–French workshop titled ***Exploring the scope of collaborations in Marine Biology and Biotechnology between France and India*** on 7–9 March 2016 at IISc. The Centre National de la Recherche Scientifique, France was one of the agencies with which the Department of Biotechnology, Government of India, partnered in organizing the event.

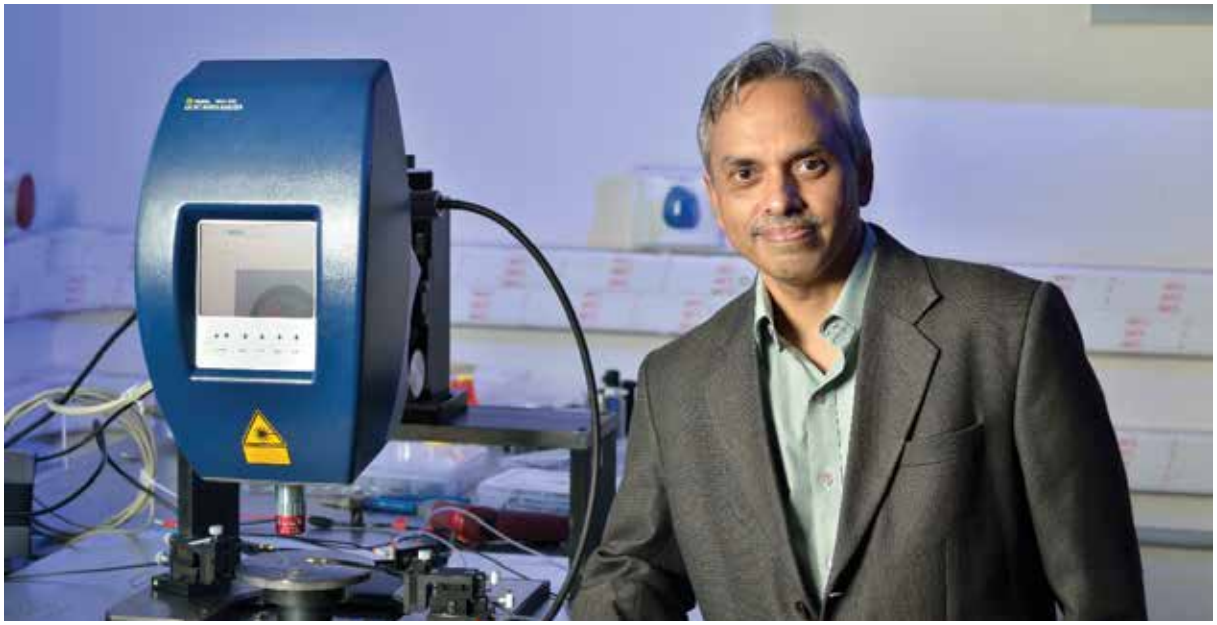
✍ **ADITI JAYARAM**

You can read more detailed accounts of these and other events at
http://www.iisc.ac.in/news-events/events/

LOOK WHO'S TALKING

Some of the important lectures delivered at the IISc in the past few weeks

INSTITUTE COLLOQUIUM: RUDRA PRATAP



MANOJ SUDHAKARAN

"Scientific research alone does not take you where you want to be. How do you overcome the temptation to stop after publishing your paper?" asked Rudra Pratap, Professor and Chairperson, Centre for Nano Science and Engineering (CeNSE), while giving an Institute Colloquium at IISc on 16 March 2016.

In the talk, titled *Turning Science into Technology: Narratives of Some Exhilarating Experiences*, Pratap addressed the question of how to turn scientific research driven by curiosity into technology and, eventually, innovative products. He did this by drawing on some of the recent research projects from his lab as well as those of his colleagues at CeNSE, which he played a key role in founding in 2010.

Pratap and his team developed a method of etching nano-sized circuits while investigating a phenomenon known as electromigration at the nano-scale—electrons in a conductor moving under the influence of an electric field transfer their momentum to the atoms, resulting in transport of material.

Pratap also spoke about how his colleagues at CeNSE are translating their research into marketable technologies. He gave the example of a diabetes monitoring device developed by Navakanta Bhat (also a professor at CeNSE) and his student Vinay Kumar, which they have commercialized with a start-up called *PathShodh*.

✍ **NITHYANAND RAO**

INSTITUTE COLLOQUIUM: S GOPALAKRISHNAN

Courtesy: S GOPALAKRISHNAN

S Gopalakrishnan, Professor, Department of Aerospace Engineering, gave an Institute Colloquium on 6 April 2016 titled *Wave Propagation in Nanomaterials and Structures*. Introducing the subject of nanotechnology, he said that the development of a form of carbon known as carbon nanotube (CNT) in 1991 was a major breakthrough in the field. Compared to steel, CNTs have superior tensile strength—100 times greater—despite being only a sixth as dense. Different forms of CNTs can be used for making various miniature sensors and actuators.

After highlighting the different approaches used in the theoretical modeling of CNTs, Gopalakrishnan spoke about his study of the propagation of mechanical waves in quasicrystals. The structure of a quasicrystal differs from that of crystals in that they are ordered but not periodic. A 3D quasicrystal tiling cannot have translational symmetry in more than two dimensions, unlike crystals which have periodicity in all three dimensions. While crystals can possess only two, three, four, and six-fold rotational symmetries, quasicrystals have other symmetry orders, such as five-fold.

The quasi-periodicity of the quasicrystals leads to two different displacement fields in the material: phonon and phason displacement modes. Gopalakrishnan spoke about his group's work on computing the wavenumber and group-speed of the waves in these two modes in 1, 2 and 3D quasicrystals. His group has also developed characteristic equations to study the variation of wave number and group-speeds in various quasicrystals.

✍ **ANUPAM PURWAR**

THE WAXING AND WANING OF LAC RESEARCH IN IISc

This article traces the early history of lac research in India and the role of researchers in IISc during that period

NUBERGER13/CREATIVE COMMONS LICENSE/WIKIMEDIA COMMONS

Shellac flakes

✍ **MEGHA PRAKASH** AND **MANU RAJAN**

A scarlet red wax stick being melted and used to seal envelopes was once a ubiquitous sight in post offices. These handcrafted seals were—and still are—made from lac.

Lac is the resinous secretion of a specific group of scale insects. Though there are many species of lac insects, the most commonly harvested species in India is *Kerria lacca*. The larvae of these insects pierce through the barks of particular host trees and suck on their sap to produce lac. The common host trees for lac insects include Ber (*Zizyphus xylopyrus*), Ghont (*Zizyphus jujuba*), Kusum (*Schleichera trijuga*) and Palas (*Butea frondosa*). The word lac is derived from the Sanskrit *laksha*, referring to the large number of the tiny insects which swarm the trees. It even finds mention in the epic *Mahabharata*—Duryodhana, the eldest of the Kauravas, has a palace called *Lakshagraha* built for his cousins, the Pandavas, in which he plans to burn them alive[1].

Lac has been used in India for centuries. Lac and lac-based products have been used to make bangles, as a seal, wood finish, cosmetic, as dyes for wool and silk, and in the food and beverages industry. In the early 20th century, shellac—the processed form of lac—was used to make gramophone records, ammunition and electrical goods, and in the paint and varnish industries.

Courtesy: HTTPS://INDIANBIJOU.WORDPRESS.COM

***Lakhera* or *Laheri*, the traditional artisan community still makes lac bangles in India**

Lindsay-Harlow Report

When World War I began, demand for shellac—particularly in Britain—rose sharply, leading to a steep increase in the price of lac in India which had a monopoly in the global market with lac exports that were, at the time, valued at Rs. 3 crores[2]. Because of its use in ammunition, shellac had been accorded the status of an industry of strategic importance. But the wide fluctuation in the prices of shellac had exposed it to serious competition from other substitutes. Besides, cultivation was in the hands of rural labourers with scanty means and little education. The government believed that the farmers neglected the crop when prices were low and were too often tempted to strip the trees of the brood lac when prices were high. There were other problems too: the use of unscientific methods in the farming of lac, local prejudice, careless manufacturing and adulteration. This prompted the British Government in India in 1920 to conduct a systematic enquiry into the different aspects of lac production and its promotion.

JEFFREY W LOTZ/CREATIVE COMMONS

Lac accumulating on the bark of a host plant

The enquiry was conducted by two government officials, HAF Lindsay and CM Harlow. Based on their investigations, the Lindsay-Harlow Report was published in 1921[3]. It made wide-ranging suggestions, including "the establishment of some form of research organization" that would "work in close touch with the Forest Department". Based on the recommendations, the Indian Lac Association for Research (ILAR) was formed in 1921 and the Indian Lac Research Institute (ILRI) was established in Ranchi in 1924.

Based on the recommendations, the Indian Lac Association for Research (ILAR) was formed in 1921 and the Indian Lac Research Institute (ILRI) was established in Ranchi in 1924

Lac Research Gains Ground in IISc

Even before the Lindsay-Harlow recommendations were being considered for implementation in 1921, JJ Sudborough, the first head of the Department of General and Organic Chemistry in IISc, and HE Watson, a professor in the same department, had been researching the purification of lac

and distillation of sandalwood oil. Another researcher from IISc who worked on lac was Gilbert Fowler, a sanitary chemist and professor in the Department of Applied Chemistry, who had earlier obtained a patent[4] for inventing an improved process for obtaining pure shellac from stick-lac (a stick with loads of eggs covered in lac). At IISc, Fowler worked on lac with S Mahdihassan and M Sreenivasaya, deputed to the Institute by the Governments of Hyderabad and Mysore respectively. The three of them jointly published a series of papers titled "Contributions to the Scientific Study of the Lac Industry" in 10 parts in the *Journal of the Indian Institute of Science* in 1924.

Mahdihassan, an entomologist, studied the anatomy and physiology of the lac insect. He succeeded in identifying the special glands that produced the various substances found in stick-lac, including wax and resins. Mahdihassan also studied the sex-ratio (which varied widely under different conditions) of the insect and found a way to determine the sex of the larva at an early stage in its development. Besides his own research, he translated an important monograph by B Hautefeuille, *Lac and its Industrial Treatment in Indo-China,* from French to English.

Sreenivasaya, on the other hand, carried out investigations to determine how the food of the insect was converted into lac. Mahdihassan and Sreenivasaya were assisted by RD Rege and DN Gupta, students in the newly established Department of Biochemistry; Rege worked on the chemical composition and physical characteristics of the host plants, while Gupta investigated the chemistry of resins and waxes produced by the lac insect, and studied the extraction of lac-dye. Two other researchers, CR Somayajulu and M Rangaswami, also contributed to the study of host plants. Later entrants into lac research included BH Krishna, who studied the nutrition of the lac insect, and MA Qadir who perfected a technique for bleaching lac and the utilization of lac dust.

Experimental Facilities

Besides laboratory and pot culture experiments, field investigations on lac were carried out in Lal Bagh, a farm in Hebbal and in the campus of IISc. The main experimental site, however, was a plantation with *jalari* trees adjoining the village of Doraisanipalya near Bannerghatta, 6 miles south of Bangalore. Here, records of the number of broods of lac insects per year and the outturn of stick-lac per crop were meticulously maintained. Facilities were created in the Institute campus for the technical preparation of seed-lac and lac-dye—a set of concrete tanks that were originally constructed for the treatment of effluent from the fermentation process for production of acetone, and located adjoining the Department of Applied Chemistry, were modified to serve as washing tanks for stick-lac. The services provided by the Governments of Mysore and Hyderabad also facilitated lac research in the Institute: Leslie C Coleman, the Director of the Department of Agriculture of Mysore and a member of the Governing Council of IISc, offered the facilities in his department for the benefit of the Institute's researchers; the Government of Hyderabad made available two artists who produced a large number of coloured drawings of characteristic lac cell formations and parasites.

Interaction with Industry

Lac researchers in the Institute interacted with local industries for the preparation of lac-based products. The Channapatna Lacquer Works collaborated with IISc for the manufacture of lacquer, a glossy material used for surface coating of wood. Sreenivasaya perfected a method to produce commercial crude lac-dye which also resulted in the making of a certain kind of French Polish, a wood finish that became prized by connoisseurs of woodworking. This polish was tested by the Mysore Railways successfully; after the testing, its large scale production by a private firm was seriously considered. The Institute staff also wrote several articles on lac products in the 2nd edition of the Munitions Board Handbook (a handbook on Industrial Chemistry).

Downturn in IISc

The setting up of ILRI in Ranchi resulted in a number of researchers from IISc moving there. ILRI's first Director was Dorothy Norris, who earlier had a brief stint with the Department of Applied Chemistry at IISc, where she worked on fermentation of alcohol, lactic acid and acetic acid. DN Gupta and M Rangaswami were appointed as Chemical Assistants. M Venugopalan, whose work was focused on the washing and bleaching of lac, and S Ranganathan, a student in the Department of Biochemistry who had worked with Sreenivasaya, joined ILRI as Field Chemists. Sreenivasaya, though, opted to continue in IISc. He was appointed as a lecturer in the Institute in 1941 and became the head of the Fermentation Technology Unit in the Department of Pure and Applied Chemistry a year later. An annual memorial award has been instituted in his honour for the best PhD thesis from the Department of Microbiology and Cell Biology[5].

The setting up of ILRI in Ranchi resulted in a number of researchers from IISc moving there

Though the strategic significance of lac waned over time, it continued to be an important commodity. Lac harvesting still impacts the livelihood of a sizable section of the tribal population of Jharkhand, Chhattisgarh, Madhya Pradesh and Odisha. These lac farmers are engaged in the cultivation and processing of lac, and interested in new ways of combating pests and increasing production. The early pioneering work on lac by researchers from IISc was built upon in successive decades by ILRI. In 2007, the research areas of ILRI were broadened, and it was renamed as the Indian Institute of Natural Resins and Gums.

The content of the article is based primarily on information available in the Annual Reports of IISc (1916-17; 1918-19; 1919-20; 1920-21; 1922-23; 1923-24; 1924-25; 1926-27; 1928-29; 1930-31; 1932-33)

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4. Process for obtaining pure shellac from stick-lac or the like, Patent No. US 975224 A, Gilbert J. Fowler (1910); www.google.com/patents/US975224
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AND THE WINNERS ARE...

Members of the IISc community who were recently honoured with awards

Courtesy: VIJAYALAKSHMI RAVINDRANATH

Vijayalakshmi Ravindranath *Professor, Centre for Neuroscience*, **Shanti Swarup Bhatnagar Prize**

MANOJ SUDHAKARAN

G Mugesh *Professor, Department of Inorganic and Physical Chemistry*, **Indian Society of Chemists and Biologists Award for Excellence**

KVS Hari *Professor, Department of Electrical Communication Engineering*, **IETE SVC Aiya Award for Excellence in Telecom Education** & **Osmania University College of Engineering Distinguished Alumnus Award**

Courtesy: G NARAYANAN

G Narayanan *Associate Professor, Department of Electrical Engineering*, **Prof. Satish Dhawan Young Engineer Award**, Government of Karnataka

Manju Bansal *Professor, Molecular Biophysics Unit,* **JC Bose Fellowship Award**

Shalabh Bhatnagar *Professor, Computer Science and Automation*, **Prof. Satish Dhawan Young Engineer Award**, Government of Karnataka

Gadadhar Misra *Professor, Department of Mathematics*, **Mathematician of the year**, Ponnala Foundation jointly with NIT Warangal

Aditya Garai *Student, Department of Inorganic and Physical Chemistry*, **Gandhi Young Technological Innovation Award**

Sai Siva Gorthi *Assistant Professor, Department of Instrumentation and Applied Physics*, **ISOI Young Scientist/ Engineer Award**, Instrumentation Society of India

Diptiman Sen *Professor, Centre for High Energy Physics*, **JC Bose Fellowship Award**

Campus Critters

Shikra

Department of Mathematics