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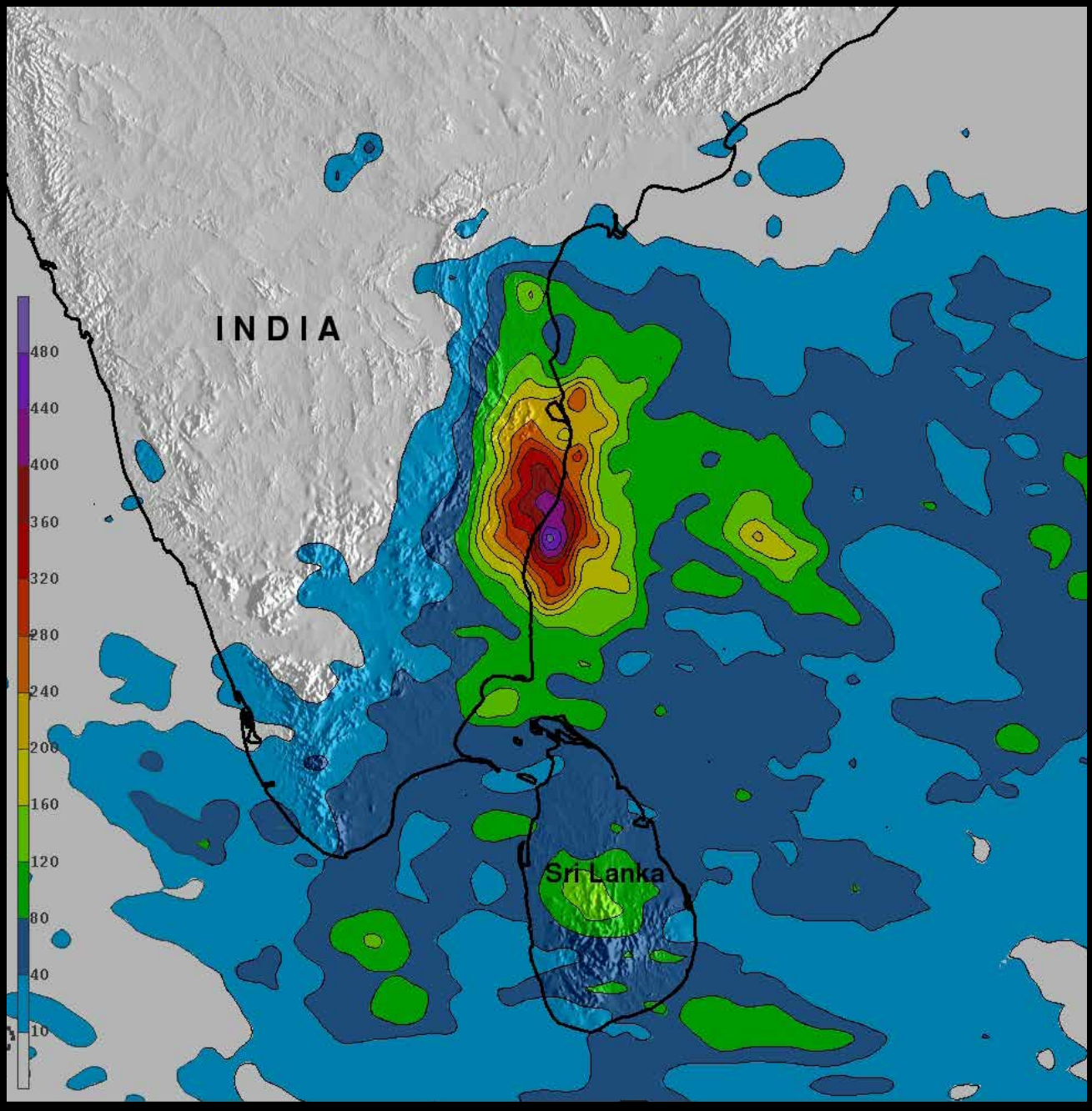
Connect

WITH THE INDIAN INSTITUTE OF SCIENCE



Urban Flooding
Causes and answers

Centre for Neuroscience
From brain to behaviour

Solid Waste Management
Towards zero waste

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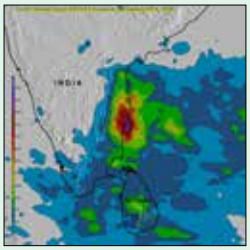

Front Cover: See Cover story for details (NASA)

Front Inside Cover: IISc Campus (MOHAN REDDY)

Back Inside Cover: Praying Mantis (NATASHA MHATRE)

Back Cover: Watercolour of Centre for Neuroscience building (BHAMA SRIDHARAN)

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FROM THE CONNECT TEAM

Greetings!

The launch of this issue of CONNECT coincides with Open Day, the annual outreach event of the Indian Institute of Science (IISc), celebrated around 28 February—a significant date in the history of Indian science.

On this day in 1928, a young man called CV Raman, working with his colleagues at the Indian Association for the Cultivation of Science in what was then Calcutta, made a remarkable discovery.

The motivation for this discovery goes back to 1921 when Raman went to London to meet many physicists, including JJ Thomson and Lord Rutherford. During the 15-day voyage back home on the SS Narkunda, the deep blue Mediterranean waters fascinated him. It also got him thinking about why the sea is blue. The prevailing explanation, provided by Lord Rayleigh, was that the sea got its colour by reflecting the light from the blue skies above.

Raman, however, was not convinced of this reasoning. Back in India, he was able to show that the colour of the sea resulted from the scattering of sunlight by water molecules. He continued working on light scattering, and after several years of experimentation, on 28 February, 1928, he and his small team that included KS Krishnan discovered a curious phenomenon: When a beam of monochromatic light is passed through a transparent medium, a small fraction of the scattered photons—about one in 10 million—have a wavelength different from those of the incident photons. The significance of this observation was understood immediately; this discovery, called the Raman Effect, won Raman many accolades including the knighthood and the Nobel Prize, and it continues to be relevant in many fields even today.

IISc is an institution that Raman was closely associated with. He was appointed as its Director in 1933. Though he remained in this position only until 1937, he served as a professor in the Department of Physics, which he also founded, until 1948. Because of the special bond that the Institute shares with Raman, it not only celebrates National Science Day with the rest of the country on 28 February, but also Open Day.

On this day, labs across IISc, using a show-and-tell approach, demonstrate their research to the thousands of people who throng its campus. It is an opportunity for the Institute to not only showcase its cutting-edge research, but also to communicate fundamental concepts in science and engineering to the visitors.

This edition of CONNECT, copies of which will also be given away to those who come to IISc on Open Day, offers plenty of good reading, including a feature on the phenomenon of urban flooding. The recent deluge in Chennai reminded us of our limitations and vulnerability in the face of nature's unpredictability. This issue also highlights a new initiative that seeks to address IISc's solid waste problem in a sustainable manner.

Happy reading!

In This Issue...

DEALING WITH DELUGE

A closer look at what causes flooding and potential solutions to this increasingly frequent phenomenon, and the contributions of researchers from the Indian Institute of Science (IISc) in both these endeavours

Courtesy: INDIAN AIR FORCE/ WIKIMEDIA COMMONS

✍ **SUDHI OBEROI** AND **NITHYANAND RAO**

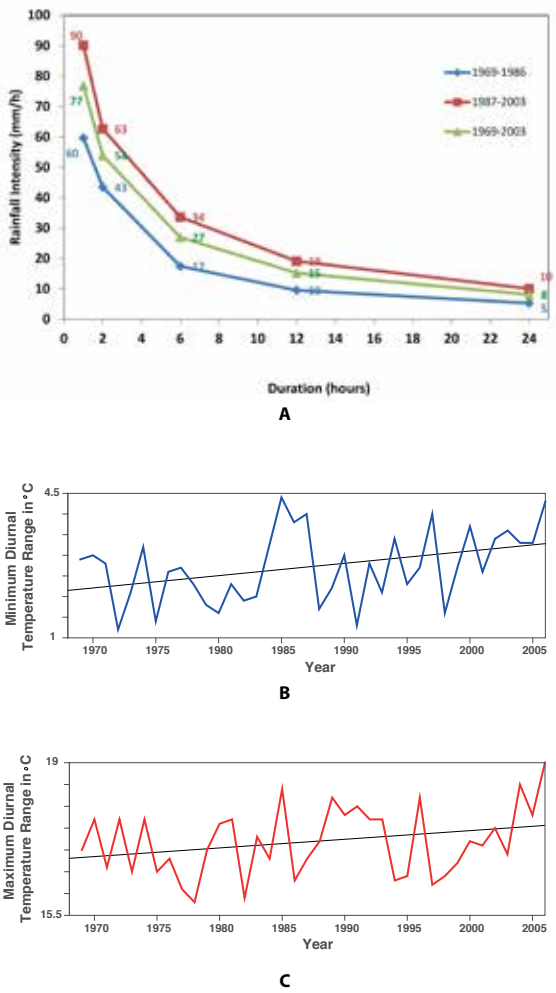
Mumbai in 2005, Uttarakhand in 2013, Jammu & Kashmir in 2014 and, most recently, Chennai in 2015. Such devastating floods have also occurred elsewhere in the world in recent years—southeast Europe in 2014 and Philippines in 2011 are two of the many examples. While floods have always been a threat to our lives and property, what is worrying is that they appear to be occurring with increasing frequency and intensity.

Earth's Changing Climate

This increasing frequency of floods may be a consequence of the Earth's changing climate. The Intergovernmental Panel on Climate Change (IPCC), a United Nations body that assesses climate change, reports that the Earth's atmosphere is 0.75°C warmer than it was at the beginning of the last century[1]. This enables it to hold more moisture which may lead to an increase in the volume of rainfall we receive. In fact, rainfall events in India which are above 100 mm per day have increased by 50% in the last 50 years[2]. The natural question to ask is whether frequent floods are the result of global warming-induced climate change. Studies suggest that at least one of them—the flood in Uttarakhand—was due to sustained, extremely heavy rainfall that can be attributed to global warming due to greenhouse gas emissions[3].

Urbanization

But climate change need not be due to global warming alone; there can be local causes too, such as rapid urbanization. For instance, the minimum temperature in March in Bangalore city, says J Srinivasan, Chairman of the Divecha Centre for Climate Change at IISc, has increased by 2°C in the last 100 years. "When you create an urban conglomerate surrounding the rural areas, it sets up a local circulation pattern," he explains. Srinivasan and his colleagues at the Divecha Centre study both natural and anthropogenic factors that contribute to our changing climate.



Source: PP MUJUMDAR'S RESEARCH GROUP

Temperature and rainfall changes in Bangalore over the years suggest that urbanization could be responsible for local climate change. (A) shows that the intensity of rainfall for any duration within a 24-hour period has been increasing (all data points used occur with an equal likelihood). (B) and (C) show an increase in the annual minimum and maximum of the diurnal temperature range [diurnal temperature range is the difference between the maximum and minimum temperatures in a day]

One such anthropogenic factor is the proliferation of aerosols in the atmosphere due to human activities. These tiny particles suspended in the air can reflect or absorb incoming sunlight resulting in a change in climatic conditions. Often called particulate matter, aerosols include black carbon, sea salt and mineral dust. These particles can also greatly influence precipitation.

El Niño

Not all the factors that contribute to variation in weather conditions can be attributed to human activities. Almost a century ago, in November 1918, when the CO_2 level in the atmosphere was much lower, Chennai had experienced heavy rainfall with more than 1088 mm pouring down on the city, a little more than the 1049 mm of rain that fell in November 2015. What is common to both the 1918 and 2015 events is that they were El Niño years. El Niño is a weather phenomenon that involves unusual warming of the eastern equatorial Pacific Ocean. This, in turn, leads to abnormal rainfall and plays a role in the development of extreme weather conditions worldwide, including in India. The years when El Niño has occurred have been associated with lower rainfall during the southwest monsoon, and higher rainfall during the northeast monsoon. "Unfortunately, the connection between El Niño and high rainfall in Chennai, for example, is not that clear," says Srinivasan.

"... the connection between El Niño and high rainfall in Chennai, for example, is not that clear"

Reliable Weather Forecasting

Though it is not easy to pinpoint the exact cause of a particular weather event, one thing is clear:

extreme weather events such as floods will likely become more frequent. And as they become more frequent, mitigation becomes important, for which the first step is reliable forecasting. With near-real-time data available from satellites, short-term weather forecasts are generally quite good. The forecast for Chennai, however, was not accurate. This was because the models used for simulation do not have sufficient resolution to predict rainfall in urban areas. "To get urban rain correctly, you need a model with a resolution of 1 km or lesser. The models that are being run have a resolution of maybe 20 km. So Chennai is one grid point," says Srinivasan.

Urban Sprawl

Flooding, however, isn't all about heavy rainfall. Again, human activities play a role in determining the extent of flooding and its impact, especially in urban areas. Rapid and unplanned urbanization—encroachment of natural water bodies, higher density of land use, improper waste management, and inadequate drainage system—means that rainwater cannot immediately be drained out, leading to flooding. "In urban areas the water runoff during rainfall is much higher and the drainage system is not adequate. The encroachment of natural water bodies due to increasing population does not provide any buffer for drainage and this is rendered even worse with solid waste clogging the drainage systems," says PP Mujumdar, Chairperson, Interdisciplinary Centre for Water Research at IISc. He says that the 2015 Chennai floods would not have been this bad if there was an efficient drainage system and the reservoirs had been operated properly.

"The encroachment of natural water bodies due to increasing population does not provide any buffer for drainage and this is rendered even worse with solid waste clogging the drainage systems"

Apart from better forecasting, mitigation of floods requires an integrated approach involving better land-use management and city planning. Drainage systems could be enhanced wherever they are found to be inadequate, but this may not always be possible in localities where extensive development has already taken place. Another possibility would be to provide a bypass, an alternative route for water to drain into the existing water bodies.

Tech Solutions

The use of technology can help prepare us to face such events. Mujumdar at IISc and his collaborators in India and abroad are working on one such project, Integrated Urban Flood Management in India, funded by the Information Technology Research Academy (ITRA). Government organizations like the Karnataka State Natural Disaster Monitoring Centre and the Bruhat Bangalore Mahanagara Palike are also involved in this effort. Using satellite imagery and a network of sensors, the project aims to help city authorities better manage urban drainage

Courtesy: PP MUJUMDAR'S RESEARCH GROUP

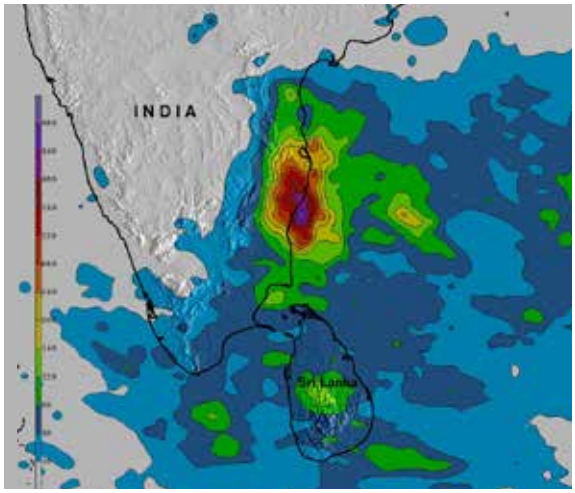
A water-level sensor indicated by the red circle was installed as part of a pilot project in the IISc campus

systems by integrating them with real-time forecasts. The team is developing high-resolution 3D terrain maps using Geographic Information Systems (GIS) to visualize how water flows in case of flooding in an urban area. This will be part of a model, an end-to-end management tool for urban floods, that will provide information right from forecast to the action plan required in such an event. Initially, it is being developed for Bangalore. "We are also building manpower," says Mujumdar, citing the importance of educating as many as possible on the use of the model.

Effective Communication

Once it becomes clear that a flood is likely to occur, the warnings need to be communicated widely and translated in terms that can be understood both by the local officials who can take necessary action and by people living in flood-prone areas. For example, in the case of the 2015 Chennai floods, the state administration reportedly did not issue timely warnings to the media and the public[4].

Communication was found lacking even during the Uttarakhand floods of 2013, though the forecasts were good, says Srinivasan. He contrasts this lack of effective communication with how, not long afterwards, authorities dealt with the cyclone Phailin in Orissa. In the case of Phailin, apart from an advance warning of five days that was provided, local authorities were empowered to take decisions without going through the circuitous, and often inefficient, bureaucratic route. When a flood is likely in an urban area, the forecast should give the public an estimate of the level of water that one can expect in their locality along with the nearest place where they can take shelter during such an event. "The



Rainfall data from 29 November to 2 December, 2015, showing unusually heavy rainfall of over 400 mm in the northern part of coastal Tamil Nadu (Image modified from NASA, http://pmm.nasa.gov/extreme-weather/southern-indias-catastrophic-flooding-analyzed-imerg)

forecast should go into the urban flood model and the research model should be flexible enough to be used by someone who is not an expert in the area," Srinivasan adds. And this is the primary goal of the model being developed by Mujumdar's team.

"The forecast should go into the urban flood model and the research model should be flexible enough to be used by someone who is not an expert in the area"

Attitude towards Warnings

But effective communication and technological solutions that help us prepare for and mitigate floods and other disasters can only go so far. "In India, you'll find that we only act after disasters happen. We react to crises, we don't react to normal warnings," says Srinivasan, suggesting that our attitude towards official warnings during such disasters must also change.

[1]https://www.ipcc.ch/publications_and_data/ar4/wg1/en/tssts-3-1-1.html

[2]http://www.sciencemag.org/content/314/5804/1442.short

[3]https://www2.ametsoc.org/ams/index.cfm/publications/bulletin-of-the-american-meteorological-society-bams/explaining-extreme-events-of-2013-from-a-climate-perspective/

[4] http://thewire.in/2015/12/09/how-official-negligence-turned-a-natural-crisis-into-a-human-made-catastrophe-16938/

ON CAMPUS

In conversation with the guests of the Indian Institute of Science (IISc)

VENKI RAMAKRISHNAN: PRESIDENT OF THE ROYAL SOCIETY

✍ **KARTHIK RAMASWAMY** AND **SUDHI OBEROI**

CONNECT

Venkatraman Ramakrishnan, better known as Venki Ramakrishnan, studies the structure and function of ribosomes, the complex molecular machines—found inside the cells of both bacteria and eukaryotes—responsible for protein synthesis. For his research, he was awarded the Nobel Prize in Chemistry in 2009, an award he shared with Thomas Steitz and Ada Yonath. Ramakrishnan is a group leader at the Medical Research Council (MRC) Laboratory of Molecular Biology (LMB) on the Cambridge Biomedical Campus, UK, where he is also the Deputy Director.

On 1 December, 2015, Ramakrishnan took over as the President of the Royal Society, a position previously occupied by the likes of Sir Isaac Newton and Sir Ernest Rutherford. He was at IISc to attend MCB75: From Molecules to Organisms*, a conference organized to celebrate the 75th anniversary of the Department of Microbiology and Cell Biology. As the conference came to an end, Ramakrishnan sat down with* CONNECT *to talk about his priorities in his new responsibility, why science is important, his own career and more.*

Q How was your experience at the conference?

I've really enjoyed it. One thing that should be said is that the organizers made it a policy that neither they nor their colleagues spoke at the meeting. That actually sets an example. It was not an exercise in self-promotion, but more of a celebration. And the quality of the meeting was very high.

Q What motivated you to choose science as a career? Your parents were also scientists…

It was slightly accidental. I wasn't very sure whether I wanted to go into science or engineering or medicine. So I hedged my bets. But I never really prepared for these nation-wide entrance exams whereas all my peers were going to coaching classes. I took these exams but did not do well. I did get into medical school, but by this time I was awarded the National Talent Search Scholarship and decided that maybe what I should really be doing is mathematics or physics. And so I withdrew my medical school admission and enrolled for a BSc

in Physics instead. Some of the professors in the Physics Department had come back from the US and had completely modernized the curriculum, which made it particularly attractive.

Q You did your PhD in theoretical physics. And then you switched to biology. Why?

Part of the reason was that I was not so excited by the work I was doing. I didn't see it leading to any new understanding of physical phenomena. A lot of major discoveries in high-energy physics and condensed matter theory had already been made and making real progress was very challenging. On the other hand, I felt that biology was in a very exciting stage as huge fundamental discoveries were being made almost every month. So it seemed like a good move. I spent a couple of years in graduate school to learn the fundamentals of biology before I did my postdoctoral work.

"... I felt that biology was in a very exciting stage as huge fundamental discoveries were being made almost every month. So it seemed like a good move"

Q In an earlier interview, you suggested that Indian scientists should focus on India-specific problems. What would be your advice to a young faculty member: work on a well-established research area or on an unexplored problem more relevant to Indian society?

I think that it's a very personal decision. They can tackle a well-established and fashionable area. If you do that, you have to ask yourself, "Can I, in relative isolation in India, compete with all these groups in the West?" For example, Umesh Varshney [Professor, Microbiology and Cell Biology, IISc] is doing some very nice genetics on initiation [of protein synthesis] and his lab is making interesting discoveries all the time. So he's obviously found a system and a niche where he knows how to tackle problems and is able to publish in very good journals. But I would say that he's more of an exception. Most of the time what will happen is that when you pick a problem, there'll be many other groups in better universities competing with you. If you're not able to compete with them, you'll be relegated to addressing fringe problems. They'll be going after the big questions and you'll be filling in the details. I'm not so sure that's very satisfying.

"They'll be going after the big questions and you'll be filling in the details. I'm not so sure that's very satisfying"

The other option is to pick problems that Western scientists are not interested in because either it's not relevant to them or they already have their own agenda. Given India's biodiversity and its problems in health and agriculture, there's probably a goldmine of opportunities here. It's surprising to me as to why more Indian scientists are not applying their know-how and modern tools on these long-standing problems. If they did this, I would bet you that they would make exciting discoveries that will be interesting by any standard. It can also lead to very interesting science that can be useful in other ways. For example, this year's Nobel Prize in Physiology and Medicine was given to Youyou Tu who discovered the drug Artemisinin from a plant used in Chinese traditional medicine. Besides saving millions of lives, a lot of interesting biology came out of the work. In India, the equivalent of this would be to look at Ayurvedic medicines—first test for efficacy and then try to identify the active ingredients and mechanism of action. But quite apart from this, there is a wealth of problems involving plants, animals and microbes that are specific to India, as well as problems of energy, water and other resources.

"It's surprising to me as to why more Indian scientists are not applying their know-how and modern tools on these long-standing problems. If they did this, I would bet you that they would make exciting discoveries that will be interesting by any standard. It can also lead to very interesting science that can be useful in other ways"

Q You come to IISc often. Based on your experience, how do you find the quality of research here, especially in your field? How can it improve?

I'd say that IISc is somewhat uneven—there are scientists here who are very good and would fit in quite well in any good university in the West, and there are others who are perhaps not at that level. But I think I'm really not qualified to talk about how it can improve because I don't know what the issues are—whether it's funding or empowerment. However, I can give you an example of why the MRC Laboratory of Molecular Biology (LMB) at Cambridge works so well, and I leave it to people to draw their own conclusions.

At LMB, we're not allowed to have very large groups. It is usually about 5; the upper limit is 8. If you have 5-8 people, then you're forced to work on problems that you think are most interesting and important. And by forcing you to work on what's most important, you also then end up doing your best work.

The second is that because of peer pressure, and also because of the history of the place, you don't feel like you can work on some little derivative problem. There is that sense that you have to achieve a very high standard, even among young scientists. That generates its own kind of success and that is perhaps why the lab is so famous. Many of the people working at MRC as well as its alumni have won Nobel Prizes. I think having high standards and high expectations is very important.

The third reason for its success is that MRC has no hierarchies. If there's a very expensive piece of equipment, a first-year graduate student has exactly the same right as a senior Head of Division or the Director to use it. It works on a first come, first served basis. We have a single canteen where everybody sits together to eat—there is no separate "faculty club" or even a separate table. We just sit wherever there is space available. This encourages a free exchange of ideas and also promotes critical thinking.

"We have a single canteen where everybody sits together to eat. This encourages a free exchange of ideas and also promotes critical thinking"

Q What can we do to encourage students in India to pursue science? And stay in science?

This is not just an Indian problem. Even in the West, there's a problem in getting people to do science as opposed to going into management or Wall Street or law school or medicine. But I think it's made worse in India because India has a huge population, and everything here, including finding a job, is more competitive. Daily life here, I have to say, is a huge hassle because cities have simply exploded without proper infrastructure. Amongst all these pressures, a young person has to make a decent living. So I believe the solution is to ensure that a life in science provides an adequate livelihood. Most scientists don't care about becoming rich. But what they want is a decent place to live; they want their daily lives to be hassle free. So that means living close to work and a decent school for their kids. These are all relatively inexpensive things. So when

universities are planned, they need to take these things into account. IISc is lucky to have onsite housing, schools and shops. This is like a paradise. If you can get a job here, you'll probably never leave. But faculty jobs are not that many. So then you have to ask: what else can scientists do? They can work in industry, government, journalism or public relations. There are lots of places where having a science background can be helpful.

"Most scientists don't care about becoming rich. But what they want is a decent place to live; they want their daily lives to be hassle free"

Q When we think of the word *science*, we think of it as an enterprise involving research, publishing, etc. But science is also a way of thinking. How we can we promote this idea?

For a start, we need to change the way science is taught in schools. Science is taught as a collection of facts and is often learnt by rote. So when children grow up, they have no sense that science is actually a method of acquiring knowledge about the world around us. If you make a statement, how do they know if it's right or not? If students learnt science properly, they would realize that everything in science is based on evidence and reasoning. This leads to a logical expansion of our knowledge. Also, scientists have often been wrong. But science is self-correcting because it allows us to correct our flawed understanding based on new evidence. That distinguishes science from bogus ideologies that are essentially frozen. They have a collection of beliefs that never change, no matter what the evidence is. People need to understand that this is an easy way to distinguish bogus beliefs from true science.

"For a start, we need to change the way science is taught in schools. Science is taught as a collection of facts and is often learnt by rote. So when children grow up, they have no sense that science is actually a method of acquiring knowledge about the world around us"

Q What is going to be your role as the President of the Royal Society? Is it set in stone or do you have the flexibility to define your role?

It's not set in stone; I have a number of priorities. One is to promote rationality and reason among people, something we just talked about. I'd like science to have a more central place in society, both among people and governments. I'd also like Fellows of the Society to become more involved because they have a huge reservoir of expertise, which can be used to promote science for the benefit of humanity.

"I'd also like Fellows of the Society to become more involved because they have a huge reservoir of expertise, which can be used to promote science for the benefit of humanity"

Q Do you think you'll get to spend time for your own research?

My position with the Royal Society is an honorary one. I'm still paid by the MRC to do my work. I plan to give the Royal Society two days a week and occasionally more if needed. I don't do much hands-on research now, but I lead a team that does, and I hope to continue guiding that research.

SHIHAB SHAMMA: DEMYSTIFYING THE LISTENING BRAIN

✍ **DEBALEENA BASU** AND **KARTHIK RAMASWAMY**

CONNECT

Shihab Shamma is a professor in the Department of Electrical and Computer Engineering, Institute for Systems Research, University of Maryland, USA. After his undergraduate degree from Imperial College in London, UK, he moved to Stanford University, USA, where he received his Master's and PhD degrees in Electrical Engineering. He also has an MA in Slavic Languages and Literature from the same institution.

A Fellow of the Acoustical Society of America, Shamma has a wide range of research interests in neurobiology, particularly in auditory neuroscience and neuromorphic engineering. He was recently appointed as the first **K Vaidyanathan Distinguished Visiting Chair** *at IISc. The Chair is endowed by Pratiksha Trust, established by Infosys co-founder Kris Gopalakrishnan and his wife, Sudha Gopalakrishnan.*

Shamma was in IISc in November, 2015 when he spoke to CONNECT *about his research interests and how they have evolved, and his new role at the Institute.*

Q Tell us a bit about your academic journey. You are trained as an electrical engineer, but you are working in neuroscience. How did that happen?

When I was doing my PhD in microelectronics at Stanford University, I started reading Russian classic literature, which fascinated me. But what fascinated me even more was the literary criticism in Russian literature. These literary critics analyze not just the text, but also the sounds of the language. I really got very intrigued by the whole idea of sound. So for my PhD, I decided to work on these devices that they put in the ear, cochlear prostheses.

That research got me interested in how the brain perceives sound. But I didn't know much about the brain. So after I finished my PhD, I studied neuroscience intensively for a year. Then I joined the University of Maryland as a faculty. They hired me to do microelectronics, but in fact I ended up doing neuroscience. Deep inside, I am still an engineer who studies the brain as a device, a really complicated device.

Q You've done a lot of work on selective auditory attention. Why is this phenomenon important? And how do the neurons in the primary auditory cortex achieve this?

Attention is the key to how the auditory system works. When you are in any environment, like here for instance, attention helps us in having a conversation, even though there's plenty of background noise. If I need to avoid a predator before I become its food, I need to be able to pick up sounds caused by the predator, filtering out all other sounds. You have to select what you want to be able to respond to and avoid distractors. That is the essence of the attention problem. This is also true with vision. Without this ability, animals would not survive.

But how you do this is not fully known. This is being studied now. However, it is clear that you need all kinds of information, and the more, the better to be able to select a target and go after it. We also believe that the source of signal of interest needs to be independent, in timing especially, in order for you to be able to separate and select it. This principle applies to images too.

"You have to select what you want to be able to respond to and avoid distractors. That is the essence of the attention problem"

Q Could you elaborate on similarities and differences of visual and auditory processing?

Light enters the body as electromagnetic radiations and sound as vibrations. So there are differences in the way the signals are transduced into neural activity in the sense organs. But once information goes into the nervous system, the two work similarly. A famous Indian scientist, Mriganka Sur, did a remarkable experiment many years ago using a ferret, an animal we also study. He re-routed the optic nerve to go into the auditory cortex in a newborn ferret. Once the brain developed, the recordings from the auditory cortex were similar to what you see in the visual cortex. This tells you that they work on similar principles. But there are differences, of course, because we had millions and millions of years of evolution to make the auditory regions evolve differently to be optimized to deal with the acoustic environment.

Q People who are blind have a heightened auditory sense…

Yes, a lot of visual areas get co-opted by the auditory areas. The brain, even an adult brain, is very plastic.

Q Why do you think there's more work done in visual neuroscience than in auditory neuroscience?

In the visual system, people had more of an intuition as to what might be going on as they found that neurons responded to various aspects of images like edges or colour. It's much harder to imagine what's going on with sound as the signal is a one-dimensional pressure wave which undergoes complicated transformations inside the ear before going into the brain. Also, researchers in visual neuroscience got some nice results in the 1950s, with David Hubel and Torsten Wiesel winning the Nobel Prize [in 1981] for their work on signal processing in the visual system and the field exploded after that. So it's partly tradition. The auditory system had its Nobel Prize [Georg von Békésy in 1961], but nobody understood what it was about (laughs)! I am exaggerating…

Q Could you shed some light on another interest of yours—neuromorphic engineering?

Siri on iPhones and other such speech recognition tools fall apart when there's any noise in the background—they don't act like a listening person. So how can you build devices that can address this problem? We first need to understand the neuroscience behind this ability [to ignore background noise] and then try to apply the

principle to build something that mimics them. People are trying to do this kind of neuromorphic engineering in their own ways. Some people like to build circuits that look very much like the brain. They call the different components, not transistors, but neurons, and the connections between them are called synapses. They even have physiology in these chips!

We built chips that do what the ear does over the years, but I tend to work more on building the algorithms and mathematical models, and I advise people on how to build the chips because I studied microelectronics.

"We first need to understand the neuroscience behind this remarkable ability [to ignore background noise] and then try to apply the principle to build something that mimics them"

Q What attracted you to this newly created position of K Vaidyanathan Distinguished Visiting Chair at IISc?

This is an exceptional institution with faculty and students of high quality. They have almost everything they need. What they require are probably more facilities in some areas and more people who are on the senior side, people who can act as guides to the researchers here, and that interested me.

Q What do you see as your role in this position?

This appointment is for 5 years. During this appointment, I will be coming here for visits of varying durations. The purpose is to meet faculty and students who are interested in neuroscience, neuromorphic engineering, computer science, and to act like a sounding board. Because I know experts in certain areas working in different parts of the world, I can put them in touch with these experts or point to their work. So I see my job as a bridge to the outside world, in places where this kind of work has been going on for a while. To do neuromorphics, you really need to have a broad understanding of many fields and learn from others who do what you don't do. My goal is to create enough of an interest in this field in this campus so that it will take off.

"To do neuromorphics, you really need to have a broad understanding of many fields and learn from others who do what you don't do"

Q Have you been to India before?

I have been to India only once before, and that was just a few months ago. I grew up in Baghdad, Iraq, and developed a great fondness for India. I grew up reading all kinds of Indian writings, like Jawaharlal Nehru's *Glimpses of World History*. My parents came to India many times and told us all about it, but I never had the opportunity to come. I went in the opposite direction—to the West. When I did come here, I had a fantastic time; it's really a great place. You should know how lucky you are.

Q Do you still have family in Baghdad?

Cousins, mostly. My immediate family left Baghdad over many years. There have been so many miserable situations over the years and my family members kept leaving. During this last war, my parents left too, and they are all in the US now. I have tried to help the University there, but every time we tried to do something, a calamity hits. We need peace. That's why (Mahatma) Gandhi is so special.

"We need peace. That's why (Mahatma) Gandhi is so special"

SOUMYA SWAMINATHAN: HEAD OF INDIA'S APEX BIOMEDICAL RESEARCH BODY

✍ **MANBEENA CHAWLA** AND **KARTHIK RAMASWAMY**

CONNECT

Back in August 2015, Soumya Swaminathan took over as the Director General (DG) of the Indian Council of Medical Research (ICMR)—the body responsible for the formulation, coordination and promotion of biomedical research in India—and Secretary, Department of Health Research (Ministry of Health & Family Welfare). Before assuming this role, she was with the National Institute for Research in Tuberculosis (NIRT) in Chennai for over two decades, including serving as its Director from 2012 to 2015.

An expert in tuberculosis (TB) research, Swaminathan has been honoured with several awards for her work. She is also a Fellow of all three science academies in India. On 18 January, 2016, she gave a talk titled ***Clinical Research in India*** *as part of an event organized by the Centre for Infectious Disease Research (CIDR) at the Indian Institute of Science (IISc). She sat down with* CONNECT *the same day to discuss her research and her priorities as the DG of ICMR.*

Q What made you choose a research career?

I was always interested in research, perhaps because of the atmosphere when I was growing up. I was not, however, thinking at that time about medical research. But after completing my MBBS, I wanted to go on to do research. It was difficult to find the balance between clinical work and research because not many institutes in India provided opportunities for doing both. My first choice was to work in a medical college because I didn't want to give up clinical work. But then many seniors advised me that it would not be possible to manage both clinical work and research. So then I opted to join NIRT.

Q With your present responsibilities, do you find any time for research?

Being the DG of ICMR, you have to give up the idea of doing research. But one can make an overall change in the medical research ecosystem in the country by bringing more people into it.

Q What is the mandate of ICMR? Does it have a role in framing the National Health Policy? And what priorities do you see for yourself as DG of ICMR?

We are involved to some extent in framing the National Health Policy, but it does not really talk much about research data and the evidence. One of my key priorities now would be to set up an

evidence-to-policy unit that would first look into all the studies being done, needs that are emerging, and data that are available. This unit would then do a knowledge synthesis to feed into policy-making, such as vaccination or treatment strategies or use of a particular diagnostic. Things have changed and much more is happening now. But we need to do more, particularly in using local data and identifying knowledge gaps, and using research to fill these gaps. We need to move in the direction of evidence-informed policy making, and having a unit like this would have an impact.

"One of my key priorities now would be to set up an evidence-to-policy unit"

Q You have spent much of your life studying TB. Can you tell us a bit about the challenges of treating TB if it is drug-resistant, or if there is a co-infection of TB with HIV?

There are different kinds of drug resistance. The bacteria can be resistant to the first line of drugs such as isoniazid, streptomycin, etc., or be multi drug-resistant (MDR), or even be extensively drug-resistant (XDR). The moment bacteria develop resistance towards any one of the drugs we are using, we need to treat it as a problem, since the efficacy of the drug regimen starts reducing. For example, if there is resistance to isoniazid alone and we treat it with the standard regimen, the outcomes would be worse.

SANTOSH PODDAR

The treatment outcomes are poor partly because the diagnosis is usually made late, only when people repeatedly fail treatment. And secondly, drugs can become toxic when they have been taken for a longer period of time. In the last two years, new drugs have been licensed for TB treatment, especially for MDR—Bedaquiline and Delamanid—and so it is possible to improve treatment outcomes, and to be able to shorten the period of treatment for MDR-TB.

With HIV co-infection, the outcome depends on the immune system of the person. So if someone who is immune-suppressed develops MDR-TB, the outcome will be poor. But with anti-retroviral treatment access improving steadily, if a person is co-infected with TB and HIV, and if their CD4 T cell [a type of white blood cell that fights infection] counts are okay, then the outcome is likely to be more positive.

Q Let's say that a patient from an economically impoverished background goes to a primary health care centre or to a hospital and is diagnosed with TB, what happens next? Is there a protocol to get them tested for drug-resistant TB?

In the *Revised National TB Control Programme*, people who have had a prior episode of TB get tested for drug resistance, because they are at a much higher risk of MDR-TB. Within the next couple of years, we are hoping to get to a point where all TB patients will have an opportunity to get a drug-resistance test, preferably through a rapid point-of-care test. You

must have heard of the GeneXpert, the diagnostic test which tells you about the presence of MTB DNA (*Mycobacterium tuberculosis* DNA), as well as about rifampicin resistance in particular. There are now versions of these tests being developed, including indigenous ones, which can be more point-of-care than the GeneXpert—a battery operated one. Also, we are trying to add more drugs to the drug-resistance tests so that it can lead to individualized treatment which is how it is done in the West. If you have TB, you get a culture or a rapid genotypic test done, and the doctor would give you drugs to which the bacteria are susceptible. In India that is not feasible right now because of logistics, costs, etc. But the aim is to get there in the next few years.

Q Tell us about the TB repository that is coming up.

The TB repository is just starting off now, jointly funded by the Department of Biotechnology and ICMR. It will be in Chennai at NIRT. Samples will come from all the different cohort sites, and then the idea is to open it to different researchers and institutes.

Q What is the influence of nutrition, or lack thereof, on HIV infection?

Malnutrition is a big problem in our country. 40% of the children under 5 years of age are stunted, and about 35-40% are under-nourished. We have tracked children from the time they are born, and HIV-positive children are more likely to be malnourished, even when they have not developed any symptoms. Along with HIV, being malnourished makes them even more immune-suppressed and more prone to infections.

Another important issue is that when children are under-nourished, and if this is not corrected early within the first 2 years of life, they become stunted and their cognitive abilities are irreversibly affected. Early interventions are very important here. In the case of HIV-infected women, there is always an issue of not being able to breast feed, and because of this limitation, babies are often left under-nourished. There is a lot of need for counselling, education and awareness. I would say that malnutrition is a problem much beyond HIV, since it affects the community as a whole. We are planning to get into a big programme of communication and advocacy regarding nutrition.

"We are planning to get into a big programme of communication and advocacy regarding nutrition"

Q You have previously talked about how little we spend on healthcare in India (and of which, only about 1% is spent on research). Many developmental economists have shown that no country can make sustained economic progress without spending on health and education. So why is it hard to convince the government to increase spending on healthcare?

I think one of the reasons for this is political priorities. Investments in health will have its returns only after many years, whereas investing in other areas like infrastructure that the public can see may pay back more immediately. The other reason could be that for research in particular, often people cannot see the relationship between research and health outcomes. I think scientists can do more to communicate better to the public about the importance of investing in research, technology and education for future development of the country, and health of the citizens.

THOMAS KAILATH: RESEARCHER, INNOVATOR AND ENTREPRENEUR

✍ **NITHYANAND RAO** AND **SUDHI OBEROI**

CONNECT

Thomas Kailath is the Hitachi America Professor of Engineering, Emeritus, at Stanford University, USA. An electrical engineer by training, Kailath has contributed extensively to the fields of information and system science. He has mentored over a hundred doctoral and postdoctoral scholars, and has also been a successful entrepreneur. His achievements have been recognized by several awards, including a US National Medal of Science in 2014, presented to him by President Barack Obama. Other major awards he has won include the IEEE Medal of Honor in 2007 and the Padma Bhushan in 2009. Kailath who has had a long and fruitful association with IISc gave the Centenary Lecture on 15 December, 2015, and later spoke to CONNECT *about his work.*

Q Could you tell us about your education and early life? What got you interested in information theory, and how did you make your way to MIT?

Most of my work has been in the broad field of information theory, which is essentially a mathematical theory of communications engineering. My interest in mathematics was sparked by a teacher in 6th standard in Pune. I went on to Fergusson College, Pune, in 1951, and then entered a new BE Telecom programme at the College of Engineering, Pune, set up by a pioneering and innovative professor, SV Chandrasekhar Aiya.

In the library there, I came across articles on mathematical subjects like Boolean algebra and Laplace transforms, and, characteristically, Aiya encouraged me to give evening lectures on them to students and special invitees. He was later also my bridge to IISc; he came here in 1960 to head ECE [Department of Electrical Communication Engineering]. That was the beginning of my long, happy and fruitful association with the Institute.

Job opportunities, at the time I graduated, were essentially only in government service. Studying abroad was not on anyone's horizon, though I used to dream about it. Serendipitously, a family friend who used to go on lecture tours to the US urged me to give him my transcript and a recommendation letter from Aiya, which he promised to present to MIT. That was very exciting, because I knew that MIT was not only a great institution, but was also the leading center for information theory, a field that had been launched by two famous 1948 papers of Claude Shannon at Bell Labs, and which I had read about while still in high school. On my own I also applied to Harvard University. I was happily surprised to be offered a teaching assistantship by Harvard, and then a research assistantship from

MIT, where I started in August 1957, dramatically changing the trajectory of my life.

Q You obtained your Master's and Doctoral degrees around the time when information and communication theory stalwarts, Claude Shannon and Norbert Wiener, were also at MIT. Were you taught by them?

Shannon never did much regular teaching at MIT, but I did take a special course he gave, in which he presented a lot of his unpublished results. Norbert Wiener was still teaching, but the one course I attended on Fourier integrals was meandering, and I dropped out of it.

There were many fine and famous teachers and researchers at MIT such as Peter Elias, Robert Fano, David Huffman, Jack Wozencraft, Jerome Wiesner, Victor Guillemin, Noam Chomsky, and visitors such as Benoit Mandelbrot and Marco Schützenberger. I also learned a lot from a remarkable group of fellow students, now widely recognized as luminaries in the world of communications science and technology: Irwin Jacobs, Robert Gallager, Jacob Ziv, James Massey, Ivan Sutherland, Leonard Kleinrock, Elwyn Berlekamp, David Forney and others. I was indeed fortunate to be at MIT during what has been called the golden age of information theory.

"I was indeed fortunate to be at MIT during what has been called the golden age of information theory"

Q Tell us a bit more about your time, influences and experiences at MIT that helped you evolve as a researcher.

My research supervisor, Wozencraft, suggested that I work on getting a better understanding of random time-variant communication channels. A particular result in my Master's thesis got considerable attention. I had found the conditions under which one could characterize such channels from transmitter and receiver data, and these explained why a recently developed and already celebrated communication system called *Rake*—developed to combat multipath propagation—failed in certain environments. Versions of *Rake* appear in every cell phone today.

Luckily, instead of accepting a very attractive job offer from Bell Labs after my Master's, I was persuaded by Robert Price and Paul Green, who had developed *Rake* at MIT's Lincoln Laboratory, to continue at MIT, with the offer of a summer job at Lincoln. I made major progress towards my PhD degree that summer, resulting in a paper in a famous June 1960 special issue of the *IEEE Transactions on Information Theory*, and another at the *Fourth London Symposium on Information Theory* in August 1960. My Master's thesis also led to my being one of the lecturers in a 1959 summer course taught by various eminent MIT professors, and inclusion in a book (*Lectures on Communication System Theory*, McGraw Hill, 1961).

"Luckily, instead of accepting a very attractive job offer from Bell Labs after my Master's, I was persuaded by Robert Price and Paul Green, who had developed* Rake *at MIT's Lincoln Laboratory, to continue at MIT, with the offer of a summer job at Lincoln"

After my PhD in June 1961, Solomon Golomb, who ran a communications research group at the Jet Propulsion Laboratory [part of Caltech], offered me a position in his group which did a lot of pioneering research in digital communications. The legendary Provost of Stanford, Frederick Terman, then offered me an associate professorship beginning in January 1963. My good fortune is that I accepted it. Terman

was building up Stanford at the time, and I have been privileged to be part of that growth.

Q There is a general perception that Indians do better when they go abroad. If so, why?

My view is that they are challenged more, and they are bright enough to rise to the challenge. And to some extent, the constraints are less. They have more opportunities and incentives. For example in India, an M.Tech graduate can get a salary of Rs. 20 lakhs in industry while his professor is getting Rs. 10 lakhs. This is unfair and frustrating. Dedication is fine up to a point, but obviously you have to support yourself and your family. But I believe that culture is changing in India. There is a vibrant start-up culture now. Salaries are higher. There are more opportunities than there used to be in the past.

"There is a vibrant start-up culture [in India] now. Salaries are higher. There are more opportunities than there used to be in the past"

Q You have also been involved in setting up a few companies. Tell us about your ventures.

Early in my career I just wrote theoretical math-based papers. But I always believed that there would be eventual applications, and I'm happy that this belief has been largely realized. In 1980, I co-founded, with my former student Naren Gupta, Integrated Systems Inc. (ISI), initially to do studies for the government on problems where ideas from control and signal processing could be useful. This led to the first suite of software products, called Matrix-x, for automating control system design. Back then, starting a company was very unusual for academics, but it is now very common in the US. ISI grew under Naren's leadership; it went public in 1990, and is now part of Intel. Three more companies were started with my students and postdocs. This includes Numerical Technologies Inc., based on a 1996 PhD thesis which improved the technology behind optical lithography; it went public in 2000 and was acquired three years later. By now, my former students and postdocs have probably started more than 20 companies of different kinds.

Q Do you think IISc is doing enough to translate research from laboratory to industry?

I have not studied this issue, but my impression is that there could be much more. The vibrant start-up culture in Bangalore provides a fruitful backdrop for progress in this direction. The departments I know best, ECE and CSA [Department of Computer Science and Automation], have attracted brilliant young faculty and large cohorts of research students, who will in time do more in this regard. There is also opportunity for more senior faculty, with secure reputations, to seek to apply their skills to challenging local and national problems; and there is scope in India for agencies like DARPA [Defense Advanced Research Projects, USA] to provide significant support for large multidisciplinary teams to advance such projects.

"The departments I know best, ECE and CSA [Department of Computer Science and Automation], have attracted brilliant young faculty and large cohorts of research students, who will in time do more in this regard"

Q Tell us about your relationship with IISc.

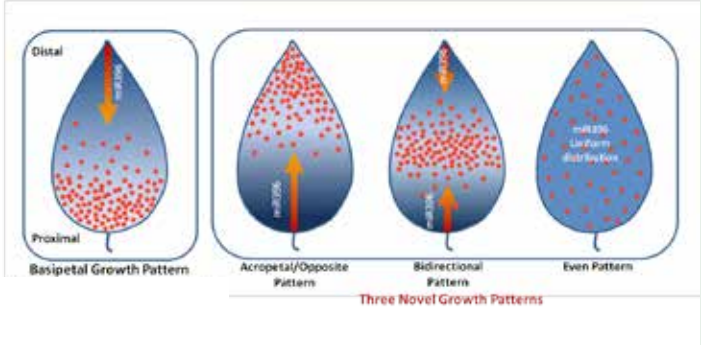
I have always enjoyed a warm and friendly reception on my numerous visits here since 1962 and in the several major campus initiatives that I have been involved with. I wish the Institute well as it moves into its second century.

HOT OFF THE PRESS

✍ COMPILED BY **NITHYANAND RAO** FROM PRESS RELEASES WRITTEN BY THE **SCIENCE MEDIA CENTER***

PLANT DEVELOPMENT

New patterns of leaf growth



Courtesy: MAINAK DAS GUPTA

By monitoring leaves of 75 plant species growing in the IISc campus, researchers from the Department of Microbiology and Cell Biology have discovered three new types of leaf growth. Growth by cell division towards the base of the leaf was hitherto thought to be the only mode of leaf development. In this study, they discovered that some leaves grow from the tip, others experience growth all over their surface, and some grow from the centre.

These different kinds of leaf growth were associated with different concentration gradients of a regulator, a microRNA named *miR396*, across the leaf. However, the growth pattern of the leaf of a model plant could not be completely modified by artificially tweaking the expression of *miR396*, suggesting that other regulators are also involved.

Published in: *The Plant Cell*
Read more at: http://dx.doi.org/10.1105/tpc.15.00196

AERONAUTICAL ENGINEERING

Making aircraft engines cleaner and quieter

Some configurations of gas-turbines—an aircraft engine is one—mix the fuel with air in a predefined ratio before combustion. This allows better control over the chemical changes and significantly reduces the emission of particulate matter and oxides of nitrogen. However, this process is often unstable, resulting in large fluctuations in the pressure and heat release inside the engine. This can damage engine parts, and produce excessive noise. Therefore, aircraft engines today use non-premixed or partially premixed combustion, resulting in avoidable emissions.

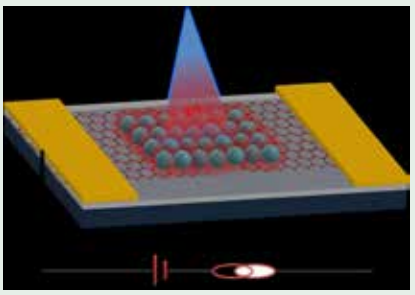
A team of researchers from the Department of Aerospace Engineering altered the engine design to spin the swirler, a device in the combustion chamber used for anchoring flames, which otherwise has remained static. Their experiments confirmed that this technique reduced fluctuations in pressure and heat release in the premixed combustion chamber.

Published in: *Combustion and Flame*
Read more at: http://dx.doi.org/10.1016/j.combustflame.2015.12.019

*Science Media Centre is a joint initiative of the Indian Institute of Science and Gubbi Labs

NANOMATERIALS

A cheaper, high-speed device for UV detection



Courtesy: ABHA MISRA'S LAB

Researchers at the Department of Instrumentation and Applied Physics have designed a new device that can detect ultraviolet (UV) light more selectively and efficiently. The device can have several applications—such as in chemical and biological analysis, flame detection, optical communications—and will be cheaper than existing UV photodetectors.

The device uses ZnO in the form of quantum dots—nanoparticles that confine charge carrier motion in all three dimensions—whose properties can be finely tuned, integrated with graphene, a 2D material known for its excellent electronic properties. When illuminated with UV light, a large photocurrent is generated, the response being rapid. Also, the energy band gap between ZnO and graphene is such that there is very little current in the absence of UV illumination.

Published in: *RSC Advances*
Read more at: http://dx.doi.org/10.1039/C5RA18663C

INFECTIOUS DISEASE

A Hepatitis C vaccine for India

The Hepatitis C virus (HCV), which can cause severe liver complications, infects an estimated 6 to 12 million people in India with genotype 3 being the most prevalent strain. Researchers from the Departments of Microbiology & Cell Biology and Biochemistry, with collaborators from Australia, have developed a vaccine against this particular strain. The two-step vaccination procedure has shown promising results when tested with mice.

First, the body is primed with virus-like particles (VLPs)—protein components of the viruses' outer shell which includes the core and envelope proteins assembled together to resemble the virus. After a couple of doses of the VLPs, a bio-engineered adenovirus, carrying the structural genes of the HCV, is delivered. This then produces HCV core and envelope structural proteins.

Published in: *Vaccine*
Read more at: http://dx.doi.org/10.1016/j.vaccine.2015.11.061

BIOENGINEERING

Treating infections with shock waves

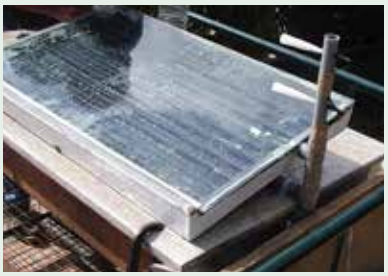
Researchers from the Departments of Aerospace Engineering and Microbiology & Cell Biology have, for the first time, used shock waves to treat bacterial biofilm infections. Common biofilm infections include tooth decay and sinusitis.

The low-energy shock waves—very large variations in pressure and temperature—were delivered using a hand-held shock wave generator, a device the researchers developed. In one experiment, they used it to disrupt a biofilm formed on a urinary catheter. In another, they used shock tubes to deliver shock waves to mice that had a lung infection, and subsequently also treated them with antibiotics. Within three days, the researchers found that the bacterial population in the biofilm had significantly reduced in the shock wave treated mice compared to a control group that had received only the antibiotic treatment.

Published in: *Nature Scientific Reports*
Read more at: http://dx.doi.org/10.1038/srep17440

SOLAR ENGINEERING

Solar stills for water desalination



Courtesy: MONTO MANI

A solar still, which can be used for small-scale water desalination, works on the same principle as rainfall—water evaporated by solar energy is collected after condensation. In a stepped solar still, there are a number of semi-circular pipe sections attached to each other, forming a slope. The untreated water is let into the top-most pipe section, and the treated water is collected from the bottom-most one. The whole setup is covered by glass and can be made using locally available materials.

Researchers at the Centre for Sustainable Technologies found that the productivity and efficiency of the solar stills were greater when the inlet valve was covered using just a filter cloth as compared to an inlet valve sealed using an air-tight cap.

Published in: *International Journal of Low-Carbon Technologies*
Read more at: http://dx.doi.org/10.1093/ijlct/ctt045

HYDROLOGY

Optimizing reservoir operations

Researchers from the Department of Civil Engineering have developed a mathematical model for the optimal release of water from reservoirs. The model takes into account factors like rainfall, water intake by crops, soil percolation, irrigation, and evaporation of water from the reservoir. For every short period into which a crop season is divided, a technique called dynamic programming is used to compute the optimal release policy till the end of the season. This is done using reservoir storage and soil moisture at the beginning of that period—fuzzy logic takes into account uncertainties—as well as grid-level rainfall forecast. The soil moisture and reservoir storage at the end of that period is then used to initialize dynamic programming for the next period.

A simulation study using the model has been done for Lakkavalli dam on river Bhadra, in Chikmagalur district, Karnataka.

Published in: *Journal of Irrigation and Drainage Engineering*

Read more at: http://dx.doi.org/10.1061/(ASCE)IR.1943-4774.0000956

NANOENGINEERING

A better technique to etch circuits

A team from the Centre for Nano Science and Engineering and the Department of Materials Engineering has developed a method for faster and cheaper patterning of nano-sized circuits. What's more, the method does not use toxic chemicals and works at room temperature.

The technique, called electrolithography, uses a thin film of chromium coated on an insulator. When an electric current is passed, the chromium melts and flows away from the negatively-biased electrode. This flow is controlled, and circuits etched, using electrodes of diameter 10 nanometres. By using probes of different diameters, one can draw circuits in varying resolutions: from a few tens of nanometres to a few hundred micrometres. None of the existing semiconductor manufacturing techniques provides this versatility in circuit resolution.

Published in: *Nature Scientific Reports*
Read more at: http://dx.doi.org/10.1038/srep17753

THRASHING OUT THE TRASH PROBLEM

✍ **NISHA MEENAKSHI** AND **BHARTI DHARAPURAM**

As the Indian Institute of Science (IISc) grows, so does the waste it generates. A look at a new initiative that seeks to address this issue using a sustainable approach

NISHA MEENAKSHI

In mid-2014, heaps of garbage accumulated all over Bangalore when the residents of Mandur prevented garbage trucks from dumping the city's waste into the landfill there. The incident led to a rude awakening to the ugly dimensions of the solid waste disposal problem among the city's denizens. Garbage wasn't out of sight and out of mind anymore.

While the issue may have largely faded from our collective memory, a group of dedicated researchers at the Centre for Infrastructure, Sustainable Transportation and Urban Planning (CiSTUP) have been busy tackling this problem in IISc, with the aim of managing solid waste efficiently leading to minimal, perhaps even zero, waste going from the campus to the city's landfills.

Thus was born project SWaMII—Solid Waste Management Initiative for IISc.

A Scientific Approach

At the core of the project is a scientific approach to waste segregation—understanding different kinds of waste and using an appropriate method to deal with each of them. SWaMII is spearheaded by JM Chandra Kishen, the Chairperson of CiSTUP and Professor at the Department of Civil Engineering. He says that his team wants to implement the best practices in the area of solid waste management for

this project. The project has already taken off, and is currently being implemented in a phased manner.

Segregation at Source

Waste segregation begins at the source itself. In each department, waste is disposed in any of the five colour-coded bins—green, yellow, blue, gray and red to dispose wet waste, non-biodegradable dry waste, biodegradable dry waste, e-waste and sanitary waste respectively. All of these bins have useful informational stickers on them to help a user dispose waste appropriately. Smaller floor bins for frequent use are also placed in each department, the contents of which are transferred to corresponding larger bins at regular intervals. The waste thus segregated at the source is collected by SWaMII employees from various locations within the campus and transferred to the Resource Recovery Facility (RRF) on a daily or weekly basis.

Courtesy: TEAM SWaMII

Waste segregation guidelines

Courtesy: TEAM SWaMII

Informational label on non-biodegradable waste

Centralized Facility

Waste segregation is further fine-tuned at the RRF. While some solid wastes are locally composted, others are routed to be recycled, or to be destroyed responsibly through a dedicated outside agency.

BHARTI DHARAPURAM

Palani, an employee at RRF, at work

Organic wet waste is composted using two aerobic digesters located within its building. The project aims to harvest the rich compost obtained from these digesters in the future. According to Chandra Kishen, plans are afoot to acquire a bio-methanation plant within a year to convert organic waste into bio-gas which can then be used as fuel within the campus. While dry waste is recycled, the disposal of e-waste and sanitary waste is carried out through authorized agencies in accordance with Karnataka State Pollution Control Board (KSPCB) standards. Each kind of waste is regularly weighed at RRF, and the data is logged to act as a reference for future studies interested in evaluating solid waste management procedures.

Outreach

The project provides a set of specific guidelines to be followed for waste segregation, and trains housekeeping staff, researchers and administrators to help members of the community understand their roles in the implementation of this initiative. The SWaMII team is in particular targeting the housekeeping staff, who, it believes, have a crucial role to play. "We have created a video [about the waste disposal procedure] in Hindi and Kannada to help the housekeeping staff understand the

BHARTI DHARAPURAM

TEAM SWaMII (from left): Andal Jaganathan, Consultant, SWaMII; JM Chandra Kishen, Chair, CiSTUP; B Vijay, Project Trainee, SWaMII

process," says Kishen.

"We have created a video [about the waste disposal procedure] in Hindi and Kannada to help the housekeeping staff understand the process"

The SWaMII team believes that the success of the project will depend on the stakeholders' understanding of the rationale behind the initiative as well as their roles. It has therefore been reaching out to departments individually and inducting them into SwaMII in a phased manner.

Challenges Ahead

The project now handles solid waste from 14 departments within the campus and has recently brought 250 residences under its wing. The source locations would eventually include all the departments, hostels and residences within the campus. With an increasing volume of waste, the team expects to face multiple challenges in the future. While more departments come into the fold of the SWaMII action plan, the project itself is constantly evolving as it moves forward.

Another major challenge is to implement waste segregation at every stage of the process, starting at the source itself. Users have to overcome their inertia towards waste segregation, to set the system in place, says Chandra Kishen. "If the waste segregation is improper at the source, the process would become very cumbersome for the staff at RRF," says Palani, an RRF employee. He gives a thumbs up to the Supercomputer Education and Research Centre (SERC) and the Department of Civil Engineering. Both these departments, he says, have meticulously adhered to segregation guidelines.

"If the waste segregation is improper at the source, the process would become very cumbersome for the staff at RRF"

Although the project has been well received by the administration and departmental coordinators, its actual success depends on a concerted effort by everyone on campus. Every link in the chain matters, says Andal Jaganathan, a consultant in CiSTUP, closely associated with SWaMII. The team believes that students can play an invaluable role in ensuring implementation of project guidelines for 'zero-waste to landfills' to become a reality here.

If this does happen, SWaMII could serve as an example of how waste can be disposed in a sustainable fashion for the entire city, one that is still searching for answers to its garbage crisis.

HELLO!

Meet new faculty who have joined the Indian Institute of Science (IISc)

COMPILED BY **MANU RAJAN** AND **SUDHI OBEROI**

CONNECT

SIDDHARTH BARMAN (Assistant Professor, Department of Computer Science and Automation) received his PhD from the University of Wisconsin-Madison, USA, in 2012 and did his postdoctoral work at the California Institute of Technology, USA. His current work focuses on algorithmic game theory and approximation algorithms. A common thread in his work is the application and extension of algorithmic techniques to address theoretical problems that capture real-world applications.

Courtesy: SANDEEP ESWARAPPA

SANDEEP M ESWARAPPA (Assistant Professor, Department of Biochemistry) hails from a town called Kadur in Karnataka. After his MBBS degree from Mysore Medical College, he did his PhD from IISc on how *Salmonella* escape death inside leucocytes called macrophages. His postdoctoral research in Cleveland Clinic, USA, was in the area of vascular biology which he is continuing at IISc.

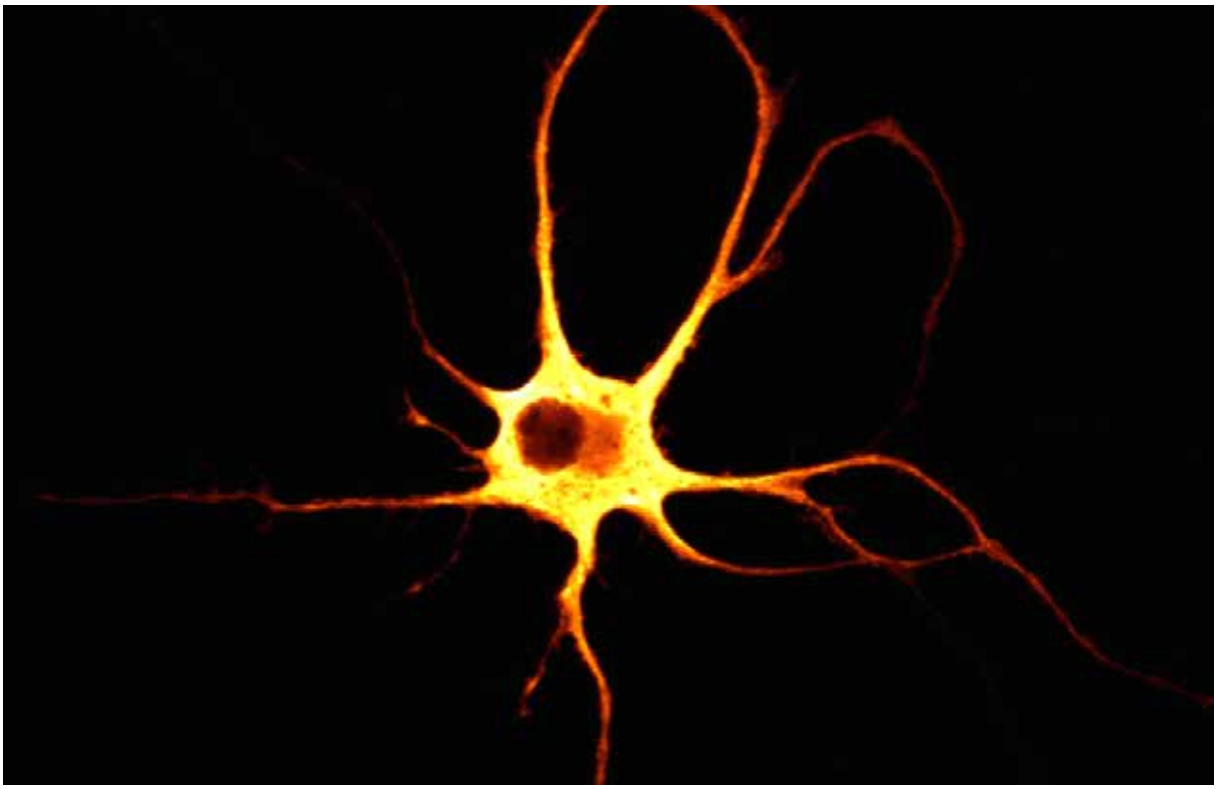
Courtesy: SUBHOJOY GUPTA

SUBHOJOY GUPTA (Assistant Professor, Department of Mathematics) got his PhD in Mathematics from Yale University, USA, in 2012. He carried out postdoctoral research at Caltech, also in the US, and then at the Centre for Quantum Geometry of Moduli Spaces in Denmark. His research areas are in geometry and low-dimensional topology. He is especially interested in understanding parameter spaces of geometric structures on surfaces, an example of which is the moduli space of Riemann surfaces.

A NERVE CENTRE FOR NEUROSCIENCE

✍ **RANJINI RAGHUNATH** AND **N APURVA RATAN MURTY**

Scientists at the Centre for Neuroscience (CNS) are delving deep into the brain seeking answers to the age-old question of what makes us who we are



Courtesy: DEBA JYOTI DAS

Your brain is, arguably, who you are. It is the seat of your personality, memories, emotions, creativity and so much more. This remarkable organ is made up of billions of nerve cells, or neurons, whose concerted activity enables us not just to survive and reproduce, but to also investigate the physical principles of the world, explore galaxies hundreds of light years away, even question the nature of our existence. Yet, its inner workings remain some of the biggest scientific enigmas, and form the crux of research at CNS.

CNS was founded in 2009, IISc's centenary year, at the "right time" when there was a "general feel" for neuroscience in India, says its founding Chairperson, Vijayalakshmi Ravindranath. Before moving to IISc, she was the founder Director of the National Brain Research Centre (NBRC) in Manesar. Tasked with setting up CNS at IISc, Ravindranath envisioned a truly interdisciplinary centre, benefitting from the diverse research ecosystem here, in contrast to NBRC that had to be set up in an isolated environment from scratch. "Here was an opportunity to see how one could leverage the existing expertise in engineering, computation, maths and physics. It seemed like a natural home for a neuroscience department," she recalls.

Making sense of the brain's fantastic complexity requires investigation at multiple levels—from

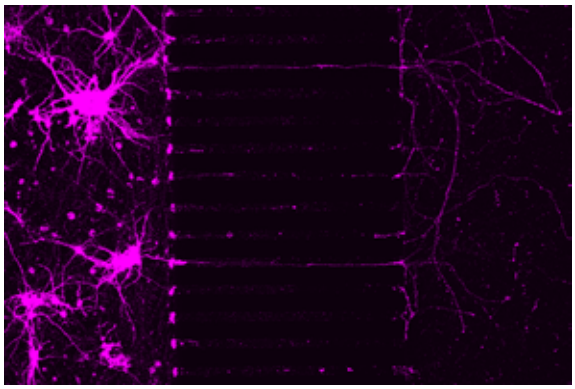
molecules and single neurons to neuronal networks, systems and, ultimately, behaviour. To take on this formidable challenge, Ravindranath decided to bring together researchers from a range of backgrounds—from molecular biology to engineering, physics and psychology. Today, CNS has a large and diverse group of neuroscience researchers.

Tracking Neural Development

Research at CNS ranges from understanding complex human behaviour to identifying tiny molecules that control flow of electrical impulses. The molecular chain-of-events governing the development, altered functioning and breakdown of nervous system components are active areas of research being pursued by Shyamala Mani, Naren Ramanan and Ravindranath.

Mani's research, for example, could provide clues about how developmental disorders and pediatric tumours arise. Her team studies granule neurons—a vital part of the circuitry in the cerebellum, the region of the brain responsible for coordinating movement. As the brain develops, these neurons have to "read" molecular cues from the environment and decide whether to multiply or differentiate. In a recent study, her lab showed that when specific developmental cues get turned off, these neurons do not proliferate sufficiently, leading to an underdeveloped cerebellum, similar to what is observed in premature babies.

Ramanan, on the other hand, is interested in the development of astrocytes, star-shaped cells involved in nervous system maintenance and various neuronal functions. His team also studies the growth of axons—the long, extended shafts of neurons—and how they can be enabled to grow after injury. They investigate these questions using genetically modified mice and primary cultures of neural stem cells, neurons and astrocytes.



Courtesy: VIJAYALAKSHMI RAVINDRANATH'S LAB

Neurons cultured in a microfluidic device to isolate the axons (centre) from the cell bodies (left)

Cutting-edge Tools

Studying the dynamics of the nervous system, which transmits information at rapid speeds, requires sophisticated and finely tuned equipment and techniques. A state-of-the-art super resolution microscopy platform, for example, has been set up by Deepak Nair to observe how proteins at live synapses—the junctions between neurons—organize themselves. This organization is vital for the nervous system to accurately relay information within milliseconds amidst other biological "noise".

Studying the dynamics of the nervous system, which transmits information at rapid speeds, requires sophisticated and finely tuned equipment and techniques

Researchers at CNS also use other cutting-edge tools: functional Magnetic Resonance Imaging (fMRI) to observe brain-wide network activity in humans, Transcranial Magnetic Stimulation (TMS) to disrupt or stimulate activity in specific regions, and Electrocorticography (ECoG) grids and multi-contact laminar electrodes to record neural activity from single neurons in specific parts of the monkey brain.

Bridging Disciplines

Ravindranath believes that in order to understand a complex biological system such as the brain, the Centre's researchers will also have to incorporate expertise from mathematics, physics and engineering.

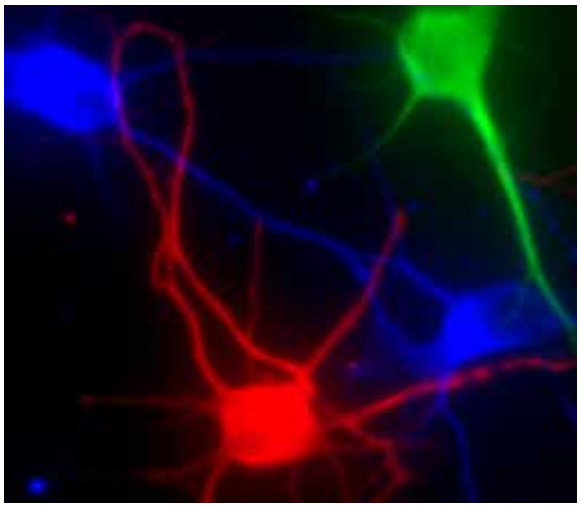
Aditya Murthy's lab, for example, is using engineering principles to better illuminate the nature of controls involved in muscle movement.

They are working with researchers from mechanical and aerospace engineering to apply approaches used in robotics to better understand human muscle control. Insights from such studies may in turn also benefit robotics. "If we understand why humans are superior in terms of flexibility, we can actually go the other way and design [better] robots," he says.

Murthy's lab is also interested in deciphering the brain computations underlying everyday actions. For instance, when you are at a traffic signal that is about to turn green, and someone suddenly walks in front of your car, how does your brain make the split-second decision change to hit the brake instead of the accelerator? Understanding how neural networks decide, plan and execute such muscle movements could provide valuable insights into motor control disorders such as Parkinson's disease.

Decoding Neural Computations

While the brain has distinct regions specialized for different tasks, neurons from one region also indulge in extensive "cross-talk" with their counterparts elsewhere. How neuronal networks communicate, work in concert and carry out complex computations underlying tasks such as object recognition, attention, learning and memory is also a focus of research at CNS. Forming and recalling memories, for example, is thought to depend on interactions between neurons at the surface of the brain and those in a deeper structure called the hippocampus.



Courtesy: MINI JOSE DEEPAK

Overlay of differentiating neurons in a culture

How neuronal networks communicate, work in concert and carry out complex computations underlying tasks such as object recognition, attention, learning and memory is also a focus of research at CNS

Scientists who study memory also posit an interesting theory to explain how the brain remembers experiences: by linking them to location. This is likely why some people, when asked what they were doing at a particular time, first say, "I was at the cinema, or I was at home," before saying, "I was watching the latest action flick," according to Sachin Deshmukh, who investigates this phenomenon.

Going beyond memory formation, Balaji Jayaprakash's lab is on a quest to understand the fate of the memory trace or "engram", once it has been generated in the brain. "How is a memory, once formed, being utilized in your day-to-day activities? Is it being utilized at all? We are addressing such questions both at a behavioural and a neuroanatomical level," he says.

Our sense organs—like our eyes—pass on information about the outside world to the brain. How the brain interprets this information is crucial for our survival. This complex problem is being addressed by SP Arun's lab. "The ease with which humans see the world belies the underlying complexity," he says. Apart from behavioural experiments and fMRI studies in humans, his team also records the activity of individual neurons in the monkey visual cortex, a region crucial for object recognition.

The amount of information communicated by the sense organs to the brain is staggering. But the brain processes only a small proportion of this information. Researchers at CNS are also trying to learn how the brain attends to relevant details

in the environment, while ignoring others—a phenomenon called selective attention. Supratim Ray studies brain rhythms that are thought to be linked to attention at different levels—from single neurons to million-strong neuron populations. He is particularly interested in the relationships between signals at these vastly different scales and their role in selective attention.

ATUL GOPAL

An Electroencephalogram (EEG) experiment underway in Supratim Ray's lab

Sridharan Devarajan, on the other hand, is investigating how cognitive processes such as perception, attention and decision-making arise from the collective actions of neurons and networks. To understand these emergent phenomena, his lab uses a unique combination of advanced imaging and stimulation techniques (fMRI, EEG and TMS) to precisely monitor or perturb brain activity in real time. Sridharan believes that these studies are also relevant to understanding the brain basis of impaired behaviour in disorders such as autism and Alzheimer's disease.

Tackling the Disease Burden

While fundamental research is necessary to understand what makes us who we are, Ravindranath believes that translational research on brain disorders, which contribute to one-third of the disease burden, is equally vital. Her lab is already working on uncovering the molecular mechanisms underlying some of these diseases.

More than mortality, brain disorders such as dementia and Alzheimer's disease contribute to increased morbidity and loss of productivity. They are, therefore, a heavier burden on caregivers and the society, she explains, adding that there is a need for people to come together to solve these larger problems.

"Which is what our effort is with the grant from Tata Trusts," she says, referring to the Rs. 75 crore funding given to CNS in 2014. "Today we believe that Alzheimer's disease actually starts 20-30 years before we see overt symptoms. The brain is so plastic that the clinical symptoms don't start manifesting overtly for a clinician or a caregiver to pick it up. So the grant focuses on very early mechanistic changes, again from molecules to cognition," she explains. CNS researchers will be working with clinicians to understand risk and protective factors that promote normal and pathological aging in human subjects. Research will also focus on developing early diagnostic tests that are far more sensitive to detect subtle cognitive changes.

Ravindranath also envisages that CNS will work closely with clinical researchers at the newly established Centre for Brain Research, set up with the help of a Rs. 225 crore grant given by Infosys co-founder Kris Gopalakrishnan and his wife Sudha Gopalakrishnan. This collaboration would mark another milestone in the rapid rise of a department only 7 years old.

Reflecting on this evolution, Ravindranath expresses her appreciation of the leadership and colleagues at IISc who gave her complete freedom and support to execute her vision. "Even as we joined, faculty would come up and say 'Welcome to IISc,'" she recalls, adding, "It is one of the best places to work."

APURVA RATAN MURTY

Researchers at CNS

CAMPUS CHRONICLES

Some of the events that took place in the Indian Institute of Science (IISc) recently

MCB75: From Molecules to Organisms

Courtesy: DEPARTMENT OF MICROBIOLOGY AND CELL BIOLOGY

From left to right: Ichizo Kobayashi, J Gowrishankar, Imran Siddiqui, DN Rao, Deepti Deobagkar and K VijayRaghavan

The Department of Microbiology and Cell Biology (MCB) celebrated its 75th anniversary by organizing a symposium, **MCB75: From Molecules to Organisms**, from 11-14 December, 2015.

Anurag Kumar, Director of IISc, inaugurated the event by presenting a brief history of the department which was founded in 1941 as the Pharmacology Unit. There were as many as 44 eminent researchers who spoke at the symposium, including Nobel laureates like Venki Ramakrishnan, MRC Laboratory of Molecular Biology, UK, and Richard J Roberts, New England Biolabs, USA. Both of them highlighted how recent technological advancements have made it possible to study basic aspects of biology.

Ujjini Manjunatha, Novartis Institute for Tropical Diseases, Singapore, and Rajesh S Gokhale, Institute of Genomics and Integrative Biology, New Delhi, talked about the necessity of discovering novel drugs and drug targets for drug-resistant tuberculosis. Ashok Venkitaraman, MRC Cancer Unit, UK, pointed out that cancer research required a shift in focus from single proteins to the affected cellular processes. Ramesh V Sonti, Centre for Cellular and Molecular Biology, Hyderabad, discussed his group's efforts in developing disease-resistant rice lines to prevent crop losses in Andhra Pradesh. The last session of the symposium featured talks by alumni of MCB, Raman Sukumar and Raghavendra Gadagkar, both professors at the Centre for Ecological Sciences, IISc.

Students from IISc and other institutes had an opportunity to interact closely with scientists in their field, particularly during the poster sessions where 144 posters were presented. A classical dance performance by students from the Dhrishti Art Centre added charm to the event. Umesh Varshney, Chairperson, MCB, said that the event marked the beginning of the platinum jubilee celebrations of the Department.

✍ **AKANKSHA DIXIT** AND **SAKSHI GERA**

PRAVEGA 2016

POOJA NATHAN

A T-shirt being painted by a participant of the *Molecular Murals* competition

The third edition of **Pravega**, the annual technical and cultural festival of IISc, organized by the Institute's undergraduate students, was held in the campus from 28-31 January, 2016.

The opening night featured music and dance performances by undergraduate students, the highlight being a contemporary reworking of Tagore's classic dance opera, *Tasher Desh* (Land of the Cards). The featured events included the *Microsoft Data Science Student Challenge*, a 24-hour hackathon where participants were asked to come up with interesting and potentially useful trends by analyzing public health-related data. There were also other technical events, such as *Whodunnit*, in which participants had to solve a "murder" using biology-based clues; *Molecular Murals*, a T-shirt painting competition in which one had to synthesize colours from chemicals provided; and *Auction*, where the objective was to maximize one's net-worth given the same starting capital. The fest also saw several quizzes, puzzle-based events and workshops.

Cultural events were held in the evenings. The first evening saw the finals of *Battle of Bands*, a music competition featuring rock bands from around the country, followed by a concert by *Lagori*, a folk rock fusion band. The second evening had a performance by *Thermal Projekt*, a well-known DJ, and the final night had a concert by *Agnee*, an Indo-rock fusion band.

✍ **SAYANTAN KHAN** (WITH INPUTS FROM PRANANDITA BISWAS)

URBANIZATION AND THE ENVIRONMENT

The **8th Biennial Conference of the Indian Society for Ecological Economics** (INSEE) was held at IISc during 4-6 January, 2016. The conference was hosted by the Department of Management Studies, IISc, in association with the Ashoka Trust for Research in Ecology and the Environment (ATREE)

and the National Institute of Advanced Studies (NIAS).

The conference, whose theme was *Urbanization and the Environment*, was attended by close to 200 participants from 12 countries, which included academicians, policy makers and activists. It saw 6 interactive roundtable discussions and several parallel sessions that covered themes such as industrialization and climate change, culture, consumption and sustainability of cities, urban commons, urban environmental governance, rural–urban environmental and resource linkages, water and air pollution, and waste management in cities.

The conference was inaugurated by Sunita Narain, Director General of the Centre for Science and Environment (CSE). In her talk, she asked, "Is the term 'sustainable cities' not an oxymoron, given that cities use huge amounts of resources, emit, excrete and discharge huge amounts of waste?" Keynote addresses during the conference featured some of the leading names in the fields of ecological economics and development studies, such as Joan Martinez Alier, who spoke on the emerging trends in responses to environmental impacts of economic growth, and Barbara Harriss-White who dealt with the vital role played by the informal economy in urban waste management. Sarath Guttikunda, Founder Director of www.urbanemissions.info, emphasized the role of data in dealing with air pollution.

The organizers expect that the conference will go beyond stocktaking of current trends in the scholarship in the field, and set in motion a dialogue on sustainability and management of urban environments.

✍ **SOUMYAJIT BHAR** (WITH INPUTS FROM BEJOY K THOMAS)

Molecules in Living Cells

The Molecular Biophysics Unit (MBU), IISc, hosted the annual meeting of the Indian Biophysical Society from 8-10 February, 2016. The theme of the conference was **Molecules in Living Cells: Mechanistic Basis of Function.**

Inaugurating the event, Raghavan Varadarajan, Chairperson of MBU, said that the idea of holding such an event "is to get people in the biophysical community from around the country to come together and share ideas."

There were talks on various topics ranging from structural studies of the basic molecules of life—DNA, RNA and proteins—to the application of MRI in cancer. The speakers included researchers from around the country, such as Ruchi Anand of IIT Bombay, Rishikesh Narayanan of MBU, Suman Kundu of Delhi University, Rahul Banerjee of the Saha Institute of Nuclear Physics, Kolkata, and NR Jagannathan of the All India Institute of Medical Sciences, New Delhi. There were also talks by leading researchers from outside India including

Michael Sheetz, founding Director of the Mechanobiology Institute at the National University of Singapore (NUS), Singapore, and Linda J Kenney who holds a joint appointment at NUS and the University of Illinois-Chicago, USA.

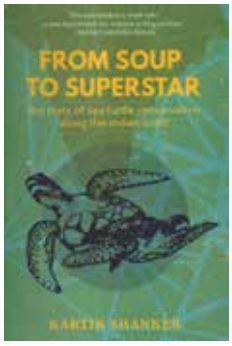
The GN Ramachandran lecture was delivered by C Ramakrishnan, a retired professor from MBU, who had worked with Ramachandran in developing his eponymous plot. "It was a truly inspirational and enthralling experience to listen to Prof. Ramakrishnan and the history behind the Ramachandran plot from one of its creators," said Mahavir Singh, an assistant professor at MBU.

Research scholars from institutions across India presented more than 80 posters on topics ranging from neurophysiology to crystallography to clinical medicine.

✍ **DISHA MOHAN**

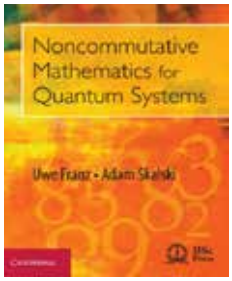
Book launches

As a young student at the Madras Christian College in Chennai, Kartik Shanker spent much of his time walking along the Chennai coast and observing turtles that came offshore to nest and lay eggs. Soon his fascination for these animals grew and he started studying them. Shanker, now a professor at the Centre for Ecological Sciences in IISc, has written a book about turtles called ***From Soup to Superstar: The Story of Sea Turtle Conservation along the Indian Coast***. The book, published by Harper Litmus, was launched at an event in IISc by the famous historian-writer, Ramachandra Guha on 8 January, 2016. Besides chronicling the early history of turtle biology and conservation initiatives, Shanker's book provides a rich account of the work done by conservationists and enthusiasts whose contributions have added to better understanding of turtles.



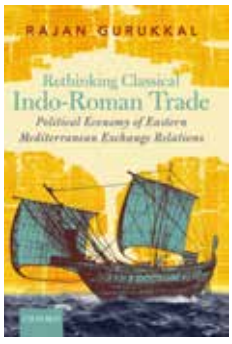
Courtesy: HARPER LITMUS

The Centre for Contemporary Studies (CCS) at IISc organized two book events in January. The first event, co-organized by IISc Press on 11 January, 2016, saw the launch of ***Noncommutative Mathematics for Quantum Systems*** by Uwe Franz and Adam Skalski, published jointly by IIScPress and Cambridge University Press. The monograph resulted from a series of lectures delivered by authors at the Indian Statistical Institute, Bangalore in 2013. Uwe Franc is a professor at the University of Franche-Comté, France, and Adam Skalski is an associate professor at the Institute of Mathematics, Polish Academy of Sciences, Poland. The book is divided into two parts, the first focusing on quantum probability and quantum stochastic processes, and the second on quantum dynamical systems. The book release was followed by a keynote lecture by Amrita Shah whose book *Ahmedabad: A City in the World* was published a few months ago.



Courtesy: IISc PRESS

In the second event, on 13 January, 2016, Rajan Gurukkal's ***Rethinking Classical Indo-Roman Trade: Political Economy of Eastern Mediterranean Exchange Relations***, published by Oxford University Press, was released.



Courtesy: OXFORD UNIVERSITY PRESS

In this book, Gurukkal, an eminent historian and a visiting professor at CCS, seeks to revise our understanding of the nature of the classical eastern Mediterranean exchange relations with the Indian sub-continent.

✍ **MEGHA PRAKASH** AND **ANKIT RUHI**

Science and Beyond

On 6 January 2016, Jon Agar, Professor of Science and Technology Studies at the University College London, UK, gave a lecture at the Centre for Contemporary Studies titled ***What are the big themes of the history of twentieth century science?*** He said that the biggest themes of 20th century science included the role of nation states in how science is done, the scale of science, swing in the emphasis from physical to life sciences, and applied science driving discoveries. The lecture was part of the *Science and Beyond* series of public talks organized by the British Council and IISER Pune.

GEETHA SN

Jon Agar receiving a memento from Amrita Shah of CCS

In another event, organized as part of the same series on 13 January, 2016, Carol Trager-Cowan from the University of Strathclyde, UK, gave a lecture at the Department of Molecular Reproduction, Development and Genetics titled ***Engaging the Public with Science and Technology—from Statues to Rainbows***. Trager-Cowan spoke about science popularization events she helps organize in Scotland. They include hands-on workshops in schools and *Science on the Streets*, a guided tour of sites of scientific interest in Glasgow. Trager-Cowan said that the science communicator must be clear, engaging and accurate during such interactions.

✍ **RAGHUNATH JOSHI**

Bioengineering Symposium

The Centre for Biosystems Science and Engineering (BSSE) organized its annual research symposium from 8-9 January, 2016. The symposium whose theme was **Cell, Tissue and Systems Engineering** began with the Sanjay Biswas Memorial Lecture delivered by Nicholas Spencer (Professor, ETH-Zurich).

The symposium served as a platform to showcase the research being done at IISc as well as other institutes. The entire event was managed and organized by the students, GK Ananthasuresh, Co-Chair, BSSE, told CONNECT. "We are happy that through this event, our students have gained confidence and have learnt to use technology to conduct an event like this," he added. To make the format interesting, the Principal Investigator (PI) or the professor from each group first gave an overview of the on-going work in his or her laboratory, followed by presentations by the students about their research.

Courtesy: BSSE

✍ **MEGHA PRAKASH**

LEAVING AN IMPRINT

✍ SRIDEVI VENKATESAN

A national initiative that includes the Indian Institute of Science (IISc) and other major institutes in the country to address pressing problems using technology

Courtesy: PRESS INFORMATION BUREAU OF INDIA

The President of India, Shri Pranab Mukherjee launching IMPRINT. He is flanked by the Prime Minister Shri Narendra Modi on his right and the Union HRD Minister Smriti Irani on his left

IMPacting Research INnovation and Technology, or IMPRINT, an initiative launched on 5 November, 2015 by the Ministry of Human Resource Development (MHRD), aims to use technology to solve some of the major problems India faces. The initiative, which involves IITs and IISc, lays down a road map for research in ten core areas which have been identified as most relevant to Indian society. It will enable researchers to participate in goal-oriented projects for which funds will be released quickly without red tape.

The first phase of IMPRINT will evolve a strategy for pursuing engineering challenges in the country, with the actual technological products or processes being developed in the second phase. One or more institutes will be in charge of each of the ten core areas. Each of these core areas will also have leading researchers as domain leaders whose role would be to identify themes within their domains and screen proposals that address specific problems. The proposals approved by the National Coordinator, Indranil Manna, who is also the Director of IIT Kanpur, would then be funded. Half the funding for an accepted proposal would come from MHRD, while the other half is expected to come from the ministry with an interest in the particular area of research.

IISc will lead the efforts in the core area of Environmental Science and Climate Change, with G Bala and Ravi S Nanjundiah of the Centre for Atmospheric and Oceanic Sciences, IISc, as the domain leaders. Bala's focus will be to develop a mathematical model of climate in India that can help us better prepare for the consequences of climate change. "IMPRINT," he says, "is reorienting our thinking about research. The aim is to redirect some of our energy from doing curiosity-driven research to solving problems that are relevant to society." He hopes to see visible results in terms of innovations that solve societal problems in three to five years.

Another core area—Water Resources and River Systems—is led by IIT Kanpur, and has Pradeep Mujumdar, Chairperson of IISc's Interdisciplinary Centre for Water Research, as a domain leader. Mujumdar's interest lies in the development of technological interventions that address the entire urban water cycle. On whether there is a risk of neglecting basic science research while focusing efforts on goal-driven research, Mujumdar says, "Even if we put 20-30% of our time into translating the knowledge that is already available into solutions, that would be excellent."

The other core areas of IMPRINT are Healthcare, Information & Communication Technology, Energy, Nanotechnology, Hardware, Sustainable Habitat, Advanced Materials, Manufacturing, and Security & Defence.

Source: http://imprint-india.org

DISPATCHES FROM THE LAB

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

✍ COMPILED AND EDITED BY THE CONNECT TEAM BASED ON INPUTS FROM THE FEATURED RESEARCHERS

SATHEES C RAGHAVAN

(ASSOCIATE PROFESSOR, DEPARTMENT OF BIOCHEMISTRY)

MANOJ SUDHAKARAN

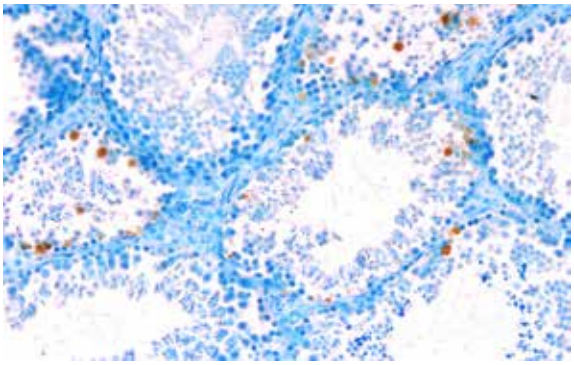
STUDYING DNA REPAIR, GENOMIC INSTABILITY AND CANCER THERAPEUTICS

Sathees C Raghavan and his group work in the field of DNA repair, chromosomal translocations, altered DNA forms, the biochemistry of antibody diversity generation and cancer therapeutics.

Recently, they have designed, synthesized and identified a novel inhibitor—*SCR7*—of Ligase IV, an enzyme involved in the final sealing of DNA double-strand breaks during NHEJ (a key DNA repair pathway). *SCR7* exhibited anti-tumour activities in most cancers and its usage improves the efficacy of existing cancer therapeutic modalities by

bringing down their effective dose. In the past year, this molecule has gained worldwide popularity by helping improve precision and efficiency of genome editing technology.

Another area of research that interests Raghavan's team is how the integrity of the genome is threatened. Among the threats to genome integrity are hazardous environmental factors like pesticides used extensively in agriculture. Pesticides have been known to damage DNA in many ways. Raghavan's team studies a commonly used organochlorine pesticide, endosulfan (ES). The World Health Organization (WHO) speculates that ES, like many other pesticides, can be detrimental to human health. However, little is known about how it causes genotoxicity. Using mouse as a model system, Raghavan and his group have demonstrated that ES exposure affects the physiology and cellular architecture of various organs. They found that it was particularly damaging to mice testes. The testicular damage ES caused was shown to be both qualitative and quantitative in nature. It affected spermatogenesis, reducing quantity and vigour



Courtesy: SATHEES RAGHAVAN

Testicular cell death in Endosulfan-treated testes seen as brown spots

of the sperm, thus leading to male infertility. The results of this study also indicate that ES is more detrimental to males than females.

Another area of research that interests Raghavan's team is how the integrity of the genome is threatened. Among the threats to genome integrity are hazardous environmental factors like pesticides used extensively in agriculture

MANOJ SUDHAKARAN

Raghavan with his team

ABHA MISRA

(ASSISTANT PROFESSOR, DEPARTMENT OF INSTRUMENTATION AND APPLIED PHYSICS)

ANWESHA MUKHERJEE

REARRANGING CARBON ATOMS FOR A BETTER WORLD

Abha Misra leads a productive research group. Her work has won her many recognitions including the Indian National Science Academy Medal for Young Scientists. She is also an Associate of the Indian Academy of Sciences and the National Academy of Sciences, India. Her research revolves around carbon, especially two of its more distinct, but related forms—graphene and carbon nanotubes.

In graphene, carbon atoms are present at the vertices of a hexagon—not unlike a honeycomb—and arranged in sheets, merely one atom thick. This structure bestows upon it extraordinary electrical, thermal, mechanical and optical properties. Graphene is also an ideal sensing material because of its high surface area. By combining a compound of graphene with hydrogen and tuning its energy band gap, Misra's lab has designed a device that detects infrared light with high sensitivity.

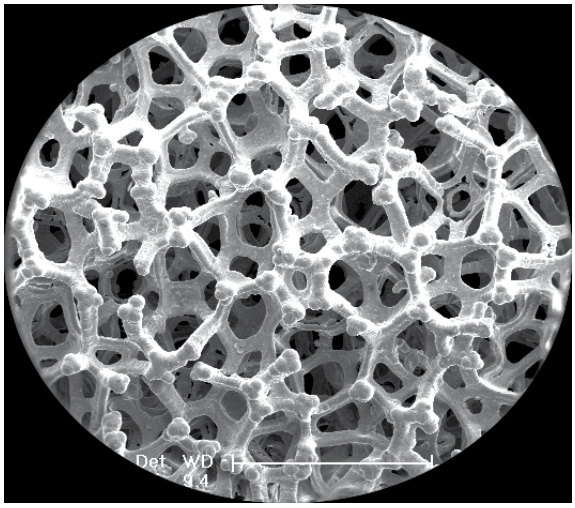
Misra's team has also found a way to enhance the generation of photocurrent—current produced when light is incident upon it—in a form of few layer graphene (FLG) by combining it with semiconducting nanowires in an arrangement that harvests energy more efficiently.

Another interesting property of FLG is that it responds differently to a flame along two different directions. This has allowed Misra's team to design a graphene-based flame sensor with a smart flame detection algorithm.

Carbon nanotubes (CNTs), by contrast, are long,

hollow structures with graphene walls. CNTs can be used to detect gases such as ammonia, sulphur-dioxide, and hydrogen sulphide even in very low concentrations through unique charge-exchange phenomena. Misra's group has exploited this property to develop a prototype of a gas-sensing alarm system applicable in gas and oil industries as well as in the detection of LPG leakage.

A unique surface interaction between CNT in bundles leads to novel applications such as impact-absorbing macroscopic foam, bulk actuators, and sensing devices—chemical, photo and mechanical devices. Misra and her team have also shown that the strength of a fluid-filled CNT foam can be tuned using a magnetic field which could then be used for making artificial joints and shock absorbers by mimicking biological systems.



Courtesy: ABHA MISRA

Graphene foam for impact absorption

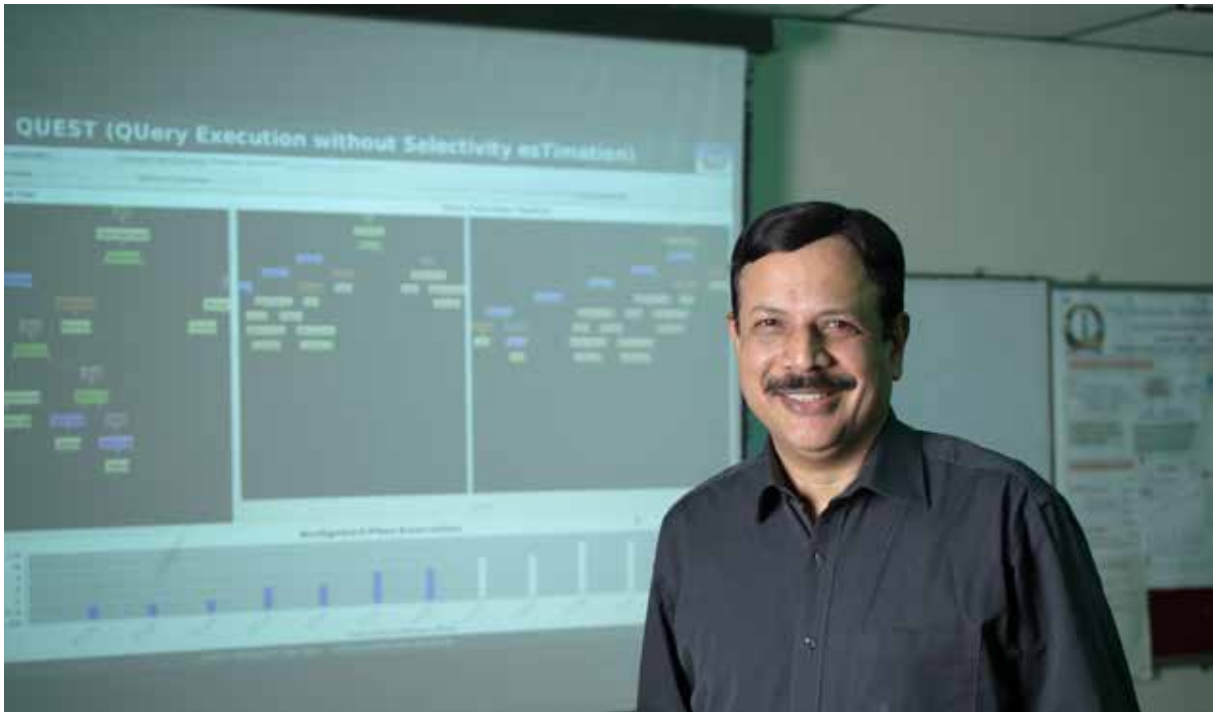
By combining a compound of graphene with hydrogen and tuning its energy band gap, Misra's lab has designed a device that detects infrared light with high sensitivity

KG HARIDASAN

Misra with her team

JAYANT HARITSA

(PROFESSOR, DEPARTMENT OF COMPUTER SCIENCE & AUTOMATION AND SUPERCOMPUTER EDUCATION & RESEARCH CENTRE)



MANOJ SUDHAKARAN

DEVELOPING ROBUST DATABASE MANAGEMENT SYSTEMS

Database management systems constitute the behind-the-scenes backbone of today's information-rich society, providing a congenial environment for handling enterprise data during its entire life cycle. A compelling instance of their grassroots impact is the centralized database created by the Government of India, under the Aadhaar card programme, for hosting the humongous corpus of personalized identification information collected from the Indian population. With the impending advent of the Big Data world, where data is expected to be the engine driving virtually all aspects of human endeavour, the role of database systems will soon assume ubiquitous proportions.

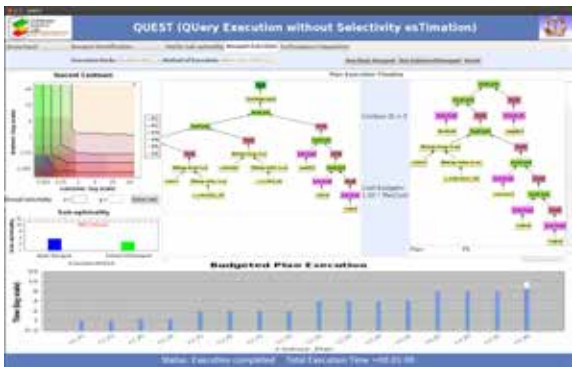
A potent and unique feature of database systems is their organic support for declarative user queries**,** where the user only specifies the search objectives, and the system is responsible for identifying an efficient means to achieve these ends. In practice, however, it is often belatedly realized after the query execution is completed, that a poor choice of strategy had been made. Therefore, a highly desirable, but equally elusive target for several decades has been the provision of performance guarantees on the specific means chosen by the system.

Jayant Haritsa leads the Database Systems Lab (DSL) at the Institute which has, over the past two years,

solved this classical problem by designing a radically different query execution mechanism called plan bouquets. This game-changing approach delivers, for the first time, proven and competitive performance guarantees. Moreover, it does so even in complex situations where contemporary commercial systems suffer significant degradation in their operational quality.

In a nutshell, DSL has developed the first-ever provably robust query processing technique, thereby fulfilling a dire and long-felt need of the global information management community. Major database vendors are currently exploring integration of these far-reaching ideas in their products.

A prototype implementation of the plan bouquet mechanism received the Best Software award at VLDB 2014, a premier international database research conference. Haritsa also won the



Courtesy: JAYANT HARITSA

Basic Bouquet Execution

prestigious *Infosys Science Foundation Award* in 2014 for his research contributions.

With the impending advent of the Big Data world, where data is expected to be the engine driving virtually all aspects of human endeavor, the role of database systems will soon assume ubiquitous proportions

MANOJ SUDHAKARAN

Haritsa with his team

LOOK WHO'S TALKING

Some of the lectures delivered at the Indian Institute of Science (IISc) in the past few weeks

INSTITUTE COLLOQUIUM: C DURGA RAO

CONNECT

C Durga Rao, a professor in the Department of Microbiology and Cell Biology, delivered an Institute Colloquium titled, *Viruses and Humans: Living in Symbiosis and Pathogenesis–Research from Dirt to Discoveries* on 20 January, 2016.

Viruses, which are organized complexes of nucleic acids and proteins, were among the first pre-cellular molecular living systems to emerge on Earth over four billion years ago. But in order for them to replicate and synthesize proteins essential for the assembly of new viral particles, they must exist inside living cells.

Rao highlighted his research which has resulted in a paradigm shift in the study of the biology of the rotavirus, which causes acute severe dehydrating diarrhoea. Working with collaborators, his group has developed a rotavirus vaccine. They have also shown that enteroviruses, such as poliovirus, coxsackievirus and echovirus, can cause acute and persistent diarrhoea in humans.

Rao concluded his lecture by saying that viruses, despite causing devastating diseases, co-exist with every living system on Earth, and have played a key role in evolution of living organisms, and in tuning and training the immune system to overcome infections.

✍ **S NAVIN**

INSTITUTE COLLOQUIUM: KVS HARI

CONNECT

KVS Hari, Chairperson of the Department of Electrical Communication Engineering, gave an Institute Colloquium on 16 February, 2016 on *Realizing the Power of MIMO Signal Processing*.

MIMO (Multiple Input Multiple Output) systems are signal processing systems which use multiple inputs and process them to generate multiple outputs. Such systems are all around us. A good example is a smartphone, which can have as many as five antennae providing inputs. "We are also a MIMO system," said Hari.

Signal processing using the MIMO framework has been used to develop models and algorithms for various applications. One such application of everyday relevance is ensuring mobile phones are able to handle signals of various strengths from multiple mobile base stations and still produce an acceptable call quality. Work on this by Hari and others contributed to the IEEE 802.16 wireless standard.

Hari then spoke about his most recent work on OpenShoe, a navigation system embedded in custom-designed shoes that can be used in emergency situations where GPS signals are unavailable. The data from the sensors in the shoes can be processed using MIMO algorithms, enabling firefighters, for instance, to know each other's locations inside a building and better coordinate their rescue operations.

✍ **NITHYANAND RAO**

2ND PROF. M VIJAYAN LECTURE: TOM BLUNDELL

Courtesy: IISC ALUMNI ASSOCIATION

Sir Tom Blundell, the well-known British structural biologist and biochemist gave the second Prof. M Vijayan Lecture at IISc on 4 January, 2016. Blundell serves as a professor emeritus at the University of Cambridge, UK. This ongoing lecture series is organized by the IISc Alumni Association in honour of the structural biologist M Vijayan of the Molecular Biophysics Unit, IISc.

In his lecture, Blundell shared his recollections of working alongside Vijayan and the Nobel Laureate Dorothy Hodgkin at the University of Oxford, work that resulted in determining the structure of insulin. Hodgkin, he said, had a "beautiful personality". He also added that besides being a brilliant scientist, Hodgkin was a warm human being who was interested in politics and music.

Blundell spoke about the importance of using computational techniques for drug discovery, especially in instances where experiments can be very slow and expensive. He also talked about his involvement in developing many widely-used computer programs like Composer, Modeller and Fugue for protein structure determination. He ended his talk by discussing the need for greater academia-industry interaction. His insights on the subject, he said, were based on his own experiences as a co-founder of Astex Therapeutics, a company that makes computer programs for drug discovery.

ANANTH KAMAT

IISc CENTENARY LECTURE: WILLIAM GODDARD III

Courtesy: WILLIAM GODDARD III

William Goddard III, the DST Centenary Chair Professor, gave the IISc Centenary Lecture on 7 December, 2015. Goddard is also the Director of the Materials and Process Simulation Center (MSC) at Caltech, USA, and his work spans many disciplines of chemistry, materials science, physics and biology. His talk was on protein structure prediction which is not only a notoriously hard problem to crack, but from an applications perspective, is one of the most important problems that needs to be solved.

Goddard presented his work on predicting the structure of G Protein Coupled Receptors (GPCRs), a class of proteins whose exact X-ray crystal structure is not known. The problem is further complicated by the existence of the many low energy configurations that these proteins can exist in. GPCRs are central to many sensing and experimental communication pathways, and are often the sites targeted by drugs. Goddard has developed new exhaustive algorithms to predict the structure of these proteins and also the binding sites for drugs. Another complex biological molecule which could play a major role in designer medicine is siRNA, short double stranded RNA, which can stop the translation of specific genes. He has shown that similar algorithms can also be used to predict the structure of these siRNA and how they interact with the RNA present inside the cell.

AMOGH KINIKAR

CELL PRESS-TNQ INDIA DISTINGUISHED LECTURESHIP SERIES 2016: KARL DEISSEROTH

Courtesy: CELL PRESS-TNQ

Karl Deisseroth delivered the 6th Cell Press-TNQ Distinguished Annual lecture on *Illuminating the Brain* at a jam-packed JN Tata Auditorium in IISc on 18 January, 2016. The DH Chen Professor of Bioengineering and of Psychiatry and Behavioral Science at Stanford University is best known for his revolutionary techniques—Optogentics and CLARITY—that allow scientists to visualize and manipulate brain circuits in real time.

A practising psychiatrist, Deisseroth said that his big moment of epiphany came during his interactions with his patients—he realized how little is known about the brain's functioning. He looked for techniques that could help investigate specific circuits in the brain while probing behaviour, only to realize that none existed. Deisseroth then developed Optogenetics which uses light to control the activity of genetically modified neurons, and can be monitored in real time, allowing researchers to switch cells on and off. This technique has fetched him several awards, including the 2015 Breakthrough Prize in Life Sciences.

The second method that he developed—CLARITY—is an imaging technique which renders the brain tissue transparent. CLARITY allows neurons to be tagged specifically and then trapped in a web of hydrogel. All other light-scattering components of the brain are then treated with detergent and removed using a small constant electric field.

✍ **SUDHI OBEROI**

3RD CNR RAO ENDOWMENT LECTURE: K VIJAYRAGHAVAN

DEBALEENA BASU

On 15 February, 2016, the 3rd CNR Rao Endowment Lecture was given by K VijayRaghavan, Secretary, Department of Biotechnology (DBT) and former Director of the National Centre for Biological Sciences (NCBS). Initiated by a generous endowment from CNR Rao, the lecture series is aimed at bringing eminent scientists from all over the world to give talks at IISc.

The talk titled *Brain and Behaviour* began with an introduction to the history of neuroscience. "To fully characterize such a complicated organ," said VijayRaghavan, "we need to find answers to three basic questions: Where did it come from? How is it made? How does it work?" He then elaborated on how the fields of evolutionary biology, developmental biology and neurophysiology are together contributing to help answer these questions.

VijayRaghavan also briefly touched upon his own research, which has shown that modulation of brain function could be both intrinsic (without any environmental influence) as well as extrinsic. He concluded by saying that as we learn more about the anatomical and functional complexity of brain circuits, we might slowly be able to decode the principles of how behaviour arises from brain activity.

✍ **DEBALEENA BASU**

AND THE AWARD GOES TO...

Researchers from the Indian Institute of Science who were honoured with awards

✍ COMPILED BY **SUDHI OBEROI** AND **MANU RAJAN**

CONNECT

MRN MURTHY

Professor, Molecular Biophysics Unit

Sir M Visvesvaraya State Award for Senior Scientist

CONNECT

ED JEMMIS

Professor, Department of Inorganic and Physical Chemistry

PC Ray Memorial Award

Courtesy: UPENDRA N

UPENDRA NONGTHOMBA

Associate Professor, Department of Molecular Reproduction, Development and Genetics

CV Raman State Award for Young Scientist

CONNECT

JAYANT HARITSA

Professor, Department of Computer Science and Automation

JC Bose Fellowship Award

CONNECT

DIPANKAR CHATTERJI

Professor, Molecular Biophysics Unit

Padma Shri

Courtesy: PN RANGARAJAN

PN RANGARAJAN

Professor, Department of Biochemistry

JC Bose Fellowship Award


MANOJ SUDHAKARAN

G MUGESH

Professor, Department of Inorganic and Physical Chemistry

JC Bose Fellowship Award


MANOJ SUDHAKARAN

KAMANIO CHATTOPADHYAY

Professor, Department of Materials Engineering

National Institute of Metals Platinum Medal


MANOJ SUDHAKARAN

A CHOCKALINGAM

Professor, Department of Electrical Communication Engineering

JC Bose Fellowship Award


CONNECT

GL SIVAKUMAR BABU

Professor, Department of Civil Engineering

Jung Bahadur Memorial Prize of Institution of Engineers and **SN Gupta Biennial Award of Indian Geotechnical Society**


MANOJ SUDHAKARAN

B SUNDAR RAJAN

Professor, Electrical Communication Engineering

JC Bose Fellowship Award


CONNECT

TG SITHARAM

Professor, Department of Civil Engineering

IGS-Kueckelmann Award


Courtesy: PATRICK D' SILVA

PATRICK D' SILVA

Associate Professor, Department of Biochemistry

DBT National Biosciences Award

B GOPAL

Professor, Molecular Biophysics Unit

Shanti Swarup Bhatnagar Award (Biological Sciences)

(Photograph not published on request of awardee)

Campus Critters

Praying mantis

Centre for Neuroscience