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Connect

WITH THE INDIAN INSTITUTE OF SCIENCE

Light
Implications and applications of its properties

SERC
More than just a computing facility

A New Bloom
First batch of UG students graduate

August 2015
Volume 2 • Issue 3

CONTRIBUTORS

Croor Singh is a PhD student at the Jawaharlal Nehru Centre for Advanced Scientific Research

Amogh Kinikar is an undergraduate student

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

Rolla Das is a PhD student at the National Institute of Advanced Studies

Bharti Dharapuram is a PhD student at the Centre for Ecological Sciences

Kanthi Krishnamurthy is a PhD student at the Centre for the Study of Culture and Society

Manu Rajan is a Technical Officer at the Archives and Publications Cell

Ipsita Herlekar is a Project Trainee at the Archives and Publications Cell

Ranjini Raghunath is a Development Consultant at the Office of Development and Alumni Affairs

Raghunath Joshi is a student in the Department of Materials Engineering

Karthik Ramaswamy is the Editor, CONNECT and Visiting Scientist, Biological Sciences

Nithyanand Rao is a Consultant Editor at the Archives and Publications Cell

Ananya Jana is a PhD student at the Centre for Ecological Sciences

Chaitanya Joshi is a PhD student in the Department of Materials Engineering

Subham Mridha is a PhD student in the Department of Materials Engineering

Shilpee Jain is an INSPIRE Fellow at the Centre for Biosystems Science and Engineering

Rahul Roy is an Assistant Professor in the Department of Chemical Engineering

Bitasta Das is a UG Instructor, Centre for Contemporary Studies

Megha Prakash is a Consultant Editor at the Archives and Publications Cell

Disha Mohan is a PhD student in the Department of Molecular Biophysics

Debaleena Basu is a PhD student at the Centre for Neuroscience

Front Cover: Laser cooling of ytterbium atoms to near-zero temperatures (KUMAR MP)

Back Cover: Watercolor of SERC building (BHAMA SREEDHARAN)

Front Inside Cover: Main Building (KUMAR MP)

Back Inside Cover: A recently molted scarab beetle (NATASHA MHATRE)

CONNECT TEAM

Karthik Ramaswamy (Editor, CONNECT and Visiting Scientist, Biological Sciences)
Megha Prakash (Consultant Editor, Archives and Publications Cell)
Nithyanand Rao (Consultant Editor, Archives and Publications Cell)
Ipsita Herlekar (Project Trainee, Archives and Publications Cell)
Manu Rajan (Technical Officer, Archives and Publications Cell)
TA Abinandanan (Chairperson, Archives and Publications Cell & Department of Materials Engineering)

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CONTACT

Email: newsletter@apc.iisc.ernet.in
Phone: 91-080-2293 2066
Address: Archives and Publications Cell
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FROM THE CONNECT TEAM

Greetings!

Though the Indian Institute of Science (IISc) admitted its first students back in 1911, it took another 100 years for it to welcome its first batch of undergraduate students. A few weeks ago, the young faces of students from this batch beamed with joy and pride. And for good reason. After four years of working hard, playing hard and making the campus richer by their presence, they graduated from this programme. While some of them have chosen to continue for another year in IISc and earn a Master's degree, many others have opted to pursue their PhDs at some of the best universities in the world. CONNECT uses the opportunity of their graduation to trace the programme's history and provide an in-depth look into this unique initiative.

The Institute has a new acquisition—*Sahasrat*, a supercomputer which has already started to assist researchers in fields as diverse as climate science and astrophysics. CONNECT showcases this gleaming new machine in a story about the Supercomputer Education and Research Centre (SERC).

In our series that celebrates 2015 as the International Year of Light, CONNECT goes behind the scenes in labs across the campus which are seeking to improve our lives by exploiting the schizophrenic properties of light. Light, as we have seen, travels as waves, but behaves like photons when it interacts with matter. This discovery, made over a century ago by Albert Einstein, was a triumph of basic physics. But not even the great man himself could have foreseen how profoundly this insight is changing the world.

In the last week of June, the sombre mood on the campus turned nostalgic when IISc played host to a global meet of its alumni who came from far and wide to relive old times. The Institute used the occasion to highlight its development and also to evolve mechanisms to include its former students as partners in its growth in a more coherent and constructive way. The initiative was greeted with enthusiasm by its alumni, keen to reconnect with their alma mater. This issue of CONNECT sees a detailed report from this rare and important event which the campus community had been awaiting eagerly for many months.

Happy reading.

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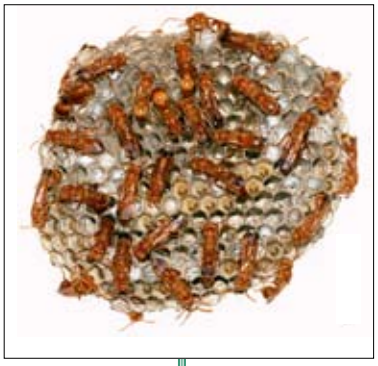

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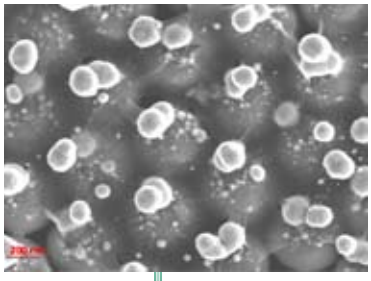

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PROPERTIES OF LIGHT:
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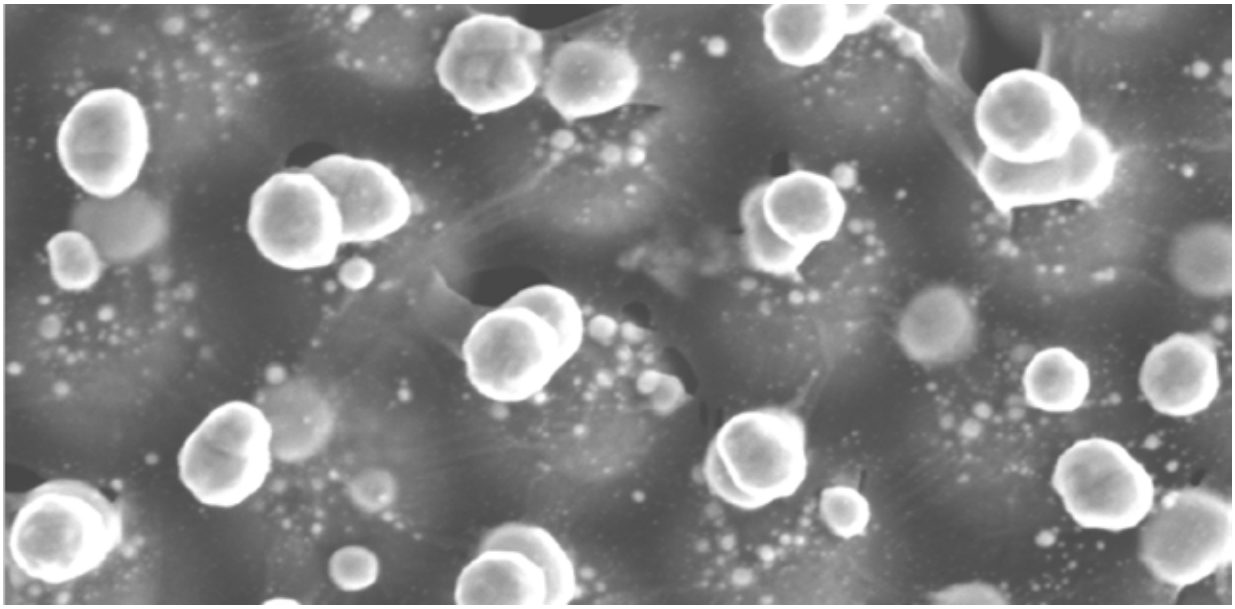


Courtesy: AMBARISH GHOSH

Silver nanospheres-graphene sandwich, the most sensitive graphene-plasmonic hybrid photodetector

To celebrate 2015 as the International Year of Light, CONNECT ***is bringing out a series of articles on light. Part I outlined the history of the science of light. In Part II, we look at some implications of the properties of light and how they are being used at the Indian Institute of Science (IISc) to improve our lives***

✍ **CROOR SINGH (with inputs from AMOGH KINIKAR)**

In the early 1900s, after two millennia of debate, we finally understood the nature of light. This came about with the prediction of the photoelectric effect in 1905 by Albert Einstein and its experimental verification in 1914 by Robert Millikan. We now know that light has properties of both waves and particles; it propagates like a transverse wave of electric and magnetic fields, but behaves like a stream of particles called photons—discrete and indivisible packets of energy—in its interactions with matter.

When scientists speak of light, they refer not just to visible light—the part of the electromagnetic spectrum seen by human eyes—but to all electromagnetic radiation, ranging from radio waves with wavelengths of a few metres to x-rays with wavelengths of a few angstroms. We owe this understanding to James Clerk Maxwell and his unified theory of electromagnetism.

Light as a Wave

Light has found many applications, sometimes even before we understood its properties completely. For instance, radio communication was invented before the end of the 19th century, and x-rays were discovered and used before we understood why they might be harmful in large doses.

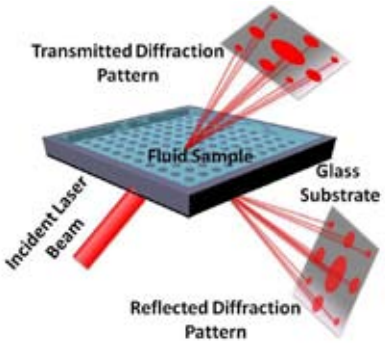
Light continues to be indispensable in sending information across vast distances. Mass media like radio and television use light, as do personal devices like mobile phones. The digital information that makes the internet possible is transmitted across continents through optic-fibre cables at the bottom of the ocean. The recent stunning pictures of Pluto

were sent back to Earth using X-band microwave, also used in most satellite-based communication.

In addition to propagation, other wave-like properties of light have found practical applications. S Asokan, Professor, Department of Instrumentation and Applied Physics (IAP), and the Chairperson of the Robert Bosch Centre for Cyber-Physical Systems (RBCCPS), and his group design and use Fibre Bragg gratings (FBGs)—sections of optic-fibre cable with varying refractive indices with the property that they reflect one specific wavelength of light while letting every other wavelength pass unhindered. The wavelength that is reflected is sensitive to minute changes in strain or ambient conditions.

FBGs are small (only a few microns in size) and non-intrusive, and can therefore be deployed almost anywhere. In addition, any number of these devices can be deployed in tandem. Asokan's group has found a wide variety of applications for FBGs, from monitoring the structural integrity of civil and aircraft structures to biomedical applications like detecting a marker for myocardial infarctions—heart attacks—called C-reactive protein (CRP) and even identifying exercises which can best prevent blood clots (deep vein thrombosis) during long periods of inactivity. Asokan adds that FBGs can also be used in geophysical applications like tsunami and earthquake detection since they can use the existing global network of optic-fibre cables.

Parama Pal of RBCCPS and Manoj Varma of the Centre for Nano Science and Engineering (CeNSE) use diffraction gratings to measure the refractive index of a sample in a micro-fluidic channel (a fluid-carrying groove about a micron wide) with a resolution of one part in a million. Measured *this* precisely, the refractive index can be used to check for contamination of the sample, with obvious applications in the food industry. They are working on miniaturising the setup so that it can be used in portable devices that check for contamination in domestic water supply. Pal and Varma also work, in collaboration with Heriot-Watt University in the UK, on detecting specific biomarkers (e.g. for diseases) using microfluidic channels and spectroscopic techniques.



Courtesy: MANOJ VARMA

Schematically shown diffraction grating used to measure refractive indices precisely

Light-Matter Interaction

Spectroscopy is the study of how light and matter interact. Matter can interact with light, broadly, in three ways: absorb it, emit it, or scatter (absorb and re-emit) it. The currency these interactions use is energy denominated in indivisible photons. Predictably, such an arrangement makes for a peculiar marketplace. In order to "buy" something from a given kind of matter, only photons of a particular denomination, i.e. energy value (and therefore frequency or wavelength), will do.

Given the nature of light and the nature of its interaction with a substance, the identity of the substance can be inferred. These "spectroscopic" techniques have been modified to suit every field of scientific enquiry, given their specificity and their ability to not alter the properties of the system being studied. One such scattering-based technique is Raman spectroscopy.

When light is scattered by matter, the re-emitted photons are mostly of the same energy as the incoming photons. But about once in a million times, the re-emitted photon is more, or less, energetic. This is the "Raman effect", and Raman spectroscopy relies on measurements of the precise differences in these energies.

Raman Spectroscopy

Spectroscopic techniques are particularly useful in situations where the system under study changes with time. In such cases, they can show exactly what changes the system is undergoing. Often,

these changes are those associated with a chemical reaction—this involves the breaking of bonds and their re-creation elsewhere.

S Umapathy, (Professor, Department of Inorganic and Physical Chemistry and Department of Instrumentation and Applied Physics) and his group use Raman spectroscopy to track the chemical composition of the sample in time-scales at which chemical bonds vibrate. Time-evolution is captured using a pulse-probe technique, which comprises of one high-energy pulse of laser light which excites the system, and a probe pulse after a time-delay which can be varied.

Courtesy: AJAY SOOD

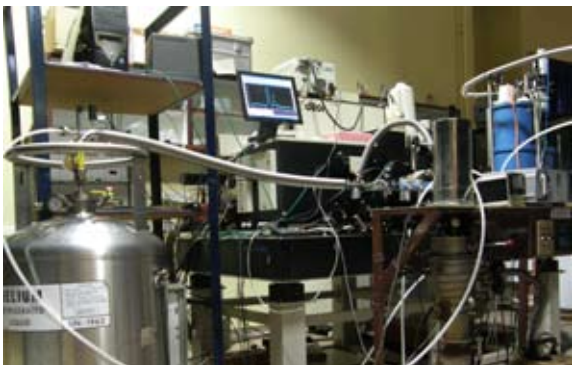
The ultra-fast pump-probe laser setup

For relatively sluggish reactions, the system only has to be probed at nanosecond intervals. For more flighty reactions, Umapathy's group uses a technique called Femtosecond Stimulated Raman Spectroscopy (FSRS), which uses an ultra-fast laser and can resolve the state of the system at femtosecond (10^{-15} s) timescales. His group was only the third in the world to build the femtosecond laser setup, now housed at the Centre for Ultrafast Laser Applications (CULA) in IISc.

Umapathy's group also works on less exotic, but no less useful, applications of spectroscopic techniques. They use Raman and infra-red spectroscopic techniques combined with microscopy as tools for biomolecular fingerprinting. These tools can be used to study not just fundamental biological processes like cell division and cell death, but also to diagnose diseases like cancer and tuberculosis.

The property of molecules that have different handedness—called chirality—to scatter polarized light differently is exploited in Raman optical activity spectroscopy to infer their structure. This finds applications in understanding protein folding mechanisms.

The changes that a system undergoes could also be physical instead of chemical, and the same techniques described above could be used. Ajay Sood, a professor at the Department of Physics, specializes in finding ingenious uses for Raman spectroscopy. His group uses Raman spectroscopy to characterize nano-scale devices like graphene field-effect transistors which could revolutionize electronics the way semiconductor transistors did half a century ago, and to study phase-transitions under extremely high pressures to understand fundamental changes in the nature of a material. The group also uses Raman spectroscopy to study how a material changes as it becomes a superconductor below its critical temperature. In all these systems, the time scales of interest are those associated with the vibrations of the molecules in the material. "Raman spectroscopy can be used as a readout for the vibrational state; we can watch the vibrational modes—called phonons—change with time," says Sood.



Courtesy: AJAY SOOD

Low-temperature Raman spectroscopy setup

A common occurrence associated with spectroscopic techniques is a kind of noise called spectral broadening—a smearing out of the frequency of light required for a specific light-

matter interaction. Spectral broadening can occur for several reasons. In gaseous systems, it usually occurs due to Doppler shifts of the light's frequency resulting from the molecules moving around at high speed. If the frequency uncertainty of the transition (its line width) is comparable to the amount by which the photon frequency is broadened, any attempt at spectroscopy is rendered meaningless, unless a special technique is used to account for the spectral broadening.

One such technique is saturated absorption spectroscopy (SAS), and is the starting point for most modern optics experiments, says Vasant Natarajan, also a professor at the Department of Physics. SAS uses a pump-probe setup. The pump and probe lasers are of the same frequency, but the pump beam is more intense. The pump beam is used to saturate the higher energy state with atoms of the gas, at which point the much less intense probe beam is not absorbed at all. This dip in absorption of the probe beam is the negative of the Doppler-corrected spectrum.

Natarajan and his group also work on coherent population trapping (CPT), a technique used in some atomic clocks, and electromagnetically induced transparency (EIT), used in laser-cooling of atoms to temperatures near absolute zero.

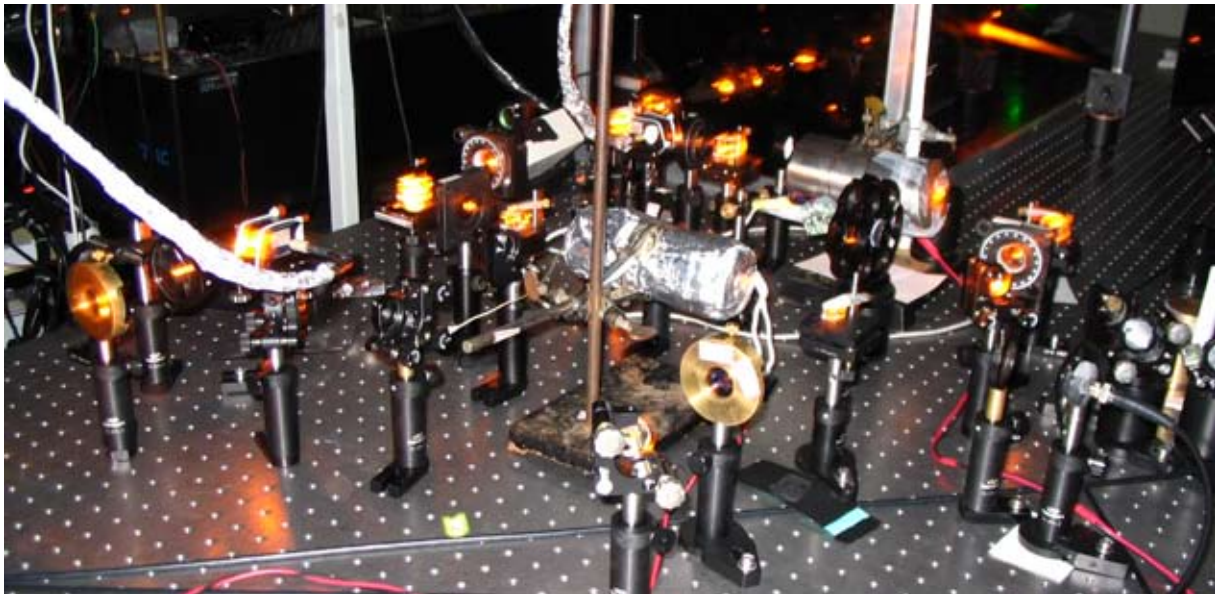
Unlike the noise associated with physical or chemical systems, which can possibly be dealt with by cleverly tinkering with the lasers, noise in biological systems comes from the system itself; spectroscopic techniques—especially Raman spectroscopy with its weak signal levels—are unsuitable when high temporal resolution or sensitivity is desired. Instead, fluorescence microscopy is used.

Courtesy: KUMAR MP

Laser cooling of ytterbium atoms to near-zero temperatures

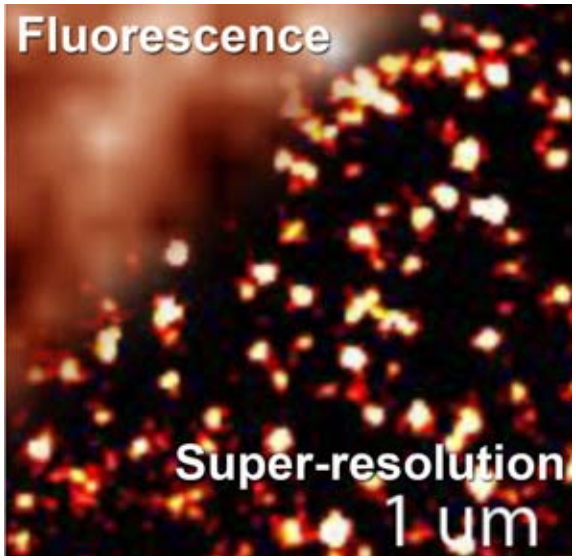
Fluorescence Microscopy and Biology at the Nanometre Scale

Rahul Roy heads the Nanobiology group at the Department of Chemical Engineering. His group works on fluorescence-based techniques to study biological systems at the nanometre scale—something Roy likens to reading a car's number-plate from outer space. An example of



Courtesy: VASANT NATARAJAN

Experimental setup to access the yellow lines of sodium



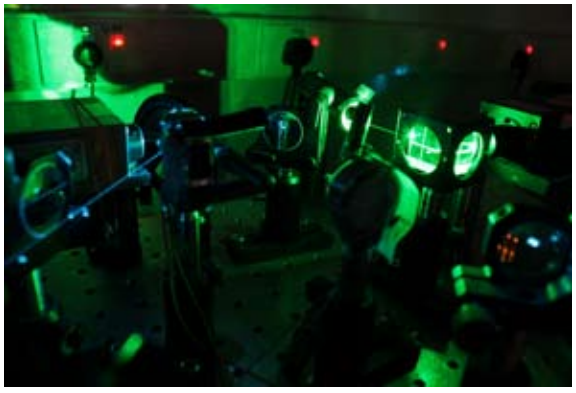
Courtesy: RAHUL ROY

RNA Polymerase II, a protein inhibited by viruses, as observed by an SRM technique

this is the mechanism by which DNA and RNA molecules are copied one base-pair at a time.

In addition to being much brighter than Raman spectroscopy, fluorescence-based techniques offer several benefits, explains Roy. Systems can be studied *in vivo,* unlike with x-rays or electron microscopy. Fluorescent proteins (like GFP—the green fluorescent protein) can also be attached precisely to the part of the molecule of interest, making these techniques highly specific.

Fluorescence microscopy is, however, limited by the diffraction of light. Light can only be squeezed to about half its wavelength, and any further constriction is counterproductive. Several techniques that seek to work around the diffraction limit, called super-resolution microscopy (SRM) techniques, have been devised in recent years. A "resolution revolution" is afoot, Roy says.



Courtesy: RAHUL ROY

Single molecule total-internal-reflection microscopy setup

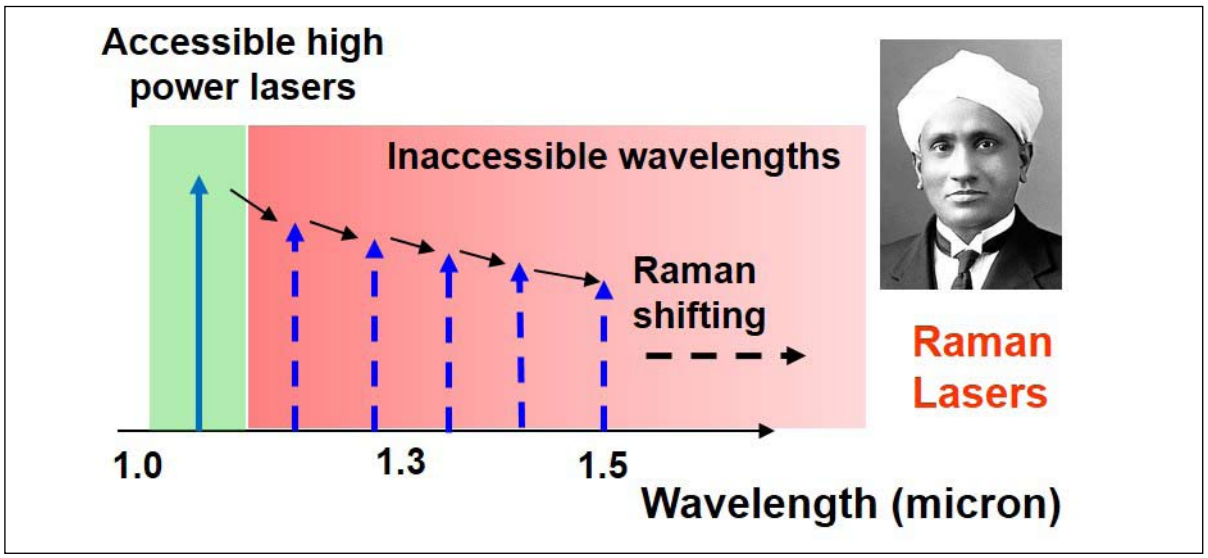
An SRM technique, called single-molecule microscopy, uses the variations in the blobs of brightness when a few fluorescent molecules are switched on and off. When several of these pictures are superimposed, the resulting image resolves molecules at the nanometre scale. Another technique, called stimulated emission depletion (STED) microscopy, uses a second laser to switch off the fluorescence induced by the first, but only selectively from the periphery of the focus. The enormous promise of these SRM techniques was recognized when the 2014 Nobel Prize in Chemistry went to researchers who pioneered its development.

Roy's group also uses other techniques like total-internal-reflection fluorescence microscopy (TIRFM), which can resolve features on the surfaces of cells by selectively illuminating only a 100 nm section of the volume near the cell's surface. Another technique used by his lab is single molecule fluorescence resonant energy transfer (FRET) microscopy, which can determine the conformation of individual macromolecules by looking for interactions between specific parts of the molecule and guessing—to within nanometres—how far they are from each other.

Photonics

The techniques described so far deal with detection or measurement of materials using light. The ideas on which these techniques are based can also be used to characterize light itself. The field of study that deals with understanding and modifying the properties of light is called photonics.

By depositing metal nanoparticles in a chiral arrangement, Ambarish Ghosh and his group at the



Courtesy: VR SUPRADEEPA

Tunable lasers

Centre for Nano Science and Engineering (CeNSE) can engineer the state of polarization of light. This, in turn, can be used to determine the structure of chiral molecules. His group has also used the same fabrication technique as above to build the most sensitive graphene-plasmonic hybrid photo detector. Their technique amplifies the electric field of incident photons by focusing it between silver nanospheres, separated by a graphene sheet which has the thickness of only a single-atomic layer.

The measurement techniques described above use lasers of a wide variety of wavelengths, many of which are inaccessible through conventional means. To overcome this, wavelength conversion and tuning of laser systems is achieved using nonlinear photonics—the idea that the properties of the medium depend on the intensity of the light being transmitted. VR Supradeepa, also at CeNSE, specializes in this field. For example, atmospheric levels of greenhouse gases can only be measured accurately using high-power lasers at hard to reach mid-IR wavelengths (> 1.5 microns), owing to high atmospheric transparency in these wavelengths and considerations of safety to the human eye. Such high-power lasers have also found use in industrial applications such as material processing and in military uses such as RADAR and directed energy. ("Purely for defensive purposes. No death stars," Supradeepa assures us.) His group is also working on miniaturizing these systems.

The principle behind the photoelectric effect—the idea that the energy of a photon can unbind electrons in a material—can be applied to make nanoscale devices that combine light and electronics, the study of which is called optoelectronics. Arindam Ghosh, an associate professor at the Physics Department, and his group are at the forefront of this emerging field. They have succeeded in creating a highly sensitive graphene-based photodetector, which also doubles as a rewritable memory device (see page 4 for image). The architecture they have pioneered is a paradigm shift and could lead to novel large-area electronic devices, says Ghosh.

When it was discovered, Einstein's photoelectric effect had no practical applications. But today, the list of applications of the principles behind the photoelectric effect is growing and seems endless, evidence that science for the sake of curiosity is not anathema to science "with a purpose".

AMRITA SHAH: SCHOLAR-IN-RESIDENCE

✍ **ROLLA DAS**

KETAKI SHETH

Amrita Shah is a journalist, columnist and non-fiction writer, and is currently a Visiting Faculty at the Centre for Contemporary Studies (CCS), Indian Institute of Science (IISc). She spoke to CONNECT *about her diverse body of work at her quaint office over a cup of freshly-brewed filter coffee, just a few days after the launch of her book on Ahmedabad.*

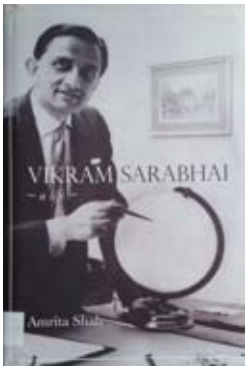
Career as a Journalist

Shah started her career as a journalist in Mumbai where she hails from. She closely followed and covered Mumbai's underworld from 1983 to 1991. "My career as a journalist had an unusual start. I stumbled upon a story involving a rivalry between two gangs which led to a series of articles on organized crime," she says. Besides writing about the Mumbai underworld, Shah wrote stories on Punjab during terrorism, on Assam after the anti-immigrant agitation and on mass violence in Gujarat.

Shah has also written on issues pertaining to the media, law, and culture. During her impressive career as a journalist, she has contributed to publications like *The Illustrated Weekly of India*, *Imprint* and *Outlook*. She has worked for the international media house *Time-Life News* service and edited the Indian edition of the International fashion magazine *Elle*. Shah has also been a columnist and Contributing Editor with *The Indian Express* for ten years.

Vikram Sarabhai: A Life

Shah's first book—*Hype, Hypocrisy and Television in Urban India*, published in 1997—came about because of her interest in the television revolution that was happening around then. She wanted to understand how the audio-visual medium became the next "big thing" and its impact on urban India. Though the book was critically acclaimed, it was her second book, about Vikram Sarabhai, published in 2007, that was more widely circulated.



ROLLA DAS

Shah's second book, *Vikram Sarabhai: A Life*, published in 2007 by Penguin-Viking

Shah knew of Sarabhai's dream of using television for development. A brief profile in a book made her familiar with his wide range of accomplishments, from founding the Indian space programme, heading the Atomic Energy programme, to founding and co-founding both the Indian Institute of Management and the National Institute of Design in Ahmedabad respectively.

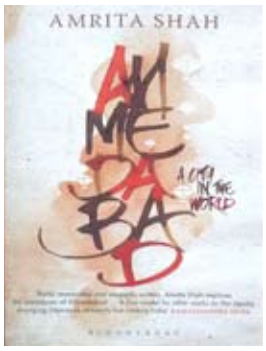
Curious to know more about Sarabhai, Shah looked around for a biography and found that it did not exist. So she decided to write one herself. "He was involved in the creation of technology. But at the same time he had a vision for India," she says of this great scientist, institution builder and visionary.

"He was involved in the creation of technology. But at the same time he had a vision for India"

Shah's research for the biography was far from easy. She was constrained by the lack of archival resources on Sarabhai, and her research was also hampered by not having the funds required for her travels. In spite of these impediments, Shah has fond memories of this phase of her life; it gave her an opportunity to revisit the fascination that she had with science as a school girl and also allowed her to study the histories of disciplines that Sarabhai contributed to, disciplines as diverse as physics, design, management studies and space technology.

Ahmedabad: A City in the World

During her many visits to Ahmedabad, both as a journalist and while researching for Sarabhai's book, Shah's interest in the city grew steadily, eventually leading to her writing *Ahmedabad: A City in the World*.

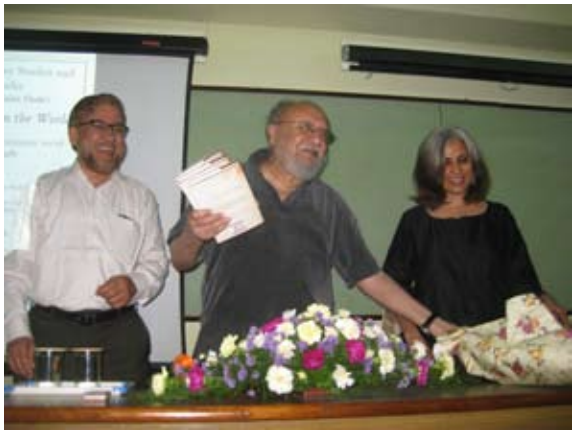


ROLLA DAS

***Ahmedabad: A City in the World*, Shah's most recent book, published by Bloomsbury**

Shah was more comfortably placed to do her research for this book than when she was writing about Sarabhai. She received a New India Fellowship and was also a Fulbright Fellow at the Institute for Public Knowledge, New York University, where she did most of her reading for the book.

The book offers a glimpse into a modern city and what the future holds for it through its people—accounts of their experiences and testimonies of their hopes, aspirations, vulnerabilities and choices. It also raises some uncomfortable questions about whether we are now re-defining our notion of well-being more in economic terms and whether glossy developmental agendas can mask the unresolved divide between communities.



BITASTA DAS

Well-known sociologist Ashis Nandy releasing *Ahmedabad: A City in the World* at CCS on 17 June 2015. Also seen are Amrita Shah and Raghavendra Gadagkar, Chairperson of CCS

Using anecdotes of people belonging to various castes, classes and religious communities, Shah captures the many contradictions the people of the city deal with—between aspirations and discriminations, between the mall city and the heritage city, and between public spaces and the 'new age' city. It presents the reader with an opportunity to see how the cultural ethos of a city and its people are intimately connected with seemingly disparate issues like aesthetics, economics and urban design.

After the communal violence of 2002, Ahmedabad and Gujarat came to be seen as heading in a separate direction from the rest of India which Shah believes was incorrect because the city, in fact, reflected trends that were national in scope.

Shah's next book, which she has started working on, follows the story of her great grandfather's journey to South Africa at the time of *Mahatma* Gandhi.

At IISc, besides pursuing her writing, Shah also teaches a two-part undergraduate course in journalism; the first part involves training in skills required to write stories and produce a publication, and the second deals with media history and issues of ethics, ownership and representation in a democracy.

A.PERUMAL: A BIRD'S EYE VIEW OF RESOURCES FOR SUSTAINABLE PLANNING

✍ **BHARTI DHARAPURAM**

BHARTI DHARAPURAM

The Department of Science and Technology (DST), Government of India established the **Sir Mokshagundam Visvesvaraya Geospatial Chair** at the Department of Civil Engineering in the Indian Institute of Science (IISc) to create awareness and encourage education and research in geospatial technology, a field that straddles the disciplines of Geographic Information Systems (GIS), Global Positioning Systems (GPS) and Remote Sensing, to provide insights into how we can better manage our natural resources.

A. Perumal, a researcher with several decades of experience in remote sensing and groundwater management, was the first professor to occupy the Chair in 2012. During his term, which he just completed, he conducted several awareness programmes and workshops explaining geospatial technology to high school students, undergraduates, university lecturers and state government officials. Working closely with the Karnataka State Council for Science and Technology (KSCST), he also spearheaded three socially-relevant research projects with the help of two Junior Research Fellows, Sharadhi SM and Ramyashree MK.

CONNECT caught up with Perumal to chat about his background, academic interests, research projects he undertook at IISc and his commitment to societal development through science as well as spirituality.

Biography

"Remote sensing was very remote back in those days," says Perumal of the early 1970s; the Americans had just launched the world's first earth observing satellite—Earth Resources Technology Satellite-1. A fresh postgraduate in Geology from Madras University, he found a job with the State Groundwater Department in Tamil Nadu. Perumal was initiated into remote sensing when his department got hold of satellite images under a United Nations Development Programme project.

This experience along with his background in aerial photo interpretation landed Perumal a job with the National Remote Sensing Agency (NRSA), now known as National Remote Sensing Center (NRSC, ISRO), where he worked for several years. While at NRSA, he did his PhD in remote sensing applications in groundwater assessment at Roorkee University. He was also involved with national-level projects like the Rajiv Gandhi National Drinking Water Mission and the Integrated Mission for Sustainable Development.

After his retirement, he taught at the Jawaharlal Nehru Technological University, Hyderabad, for a brief period and subsequently moved to the National Institute of Advance Studies (NIAS), Bangalore, where he was the Regional Coordinator for Global Water Partnership (South Asia). His next and final academic stint was at IISc.

"The idea of creating this Chair [by DST] was to popularize geospatial technology by various means—training, lectures, short courses with the option of doing research projects," Perumal explains. "I took up three research projects out of my own interest," he adds.

"The idea of creating this Chair [by DST] was to popularize geospatial technology"

Research Projects

Perumal's projects revolved around the use of GIS and remote sensing to monitor land-use changes and conduct groundwater assessments in order to advise civic authorities about how best to carry out developmental activities. These projects were carried out in the new IISc campus at Challakere in Chitradurga district, in the fast-drying Hesarghatta catchment area in North Bangalore and in the proposed solid-waste dumping sites around Bangalore city.

Water-Use Planning in Challakere

IISc, along with ISRO, DRDO and BARC, is developing its new campus in Challakere, a dry, hilly town in Karnataka. "IISc wanted the Challakere area to be studied. P Balaram [former Director, IISc] was very keen on it," Perumal says of the first project. His group carried out studies on land-use, geology and groundwater assessment, and identified specific locations for construction of check-dams and tanks to harvest rainwater efficiently. They have also made recommendations to improve water resources—including rejuvenating existing tanks and dug-wells, and planting trees along bunds. Perumal hopes these recommendations would be put to good use.

Courtesy: A. PERUMAL

Satellite image of new research campuses at Challakere; IISc's campus is highlighted with an arrow (Source: KSCST Report, 2014)

Hesarghatta's Disappearing Water Bodies

Created in 1896, Hesarghatta lake is a man-made reservoir on the Arkavathy river, a few kilometres northwest of Bangalore. It was conceived by K Seshadri Iyer, the then Dewan of the erstwhile Mysore state and constructed by the British to meet the drinking water needs of the city.

However, Arkavathy has seen low inflow in recent times and the reservoir has almost dried up. As part of his second project, Perumal studied the 750 sq. km Hesarghatta catchment area by mapping its topography, geology, surface hydrology, groundwater and rainfall patterns over the years using satellite data. He also carried out a time-series analysis of land-use changes over the last two decades using satellite images to understand the reasons for its collapse.

Perumal's study found that the land under human settlement has doubled since 1992, while plantation area has halved. During this period, water level in the reservoirs and tanks has shrunk drastically and the water-spread area in Hesarghatta lake now covers

Courtesy: A. PERUMAL

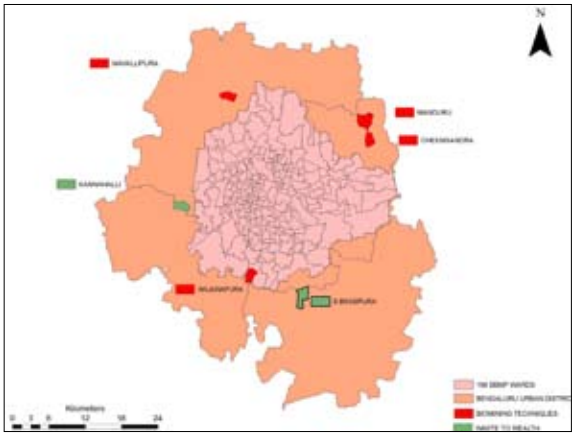
Land use changes in the Hesarghatta catchment area. Images from 1992, 2000 and 2014 (L to R). Blue indicates water-bodies, red represents area occupied by human habitation and industries, yellow corresponds to waste lands and dark green represents tree plantations (Source: KSCTS Report, 2014)

a mere 1.6 sq km. His group has identified a total of 197 water-holding tanks of various sizes in the catchment area, many of which have dried up due to poor inflow of water and encroachment. To make the situation worse, new borewells are sucking up groundwater faster than it can be replenished as the city is expanding northwards at an alarming pace, Perumal's study finds.

To deal with the looming water crisis, Perumal suggests creating feeder channels for rainwater run-off, increasing the green cover to contain soil erosion and revamping the few remaining water-holding structures. He elaborates on the importance of the many artificial tanks that Bangalore was once famous for. They helped retain rainwater and allowed it seep into the ground; excess water from the tanks was diverted to agricultural fields. Some tanks were also used as a source of drinking water, much like the temple tanks, or *kalyanis,* of the yore.

Assessing Suitability of Bangalore's Landfills

The recent agitation by residents in and around Mandur against dumping of garbage leading to unhygienic living conditions, contaminated drinking water and disease has brought the issue of waste disposal to the fore. Bangalore alone generates about 1500 tonnes of waste each day, which is diverted to landfill sites around the city. Using land-use maps, topographic and drainage models, and groundwater assessment, Perumal initiated a project to study the suitability of various landfill sites identified by the city's municipal corporation.



Courtesy: A. PERUMAL

Map showing landfill sites around Bangalore city. Different colours indicate proposed methods of waste processing at each site (Source: KSCST Report, in prep.)

Perumal classified landfill sites based on their proximity to water bodies, soil characteristics, cultivability, land forms, drainage patterns, and neighbourhood population size. His team also generated maps indicating the amount of solid waste generated in different wards of Bangalore. Though the project could not be completed in his term, Perumal says his study could potentially help design area-specific measures to contain waste. He emphasizes the importance of waste segregation at the source along with conversion of bio-waste to manure and energy as possible ways to deal with solid waste accumulation. He also warns that the careless disposal of medical waste by hospitals will be a huge issue in the years to come, requiring serious intervention.

Perumal believes that in order to solve environmental issues, it is also important to educate people about them. "Most people's concerns stop with their own lives while the problem builds in the background and catastrophe strikes when it reaches a breaking point. Unless society is sensitized about disturbances to the natural system and reparative measures are initiated at ground level, the problem cannot be solved. Unfortunately, our education system which should be inculcating these values in society is obsessed with marks and ranks rather than creating responsible citizens," he says.

Reaching Out

After handling several projects of national importance, the 67-year-old Perumal has finally hung up his work-shoes to spend time with family. However, he plans to continue practicing and teaching *Raja yoga* meditation which he has done for several years now. While in IISc, he conducted weekly meditation sessions for the Institute fraternity, classes which continue even after he left. He believes that meditation creates harmony within oneself, encourages self-awareness and also provides direction in our lives.

Perumal ends the conversation by quoting a Tamil adage: *Yānpetra inbam peruga ivvaiyagam* (May the world experience the joy I have experienced).

ASHIS NANDY: EMINENT POLITICAL PSYCHOLOGIST AND SOCIAL THEORIST

✍ KANTHI KRISHNAMURTHY

CONNECT

Ashis Nandy is a former Director of the Centre for the Study of Developing Societies (CSDS), New Delhi, where he currently serves as a Distinguished Fellow. He was recently at the Indian Institute of Science (IISc) when he spoke to CONNECT *on a wide range of subjects.*

On switching from medicine to the social sciences:

My family was full of well-established doctors and they were all hoping that I would join them in some form or other after getting my medical degree. They were constantly giving me sane advice. But I found all this terribly boring. Medical education too, at the time, was not particularly inspiring. If some imaginative person had seen the kind of things I was trying to do in other spheres of life, he or she might have advised me to specialize in psychiatry. But that did not happen. I survived as a misfit for three years and, then, to the chagrin of my family but with the support of my two doting aunts, switched to sociology and then to psychology. Such drastic changes do give you a different kind of psychological sensitivity and force you to look within and push you into early adulthood. At least from then onwards, I have remained interested in the complexity of human nature—what makes us what we are.

On his memories of the Partition and its impact:

I was nine when Partition violence began in Calcutta. For many years, I thought I had forgotten all about it, but the memories came back to me vividly when I saw the anti-Sikh pogrom. As I walked through the streets and slums of the affected communities, the spots of dried blood and the remnants of burnt living spaces brought back memories of the Partition.

My last empirical work has been on Partition violence. We have interviewed roughly 1500 people, perhaps the largest such study ever done. While others have written about Partition, I wanted to handle it from a slightly different angle; I wanted to study the resistance to such violence in ordinary people.

Partition violence survives in memory. It is everywhere, behind every diplomatic negotiation, behind every cross-country dialogue in the sub-continent. It is behind the work of many artists, novelists, poets and film-makers. Its memories inflect the fears and anxieties of a large cross-section of people who may never admit that. And I don't think we shall come out of it in the near future. However, the actual victims, we have found, are less bitter. Often they themselves said to us something like, "Yes, they were killing us, but we were also killing them." Their children and grandchildren are less forgiving. My suspicion is that the memories have been transmitted to the following generations in packaged forms, in the sense that they have been

re-organized around the cruelties and the suffering. They have hardened.

"Objectivity is at the heart of modern science and it has its place up to a point. But an over-emphasis on it can also lead to objectification of persons, nature and human collectivities"

On modern science:
I am a psychologist and have to scrutinize the psychological assumptions or demands underlying the axioms of many kinds of creative ventures. As for modern science, it makes two demands from *each individual scientist*. First, the practitioners of modern science must learn to draw a line between themselves and the subject they study. Second, they must also learn to divide themselves into two parts while doing science–to make sure that their cognitive self and cognitive skills are not affected by their emotions or passions. Both must be done for the sake of objectivity.

On the problems of modern science:
Such objectivity is at the heart of modern science and it has its place up to a point. But an over-emphasis on it can also lead, as we have seen in the last 150 years, to all-round objectification of persons, nature and human collectivities. I believe that we live in a world which has been shaped by this kind of objectification. The world's most successful genocide was that of the indigenous Americans—about 120 million were killed. Then the Atlantic slave trade thrived, in which one-third of the future slaves died during the Atlantic passage itself. Entire communities in Africa were destroyed, and in the Americas and in Europe, not only the slaves but the perpetrators and the societies profiting from slave trade too were brutalized. We also have the genocide of the Hereros and the Namas in Africa and, four decades later, of the Jews in Europe by the Germans. They brutalized and they de-civilized. This kind of mass annihilation is not possible without large scale dehumanization of the perpetrators and their ability to objectify human collectivities. If you go into our past, you will find similar instances of de-humanizing objectification.

During Nazi rule in Germany, its scientific establishment justified the killing of homosexuals, the mentally ill, and the epileptics. The near annihilation of Hereros and Namas in Africa and of the Jews of Europe was justified by social Darwinism and scientific theories of public hygiene. Likewise, Hiroshima was chosen for nuclear bombing though it had no military significance; the scientists insisted on it against the wishes of the military leaders because, as scientists, they wanted a pristine, untouched city so that they could correctly measure how much damage the new bomb could do. This is objectification at its purest.

On the scientific achievements of ancient India:
Yes, there were major achievements, but attempts to flaunt them as precursors of planes, antibiotics or plastic surgery is ludicrous. I am a great admirer of traditional sciences; I think they have much to offer to our corporatized medical system and to our heartless, ecologically devastated world.

If you are interested in traditional knowledge systems, you must take interest in the living traditions that are in continuity with traditions. You gain nothing by striking a stupid, defensive posture to please political bosses. It is like comparing Greek and Arab sciences with modern science and claiming that the mention of unicorns in Greek epics showed that the Greeks knew about genetic engineering and mention of magic carpet in Arab epics showed that Arabs knew of ecologically sustainable aviation technology.

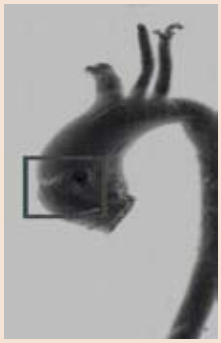
During this visit, I have also released a book on the work of RL Kumar, a young architect, who kept alive and used vernacular architectural traditions very creatively. I would rather spend five years of my life writing about such people than attempting to sell gullible fools the idea that the *pushpaka vimana* had anything to do with aviation technology or Ganesha's elephant head with plastic surgery. Such silly claims come from deep feelings of inferiority.

HOT OFF THE PRESS

Research highlights from the Indian Institute of Science (IISc)

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

BIOMEDICINE



Courtesy: BIOMECHANICS LAB

Strains on a swelling heart

An aortic aneurysm is the swelling or bulging of a section of the aorta, the artery that distributes oxygen from the heart to the rest of the body. This condition could eventually lead to a rupture called an aortic dissection. A group of scientists at the Department of Mechanical Engineering and the Centre for Nano Science and Engineering have found that aortic tissues, especially from patients who are less than 65 years old, have greater stiffness compared to healthy aortic tissues from a control group. This study is the first to report biomechanical statistics of aortic tissue for an Indian population. Today, it is recommended that those who have an ascending aorta of more than 55 mm undergo surgery. However, in many cases, tearing could happen even before this critical size is reached. Therefore, knowing the stiffness of the aortic tissue and its ability to withstand strain could assist doctors in making decisions about surgery.

Published in: *Journal of Biomechanical Engineering*
http://goo.gl/7ybo9E

AGRICULTURE

A low cost, low power soil moisture sensor

It is the moisture present in the soil that carries nutrients to a plant's roots. An easy to use soil moisture sensor is therefore an essential tool for farmers. Sensors currently being used, which estimate moisture content by measuring the soil's ability to store heat, are expensive and consume a lot of power. Researchers at the Department of Mechanical Engineering in collaboration with a team from IIT Bombay have developed a solar-powered soil moisture sensor that is inexpensive and can work continuously for three days. It can test different kinds of soils and accurately measure moisture content of up to 30%, which is above the saturation limit for most soils. The sensor is currently undergoing field trials.

Published in: *Sensors and Actuators A: Physical*
http://goo.gl/QX9F1k

TRAFFIC MANAGEMENT

A method to better manage traffic signals

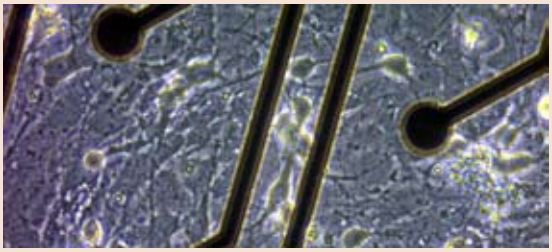
Researchers at the Department of Computer Science and Automation have proposed a new method to manage traffic lights which could reduce your waiting times at traffic signals. In this method, the lane with maximum number of vehicles will get the green signal first. At every junction, the lane that is prioritized is determined by the traffic congestion levels, obtained using traffic sensors. High-traffic lanes will stay green for a longer time while the low-traffic lanes will stay green for a shorter duration or can also be skipped. The various junctions thus organize themselves by talking to their neighbours, clearing congestion quicker.

Published in: *Conference Proceedings of the 7th International Conference on Communication Systems and Networks (COMSNETS), 2015*
http://goo.gl/wN9NW9

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

NEURO ROBOTICS

Teaching a plate of brain cells to control a robot



Courtesy: JUDE BABY GEORGE

A group of researchers at the Centre for Nano Science and Engineering have "taught" brain cells—taken from a rat and cultured on a glass plate covered with multiple electrodes—to navigate a robot through an arena while avoiding obstacles. A moving robot wirelessly relays information about obstacles in its path from its light sensors back to the plate. The information received by the plate is converted into a specialized stimulation sequence. The brain cells respond to this sequence by generating their own electrical activity. A software analyzes this activity and maps it to appropriate commands for the robot that allow it to avoid obstacles while moving. Such experiments take us closer to understanding how the neuronal system works and to potentially building computing systems with "wetware" working synergistically with hardware and software.

Presented at: *The 28th International Conference on VLSI Design and Embedded Systems, 2015*
http://goo.gl/lXJ9TC

NANOSENSORS

A superior hydrogen gas sensor

Hydrogen gas is readily combustible and therefore its detection is important. A research group at the Centre for Nano Science and Engineering has designed a hydrogen gas sensor that is superior to ones presently used in many ways: it can be deployed at room temperature, is a hundred times more sensitive, is power efficient, and can be designed to run on solar or wind energy. It can generate an alert within a second (conventional ones take 15 minutes) and is at least 50 times more cost effective. It consists of a rod of platinum 10 nm thick placed inside a platinum oxide shell in the shape of a cylinder. This structure is suspended in air on top of a silicon wafer. Hydrogen gas reacts with oxygen adsorbed on top of the sensor surface and results in an electrical current which can be detected. By using different material combinations for metal core and semiconductor shell, the design can be extended to sense low levels of other gases such as hydrogen sulphide.

Published in: *Journal of Applied Physics*
http://goo.gl/w03Pwe

COMPUTATIONAL DIAGNOSTICS

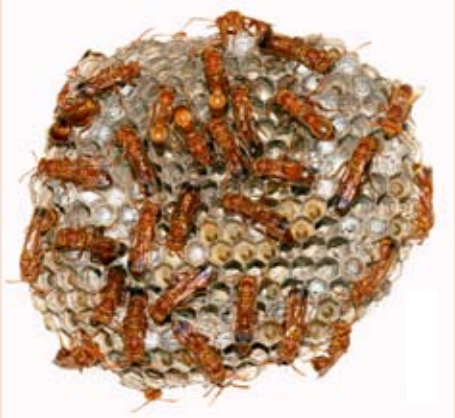
Virtual reality machines to train endoscopists better

To look inside the human body, doctors use an endoscope—a flexible pipe with a camera at the tip—which, after being inserted through the mouth, beams back images of the inner walls of the gastrointestinal tracts. But ensuring that the endoscope goes through the esophagus and not the larynx is a crucial and challenging task. Using computational data, researchers from the Department of Mechanical Engineering have developed an endoscope simulator which is superior to those that are commercially available. They calculated the forces exerted on the endoscope by various parts of the gastrointestinal tract and recreated those forces in a haptic device that simulates an endoscopic procedure. Now, trainee endoscopists can practice with this new tool until they develop the necessary instincts required to perform this procedure. The tool can also simulate the effect of the endoscope entering the throat.

Presented at: *The TrC-IFToMM Symposium on Theory of Machines and Mechanisms, Izmir, Turkey, June 2015*
http://goo.gl/1DAxcn

ANIMAL BEHAVIOUR

"Flying back home" paper wasps amaze researchers



SOUVIK MANDAL

The paper wasp *Ropalidia marginata*, only about 1.5 cm long, is able to return to its nest from distances of up to 1.5 km, researchers at the Centre for Ecological Sciences have found. This is the equivalent of humans finding their way back home from a distance of 170 km. The researchers discovered this when they carried out an experiment that involved releasing wasps systematically at 100 m intervals from their nests. The investigation was carried out in and around the campus of IISc. Such studies had previously been done for bees and ants, but not for wasps which differ in their food preferences and in their foraging pattern. Being able to find their way back from such distances is remarkable for a tropical species because tropics typically have abundant food resources. The researchers now plan to investigate the strategies the wasps use to accomplish this feat.

Published in: *Journal of Comparative Physiology*
http://goo.gl/oOBTVz

TOXICOLOGY

A sleep-inducing compound from snail venom

Conus araneosus is a rarely-studied marine cone snail endemic to the southeastern coast of India and Sri Lanka. Researchers at the Molecular Biophysics Unit have identified 14 different peptides—small proteins—in its venom, five of which were then injected into mice as pure solutions in saline. One of the peptides, dubbed *ar3j*, made them fall asleep within four minutes of being injected; and they remained asleep for about two hours. The period of sleep induced was found to vary with the dosage. The researchers now aim to understand why and how the peptide induces sleep in mice and whether it can be developed into a therapeutic drug for treatment of sleep disorders such as insomnia and sleep apnoea. Already, there are several drugs obtained from *Conus* toxins that are either in use or in clinical trials as non-addictive painkillers in cancer and neuroscience research.

Published in: *Toxicon*
http://goo.gl/pgy4H8

ASTROPHYSICS

Interstellar gas helps galactic spiral arms survive longer

The spiral arms in galaxies like our own Milky Way do not last for the lifetime of the galaxy. Since the 1960s, astrophysicists have believed that they last for only about a billion years. Researchers at the Department of Physics who had earlier shown that the interstellar gas present in any spiral galaxy profoundly influences the structure and motion of the galactic disk, have now found that it also allows the spiral pattern to survive longer than previously thought, even for several billion years. This is because the gas reduces the time for the propagation of waves. The study also showed that interstellar gas is essential to account for the observed speed of the spiral arms of the Milky Way Galaxy. They are now investigating if this is true for other galaxies.

Published in: *Monthly Notices of the Royal Astronomical Society*
http://goo.gl/XB5mzs

RAISING ISSUES OF CONCERN

✍ RAGHUNATH JOSHI*

A student organization in the Indian Institute of Science (IISc), comprising a small, but dedicated group of members, highlights and debates pressing socio-economic and political issues

Scientists too are part of the social milieu and stakeholders in the socio-economic and political issues confronting us. Science is not done in vacuum and the socio-economic context in which scientists pursue their research influences both the nature of questions they ask as well as how they address them. In order to facilitate an awareness of that socio-economic context, a student organization called *Concern* has taken it upon itself to sensitize the scientific community at IISc about the larger issues affecting our society.

Activities

Concern organizes lectures, panel discussions and documentary screenings in the Institute on several human and civil rights issues such as the plight of Sri Lankan Tamils and Palestinian refugees, women's rights, LGBT rights, custodial torture, Dalit rights, right to education, food security, tribal rights, rights of displaced families, right to privacy and the free software culture. In 2012, *Concern* co-organized a conference on *The Political economy of India and Development* with the Centre for Contemporary Studies. It has, over the years, brought many notable activists, academics and artists to IISc, providing the campus community with an opportunity to interact with them.

Concern also strives to popularize science and scientific temper among the public by inviting scientists and rationalists to speak on various issues. The last talk organized by this group before this article went to press was by R Ramanujam, a professor of computer science at the Institute of Mathematical Sciences, Chennai, who spoke about his experiences in popularizing science among school children in Tamil Nadu. The group also works closely with the IISc chapter of the Bharat Gyan Vigyan Samithi.

Concern has been active on campus in other ways too. A former convenor of the group, Sarita Dhawan, helped in founding the Women's Cell in the Institute's Students' Council. When a policy of privatization of messes was being considered, *Concern* protested against the move because it believed that this would endanger the employment of mess workers.

Members of *Concern* have reached out to the larger community outside IISc as well. They have studied, among other issues, the living conditions of labourers hired to build the metro rail in Bangalore and the working conditions in a school operated by the Kolar Gold Field which was facing closure. In addition, it raised funds for those affected by the Bengal cyclone in 2013 and for evicted poor families from a slum in Ejipura in Bangalore.

Besides organizing its regular activities, *Concern* has always tried to reach out to the Institute community in other ways—from putting up hand-written A4 sheets of paper (in the pre-internet era) to A3 posters on the notice boards to raise awareness on

COURTESY: CONCERN

Some of the speakers invited by Concern to IISc (L to R) : Journalist P Sainath, social activist Medha Patkar, free software & internet privacy activist Eben Moglen, historian Romila Thapar, human rights activist Binayak Sen and film maker & activist Anand Patwardhan

Courtesy: CONCERN

"Concern is an exception to the view that science and technology students are distant from the socio-economic realities of the country."

- Vijoo Krishnan, All India Kisan Sabha

various important issues. It has recently launched a newsletter called *Issues of Concern* to discuss relevant and contemporary socio-economic themes.

Apart from students, faculty members too have taken an active part in the events hosted by *Concern*. Among others, the late Sanjoy Kumar Biswas (former Professor, Department of Mechanical Engineering) and DP Sengupta, currently a Visiting Professor at the National Institute of Advanced Studies (NIAS), helped organize protest meetings against the Pokhran nuclear testing in 2000 and the attempt to introduce Vedic Astrology as a science subject by the UGC. Prabhu Nott, a professor in the Department of Chemical Engineering chaired a panel discussion after the screening of a documentary *Jai Bhim Comrade,* a documentary about violence against Dalits by noted film-maker Anand Patwardhan.

Origins and Growth

In 1995, a few students from the Institute—Arvind, Sreekumar, Parthasarathi, Sunil, Pinaki and Dhiman—came together to raise and discuss critical contemporary social issues under a group they named *Concern*. They were soon joined by Kavita Durai and Venkatachalam Suri.

Over the years, it has become an active and independent student organization which brings together people with progressive ideas in the Institute community under one umbrella. The organization prides itself on being self-funded and democratic in its functioning.

Courtesy: CONCERN

A poster for one of the many talks organized by *Concern*

Courtesy: CONCERN

Dhiman and Arvind, alumni of IISc, were among the founder members of Concern. They are now faculty at IIT Madras and IISER Mohali respectively

Concern is more than just a student body for its members. "It has been a moving experience to listen to the real stories of people from different walks of life such as Kashmiri farmers who came all the way to Bangalore to earn a living working at Bangalore's many construction sites," one current member of *Concern* told CONNECT.

Response

In 2012, when *Ram Ke Naam*—a documentary on the demolition of Babri Masjid—was being screened, some students disagreed with its content and wanted to stop its screening. Eventually, they were persuaded to let the event continue. However, such incidents have been few and far between.

Members of *Concern* feel that the response from the Institute community has been very enthusiastic. They also believe that the Institute's administration has been supportive of their activities and generous in providing venues for its events in the spirit of cultivating free speech.

Concern, now in its 21st year of existence, hopes to increase its visibility by having more activities and to expand the scope and reach of its newsletter.

* Raghunath Joshi is a member *of Concern*

MORE THAN JUST A COMPUTING CENTRE

Besides serving as the hub for computational facilities at the Indian Institute of Science (IISc), the Supercomputer Education and Research Centre (SERC) also imparts education and carries out its own research

✍ **KARTHIK RAMASWAMY**

"Even though the facilities we manage are significantly large, it should not undermine our emphasis on research and education," says R Govindarajan, the Chair of SERC, underlining the dual role played by this unique centre in India. SERC, renamed in 1990, began as the Computer Centre back in 1970. Today, besides providing state-of-the-art computing facilities to faculty members and students in the Institute, the Centre also carries out its own research and offers Master's and PhD programmes.

Metamorphosis

"It was the vision of Prof. V Rajaraman and Prof. N Balakrishnan that education and research should be integral to SERC," Govindarajan adds. Rajaraman, a pioneer of computing in India, was invited in the early 1980s from IIT Kanpur to head the Computer Centre at IISc. He steered the transformation of this Centre into its current avatar along with Balakrishnan. Under the chairmanship of Balakrishnan, who succeeded Rajaraman, the Centre rose to the level of a leading supercomputing facility and was dedicated to the nation.

Balakrishnan says that the expansion of the Computer Centre and its transformation into an academic department received whole-hearted support and encouragement from S Ramaseshan, the Director of IISc from 1981 to 1984, and then from CNR Rao, who headed the Institute from 1984 to 1994.

Blessing in Disguise

Among the first initiatives that Rajaraman and his team undertook was to acquire a supercomputer. After visits to several high-performance computing centres in the UK and US, a specially

appointed committee that included Rajaraman and Balakrishnan decided on a Cray Y-MP. However, export restrictions imposed by the US government—still fighting the Cold War—prevented the transfer of this machine.

V Rajaraman, the founding Chair of SERC

Reflecting on this inauspicious start in its efforts to reinvent the Computer Centre, both Rajaraman and Balakrishnan believe that this was a "blessing in disguise." With the same money, the Centre was now able to put in place a set of distributed computing systems. This included a high-end mainframe computer from IBM, a large number of workstations, graphics machines and several mini-computers. And for the first time in the country, a campus-wide fibre optic network was also established. Govindarajan believes that the functionally distributed supercomputing setup, introduced at that time, helped the Centre retain its edge in supercomputing, despite the fast obsolescence of computer systems.

Facilities

Over the years, SERC has had several supercomputers. A supercomputer is any machine that has a set of processors that are connected together, says Govindarajan. But he is quick to add that what is considered a supercomputer today will not have the same tag a few years down the line. "I always define them as the few fastest systems in operation today," he explains.

In the last few decades, as parallel processing speeds have grown exponentially following Moore's predictions, SERC's computing facilities too have been constantly upgraded. Its latest acquisition is a Cray XC40, India's fastest supercomputer (see box). "We want to ensure that the best technology is available to our users," says Govindarajan. SERC also procures and manages licences for software—both generic and specialized—for the Institute's researchers.

The role of SERC as a central computational facility—used by researchers cutting across various disciplines—is articulated by J Lakshmi, a principal research scientist at the Centre. "Large-scale systems are complex and expensive. Individual departments cannot manage and maintain these systems. In addition to skilled system administrators, you also need a good, reliable infrastructure that includes uninterrupted power supply with backup and cooling. So it makes sense to have a central facility," she says.

Education

Besides offering PhD and research-based Master's programmes, SERC also has an M.Tech programme in Computational Science. Govindarajan is keen to emphasize that this M.Tech is different from traditional computer science programmes. "The programme focuses on helping students—who come from different disciplines in science and

R Govindarajan

engineering—use computers effectively to solve large problems in their fields," he clarifies. Besides courses in programming, numerical methods etc., students also take courses in their fields of specialization. The two-year programme culminates with a domain-specific dissertation project which is computational in nature.

Research

Sathish Vadhiyar, an associate professor at SERC, works in high performance computing systems. His research interests include building middleware and runtime systems. Middleware is the interface between the user and the system. The supercomputers at SERC have multiple users who submit their tasks for execution; this leads to job queues. Vadhiyar builds middleware that predicts queue waiting times and also advices users on the most optimal strategy to use to reduce the total response time (the sum of queue waiting time and execution time). His other area of research in runtime systems seeks to speed up specific scientific applications—for example, climate modelling—using state-of-the-art accelerators.

Vadhiyar is among the more than 20 faculty members at SERC who carry out research in two broad areas of computing: *Computational Science* and *Computer Systems*. "In the area of Computational Science, which deals with computational methods and their applications to other areas of research, we have faculty members who work on fields as diverse as medical image processing, computational photonics, and bioinformatics. In Computer Systems, we have research that focuses on computer architecture, high-performance computing systems, cloud visualization and the like. We also have faculty who work on database systems, information systems and video analytics," says Govindarajan, speaking about the breadth of research carried out by SERC's faculty members.

Among SERC's many research projects is the Digital Library of India (DLI)—one of Balakrishnan's initiatives. It is a digital collection of books, many of them rare, from various libraries in India. DLI, hosted at SERC, aims to archive all significant works—in different fields of human endeavor including science and literature—and make them freely available on the internet. "About 144,000 pages are downloaded every day," says a delighted Balakrishnan, highlighting the success of the initiative.

N Balakrishnan

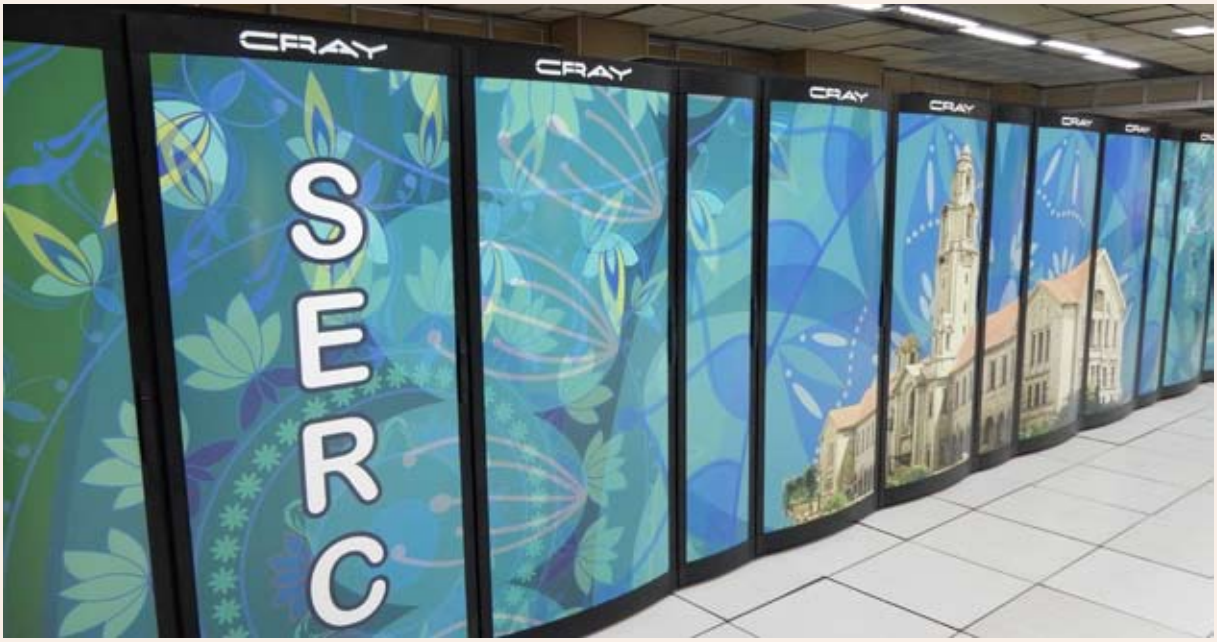
The research efforts of Jayant Haritsa, a professor at SERC, has also drawn attention—it has resulted in copyrighted software, widely downloaded and used in both academia and research.

National Supercomputing Mission

The Government of India only recently approved the National Supercomputing Mission (NSM). The Mission, said to cost Rs 4,500 crores, will establish a few dozen supercomputing systems in academic and R&D institutions across the country. IISc and the Centre for Development of Advanced Computing (C-DAC) will be the two major implementing agencies for this Mission that seeks to take supercomputing to different parts of India.

Besides being a nodal agency for this project, IISc has played a crucial role in conceiving NSM. Balakrishnan, who has piloted the Mission since its inception and will be leading its activities nation-wide, says that IISc was approached by the Government to take a lead in NSM because of its many years of experience in supercomputing and networking.

sahasrat: India's First Petascale System



Some stars die dramatically in massive explosions called supernovae. Prateek Sharma, an astrophysicist from the Department of Physics, is interested in how multiple supernovae going off in a small volume—sometimes almost simultaneously—affects the interstellar medium around it (and how the medium in turn influences the birth of new stars). To understand this phenomenon, he runs complex simulations by exploding virtual stars in a patch of interstellar medium on IISc's newest supercomputer—a Cray XC40 christened *Sahasrat*.

"It is no ordinary machine," says Balakrishnan about *Sahasrat*, India's fastest supercomputer. The speed of a supercomputer is measured as the number of floating-point operations it performs per second (or just FLOPS). *Sahasrat* has a peak performance of 1,320 TeraFLOPS ($1,320 \times 10^{12}$ FLOPS)—hence the name *Sahasrat*—and a sustained performance of over 900 TeraFLOPS.

Not surprisingly, *Sahasrat*'s architecture is complex and its design, intricate. Its basic unit is a replaceable blade; each blade is made up of four nodes; each node in turn has 24 cores; 16 such blades are assembled on a chassis; three chassis units comprise a rack, of which there are 8. In all, this workhorse has 33,000 cores. "Each node can have its own software and operating system. In that sense, each node is an independent computing system," Lakshmi explains.

Sahasrat has Intel's Haswell processors at its heart, delivering its computing power. Another crucial factor that influences its performance is how the different nodes in the machine "talk" to each other—called network topology. *Sahasrat* has a topology named Dragonfly with an Aries Network-on-Chip (NoC). But the hardware alone does not determine a supercomputer's performance; it also needs the appropriate software environment to exploit its architecture. *Sahasrat* comes with a specialized, complete Cray software stack. With one eye on the future, SERC has also ensured that *Sahasrat* has two accelerator-based cluster systems—one having graphics processing units and the other having Intel's Many Integrated Cores (MIC).

Though it was installed only a few months ago, *Sahasrat* has a utilization of more than 80%. According to Govindarajan, at least three research groups on campus have been able to utilize the capabilities of the machine as a large High Performance Computing (HPC) system. "It has been very well received," an understated Lakshmi adds with a smile.

HELLO!

Faculty members who have joined the Indian Institute of Science (IISc) recently tell us about themselves

MRINMOY DE (Assistant Professor, Department of Organic Chemistry)

Mrinmoy De hails from Tamluk in West Bengal. He did his PhD from the University of Massachusetts (Amherst), USA, where he worked on engineering the nanoparticle surface by ligand fabrication; this is used for protein recognition and biological applications such as protein folding and sensing. His postdoctoral work was on theranostics (a combination of therapy and diagnostics) application of magnetic nanomaterials in Alzheimer's disease at the Northwestern University, USA. His current research interests include the development of supramolecular chemistry using 2D material platforms.

Take Five with Mrinmoy

- **My idea of a developed nation is...** a nation free of corruption.
- **If I was the Director of IISc for a day I would....** I am not sure what I could do in a single(!) day.
- **My favourite dessert is...** cheesecake.
- **The four things I always carry when I leave home are...** purse, phone, key and a plan.
- **Given a choice, I would always travel in...** my own car.

CHANDRAMANI KISHORE SINGH (Assistant Professor, Department of Electronic Systems Engineering)

Chandramani Singh grew up in Bharthui Garh, a village in Siwan district of Bihar. He has a PhD from IISc for his work on resource management in cellular and mobile opportunistic networks. He did his postdoctoral work on fair and efficient medium access in ad hoc networks jointly with TREC (a joint research team of INRIA Rocquencourt and ENS de Paris in France) and University of Illinois, USA. His current research interests include modeling and analysis of communication networks using control, optimization and game-theoretic techniques.

Take five with Chandramani

- **My favourite sportsperson is...** Sachin Tendulkar.
- **What I dislike about science is...** nothing, but I often don't like the way science is presented or taught, which is undoubtedly an art.
- **If I had a pet, it would be...** not fond of pets, but in case I have to have one, it would be a kitten or puppy.
- **My idea of leadership is...** capability to translate vision into reality.
- **My morning beverage of choice is...** green tea.

Courtesy: VIJAY SETHURAMAN

VIJAY A SETHURAMAN (Assistant Professor, Department of Materials Engineering)

An electrochemical engineer by training, Vijay Sethuram graduated from the Central Electrochemical Research Institute, Karaikudi. He has a PhD in chemical engineering from the University of South Carolina, USA, and completed his postdoctoral work from the Lawrence Berkeley National Laboratory, USA. He worked at the School of Engineering at Brown University for four years before joining IISc in 2014, where he is in the process of setting up facilities to fabricate and test lithium-ion batteries.

Take five with Vijay

- **An activity that gives me an adrenaline rush is...** driving in Bangalore traffic!
- **A movie that made me cry was…** *Life Is Beautiful*.
- **If there's one thing I'd like to change about my past, it would be...** nothing (If I did, I wouldn't be here in IISc).
- **If I could have one superpower, it would be...** to make food appear instantly (I spend too much time cooking these days)!
- **My favourite sport is…** soccer.

Courtesy: HIMANSHU TYAGI

HIMANSHU TYAGI (Assistant Professor, Department of Electrical Communication Engineering)

Himanshu Tyagi grew up in Delhi and pursued a dual degree in Electrical Engineering from IIT Delhi. He received a PhD in Electrical and Computer Engineering from the University of Maryland, USA, and completed his postdoctoral work at the Information Theory and Applications Center at the University of California (San Diego), USA. At present, his research interests lie in the application of information theory in communication, computer science, statistical learning and control.

Take five with Himanshu

- **The strangest thing I have ever eaten is...** not sure; I could only bite a part of it before it left my mouth.
- **The social cause I most care about...** it keeps changing; most mornings I am very concerned about the convergence issues in running gradient descent on Bangalore roads.
- **The fictional character I most wish to be...** depends on the book I am reading; these days it is Lord Henry Wotton.
- **In school I was...** comfortable answering the question below.
- **My favourite colour is...** is this question still around?

Courtesy: PARIMAL PARAG

PARIMAL PARAG (Assistant Professor, Department of Electrical Communication Engineering)

Parimal Parag hails from Munger in Bihar. He received his B. Tech and M. Tech degrees from IIT Madras. After his PhD from Texas A&M University, he worked as a senior systems engineer at ASSIA Inc. Parag's research focuses on network theory, applied probability, optimization methods, and in their applications to distributed systems; he is also interested in the areas of applied statistics, game theory, queueing theory, information theory, and combinatorics.

Take five with Parimal

- **The last book I read was...** *Pro Git*.
- **My favorite TV show of all time is...** *Breaking Bad*.
- **A piece of advice I give my students is...**to follow your passion.
- **What I find most satisfying about research is...** intellectual freedom.
- **A hobby that I would like to pick up is...** sailing.

Courtesy: SRIDHARAN DEVARAJAN

SRIDHARAN DEVARAJAN (Assistant Professor, Centre for Neuroscience)

Sridharan Devarajan grew up in Chennai and obtained his Bachelor's and Master's degrees in Engineering from IIT Madras. He then moved to Stanford University, where he completed his PhD and postdoctoral work in neuroscience. His research now focuses on understanding how cognitive phenomena, such as attention and decision-making, emerge from elementary neural computations in the human brain. His work combines neuroimaging (fMRI, dMRI, EEG) and neurostimulation (tMS, tES) technologies and seeks to identify key theoretical and computational principles by which neural processes of the brain shape behavior.

Take five with Sridharan

- **My favourite day of the week is...** any day without deadlines.
- **One thing I would like to change about myself is...** to learn to accept myself as I am.
- **Science to me means...** burning curiosity tempered by integrity.
- **My idea of a perfect holiday is…** taking leave of my senses (a.k.a. meditation).
- **My favourite season is...** (f)estival.

✍ Compiled by **MANU RAJAN** and **IPSITA HERLEKAR**

A GIANT LEAP FOR BRAIN RESEARCH IN INDIA

✍ MEGHA PRAKASH

*Back in 2014, Senapathy Gopalakrishnan, better known as **Kris Gopalakrishnan**, former Executive Vice Chairman, Infosys, announced a grant of Rs. 225 crores from Pratiksha Trust, a charitable organization he co-founded with his wife Sudha Gopalakrishnan, towards the setting up of the **Centre for Brain Research (CBR)** in collaboration with the Indian Institute of Science (IISc). He recently spoke to* CONNECT *about what motivated his benefaction, his vision for CBR and more.*

Courtesy: INFOSYS SCIENCE FOUNDATION

Q When and how did you get interested in neuroscience? And what motivated you to fund research at IISc?

I got interested in understanding the brain a few years ago. I always used to read about the latest research on it. I got even more interested when I started reading about plasticity of the human brain. I also knew people who had Parkinson's, Alzheimer's etc.

A few years back, I also used to support the Parkinson's Research Foundation in Bangalore. And after I retired, my interest and personal experiences prompted me to think big—to look at establishing a research facility on ageing and on some of the diseases related to ageing like Parkinson's, dementia, Alzheimer's etc. IISc also showed some interest and the former Director, Professor P Balaram asked me if this can be jointly done with IISc. I immediately agreed. This is how the Centre for Brain Research came about.

Q Could you tell us about the Chairs in neurocomputing that you have instituted at IISc?

In order to understand the brain, you need to look at how it performs as a computer—a human computer. It's one of nature's most complex creations. Of course, we humans ourselves are complex creations, but the brain is the last frontier for us to understand and decipher. So clearly this—how the brain functions as a complex computer—is something which I thought would be interesting to study here in India. I also saw that there were various initiatives in Europe and the US to study the brain in the last few years. Globally there is an effort to understand the brain better. An important benefit of understanding the brain is of course that we can better understand disorders associated with the brain. And perhaps even find cures. Another benefit of this effort will be that better models of computing will be developed and computer science itself will advance further.

The initial years of computing focussed primarily on numerical computing and we've created a machine that's far, far superior to human beings in numerical processing. It can process billions of arithmetic operations in a second and we've been able to achieve that now. But some of the new and interesting challenges are in the areas of information processing, machine intelligence, etc. Hence I felt that this is an appropriate time to launch this initiative here in India. I got support again from IISc and also from Indian Institute of Technology (IIT) Madras; I instituted three chairs each at IISc and IIT Madras. Four of these chairs have already been filled and a significant amount of work has been started in these two places.

Q What is the vision you have for CBR?

CBR will be focused on clinical research. More specifically, it will focus on ageing and age related disorders like Parkinson's, Dementia and Alzheimer's. Hopefully, the Centre, once it is in full swing, will help us understand these diseases better; help slow it down or maybe even find a cure for some or all of them. So that is the vision for CBR.

"CBR will be focused on clinical research. More specifically, it will focus on ageing and age-related disorders like Parkinson's, Dementia and Alzheimer's"

CBR will work collaboratively with other institutes across India and other parts of the world so that we can together achieve our goal of furthering computational brain research—to create better models of computing and to create new solutions for information processing. In the near future, with the internet of things, we are going to have a large number of sensors deployed everywhere that will give us real-time information about anything that we want to measure. That may be an opportunity

Courtesy: PUBLIC RELATIONS OFFICE

The Prime Minister Narendra Modi inaugurating the Centre for Brain Research during his visit to IISc on 18 February, 2015

to again model the brain and understand how the brain makes decisions and to use it to create better appliances and devices. A good example of this is the self-driving car. It is done using artificial intelligence to mimic how a human driver would navigate and drive. And we will be creating many such self-managed systems and this is an exciting area of what could happen in the future in computer science.

Q Can you tell us more about the Pratiksha Trust and its activities?

Pratiksha Trust is a family trust set up by my wife, myself and our daughter. It is involved in philanthropic and charitable activities in the areas of education and research. We provide scholarships to deserving students who want to go for higher studies. We support old people through a pension scheme. We support some educational institutions across the country and of course, we are now into two areas of research which have become part of the core activities of Pratiksha.

"It (Pratiksha Trust) is involved in philanthropic and charitable activities in the areas of education and research"

Q Besides computer science and neuroscience, what other subjects interest you?

Definitely physics is an area of interest. I studied physics during my postgraduate and undergraduate years in college. I am also an avid reader. I try and read a few articles on science on a periodic basis to keep myself updated on what is happening.

Q What keeps you motivated?

You've got to be curious about the things around you. There are lots and lots of things that are still not known; there are still exciting things that need to be understood better. One of my main motivations is curiosity and trying to learn new things and understand things better. Secondly, I have been very lucky and I feel the need to give back to society—to people who want to come up in life, who want to create something new, who deserve to be supported. The activity has to be limited by what my Trust can do. It is not a big trust; so whatever we can support, we will. And the third is the excitement of what's coming.

"You've got to be curious about the things around you. There are lots and lots of things that are still not known; there are still exciting things that need to be understood better"

Q Any message to young students?

If you are in college today, if you are looking at the future, I think it looks extremely bright; it is very exciting. I believe that the next 30 years are going to be even more exciting and innovative than the last 30 years. It is going to be a period of amazing innovation, especially in the field of computer science. This means that students who are passing out today have the opportunity to be part of this journey to create a better, brighter future.

"It is going to be a period of amazing innovation, especially in the field of computer science"

Q What do you do for leisure?

Technology interests me. I like to play with technology. I like to buy and use new gadgets. I feel that constant playing with new gadgets helps me to be sharp and to be up to date with what is happening in the world around, especially in computer science. Reading is another passion. I read different types of books—fiction, science, and some management books. I am currently reading *Super Brain* by Rudolf (Rudy) Tanzi and Deepak Chopra.

CAMPUS CHRONICLES

Recent events from the Indian Institute of Science (IISc)

ECOLOGY IN SPACE AND TIME

The Centre for Ecological Sciences (CES) organized **Ecology in Space and Time**, an international conference from 8-10 April, 2015 at IISc aimed at fostering exchange of diverse views on various conservation issues and the latest techniques employed in research in ecology and climate change.

The conference dealt with topics as diverse as forest ecology, biodiversity, climate change, paleoclimate, human-wildlife conflict and conservation research, besides issues related to policy and its implementation.

Apart from talks by renowned experts like Madhav Gadgil, Ramachandra Guha, Raghavendra Gadagkar, R Sukumar, Ullas Karanth, and international scientists like Peter Ashton, Stephen Hubbell, Stuart Davies, the contributions made by R Sukumar (Professor, Centre for Ecological Sciences and popularly known as the "Elephant Man of Asia") were traced to mark his 60th birthday, which coincided with this event. The conference also witnessed a panel discussion on the future of wildlife conservation in India.

The conference concluded with a two-day field trip to Mudumalai Tiger Reserve, located in a tropical forest, which gave the students ample opportunity to interact with the speakers, many of them legends in their fields and pioneers of long term conservation research.

Courtesy: EST CONFERENCE

R Sukumar whose contributions to research were also honoured during the meet

✍ **ANANYA JANA**

FRONTIERS IN ADVANCED MATERIALS 2015

Frontiers in Advanced Materials (FAM) was jointly organized by the Solid State and Structural Chemistry Unit (SSCU), IISc, and the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) from 15-18 June, 2015. The conference sought to bring together researchers working in three areas of research: experimental studies on correlated electron systems, nano-science and various theoretical methods.

In his inaugural talk, CNR Rao (Linus Pauling Professor, JNCASR) spoke about the advantages of aliovalent anion substitution (having oxidation states different from parent atoms) on electronic structures and properties of metal oxides and sulphides. Stuart Parkin (IBM Research Centre) talked about the effects of ion currents in oxide thin films which he called cognitive devices. TV Ramakrishnan (Professor, Benaras Hindu University) and Indra Dasgupta (Professor, IACS Kolkata) presented their results on high temperature superconductivity. PS

Courtesy: FAM 2015

DD Sarma was felicitated during the conference

Anil Kumar (Associate Professor, IISc) spoke about magnetic oxide semiconductors and spintronics. Umesh V Waghmare (Professor, JNCASR) discussed multi-scale hyperelastic simulations.

Speaking to CONNECT, S Ramasesha (Professor, SSCU), one of the organizers of conference, said, "The meeting was attended by the leading researchers in the area of advanced electronic materials."

The conference also felicitated DD Sarma (Professor, SSCU) for his contributions to the field, and to celebrate his 60th birthday.

✍ **CHAITANYA JOSHI & SUBHAM MRIDHA**

THE GLOBAL ALUMNI CONFERENCE 2015

Memories of being in IISc were still fresh as the green grass on its campus in the minds of many of the alumni who got together to be part of the third edition of the Global Alumni Conference, organized by the Alumni Association of the Institute from 26-28 June, 2015.

This edition had added emotional value because this was the first time the mega event was held in IISc. The idea of having IISc as the venue was to give a chance to all its alumni to revisit its alma mater and stay on campus for a few days, N Balakrishnan (former Associate Director, IISc, and one of the members of the organizing committee), told CONNECT.

For Krishnamachar Sreenivasan, who graduated in Mechanical Engineering in 1958, it was an opportunity to meet the younger generation of scientists. He said that the conference also facilitated the exchange of ideas.

While the conference did serve as the platform for a nostalgic reunion, it was organized to showcase the contributions made by IISc in various areas of science, the role played by the Institute in promoting science in our society and also to reflect on its growth over the years.

In his address, Anurag Kumar (Director, IISc), highlighted some of the recent research breakthroughs and technologies developed by the Institute's researchers in diverse disciplines. He also outlined the Institute's plans to realize its goal of being counted "among the world's foremost academic institutions". To achieve this goal, he said, IISc would be developing state-of-the-art infrastructure and connectivity on the campus, strengthening relations with alumni and increasing international collaborations.

Courtesy: IIScAA

S Ranganathan (Emeritus Professor, Department of Materials Engineering and IISc alumnus) during the conference

Homecoming for Notable Alumni

Sudha Murthy (Infosys Foundation) and Roddam Narasimha (former Director, National Aerospace Laboratories), both alumni of IISc, shared their experiences as students. Some of the key speakers including AS Kiran Kumar (ISRO), Bhujanga Rao (DRDO), Baldev Raj (former Director, Indira Gandhi Centre for Atomic Research) and Kota Harinarayana (former Chief, Light Combat Aircraft Programme), all accomplished in their fields of research, highlighted the pivotal role the Institute has played in establishing the country's strategic sectors like defence, space and nuclear energy.

CNR Rao (former Director, IISc), who was also felicitated during the conference, joked about how he had caught the virus of science on his first visit to IISc as a school boy, when he was shown around the laboratories by the legendary Sir CV Raman himself. "My life has been intimately connected with the Institute," he said, reminiscing about his long association with the Institute and its people, including the likes of Satish Dhawan (also a former Director of IISc) and JRD Tata.

Talks and Scientific Sessions

A session on *Nano Science and Engineering* focused on the contributions made by Indian scientists to this field, especially those from IISc. R Chidambaram (Principal Scientific Adviser to the Government of India and an IISc alumnus), highlighted India's increased research output in the field of nanoscience and its contributions to areas such as solar photovoltaics, plasmonics and sensor networks. Subramanian S Iyer (IBM Fellow and Distinguished Chancellor's Professor, University of California Los Angeles) shared his insights into the evolution of chip design and what the future holds for integrated design development. Rudra Pratap (Chairperson, Centre for Nano Science and Engineering, IISc), in his talk, showcased the evolution of the Centre which boasts of a state-of-the-art nanofabrication facility, one that has enabled IISc scientists to develop cutting-edge applications.

The session on *Brain Research*, featured a talk by neuropsychiatrist, Dilip Jeste (University of California San Diego), who spoke about the neuroscience of well-being. The session also saw a discussion on changes occurring in the brain due to aging and the involvement of protein interaction networks in neuropsychiatric diseases such as schizophrenia. Aditya Murthy (Associate Professor, Centre for Neuroscience, IISc) introduced the audience to the Centre for Brain Research, which is being established at IISc with the help of a generous endowment of Rs. 225 crores made by Kris Gopalakrishnan and his wife Sudha Goplakrishnan's Pratiksha Trust. The Centre aims to foster interdisciplinary research on ageing and age-related brain disorders.

The conference also saw other interesting talks by many guest speakers including Michael L Norman (University of California, San Diego) who spoke during the session on *High Performance Computing and Big Data Analysis*. Norman introduced the audience to Gordon—the world's first supercomputer to use flash storage—located at the San Diego Supercomputer Center, and its applications in areas such as stock market analysis and genomic medicine.

In order to engage more effectively with the outside world, a session titled *Mind to Market* was organized to learn ways in which the Institute could better connect with its alumni, industry and others.

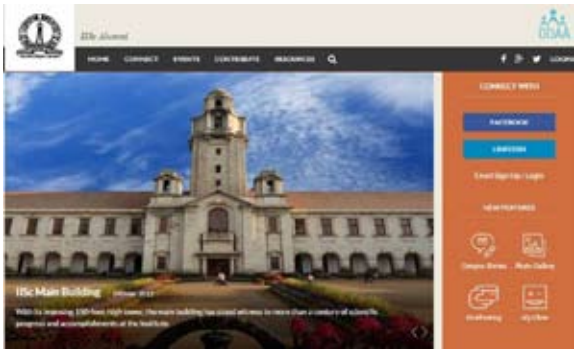
This was followed by a session on *New Initiatives @ IISc* with Umesh Varshney (Dean, Undergraduate Programme, IISc) providing an oversight into the four-year undergraduate programme offered at IISc which saw its first batch of students graduate on 15 July, 2015. BN Raghunandan (Chairperson, Development Committee) shared with the audience the progress achieved and the new initiatives at IISc's new 1500 acre campus at Challakere in Chitradurga.

In a session titled *Perceptions*, VS Arunachalam (former chief, DRDO), urged scientists to prioritize research that is both cost effective and of greater relevance to society. Eminent journalist and former Member of Parliament, Arun Shourie, in his talk, commended IISc's commitment to excellence and contributions to science in the country. He added that IISc should work harder in highlighting its achievements better. He asked the Institute to educate the public and build synergistic interactions with other leading institutes in India. "We should benchmark ourselves against the best in the world," he said.

During the session *IISc as a Global Institution: Reaching the Top*, P Balaram (former Director, IISc), who also chaired the session, introduced

Courtesy: IIScAA

During the session *IISc as a Global Institution: Reaching the Top*, chaired by P Balaram



Web portal launched by ODAA during the conference

the audience to different global university rankings and the parameters these rankings deploy to rank universities. Given the enormous constraints under which universities in India function, Balaram said that IISc needs to be more pragmatic in its aspirations as it seeks to climb the ladder of global rankings. Sunil Kumar, an alumnus of IISc and currently the Dean of the Booth School of Business at the University of Chicago, emphasized the importance of making IISc distinctive in certain areas of research and pedagogy and highlighted the need to take risks as the Institute embarks on this journey.

Connecting with Alma Mater

VK Aatre (former chief, DRDO), another distinguished alumnus and coordinator of the conference, led a panel discussion on how the alumni of IISc can contribute to the growth of their alma mater. Speaking to CONNECT, he said that "the principle focus of bringing the alumni together was to see if they could help raise funds for some of the student activities and training programmes and if the alumni could also mentor students".

To help connect better with the alumni, the Office of Development and Alumni Affairs (ODAA) introduced its new web portal to the audience. The portal seeks to build an online alumni community and will also enable alumni to make easy and safe financial contributions to the Institute's various initiatives.

✍ **IPSITA HERLEKAR**

(With inputs from RANJINI RAGHUNATH & KARTHIK RAMASWAMY)

STRINGS CONFERENCE 2015

This year marks the centenary of Albert Einstein's general theory of relativity which radically changed physicists' conception of space-time—the union of space and time which emerged from his special theory of relativity in 1905—from a passive stage on which matter and energy played out their cosmic drama to an active participant which could influence them and, in turn, be influenced. The central character in this drama is gravity, which could alter the geometry of space-time, previously thought to be flat.

Courtesy: ICTS

A packed audience at Strings 2015

"Before Einstein, cosmology—the study of the universe and its history—was addressed by religion and philosophy, but not by physics," said David Gross, Director of the Kavli Institute for Theoretical Physics at the University of California Santa Barbara, who gave a talk on Einstein's enduring legacy, the first of a series of talks on June 26 that commemorated the general relativity centenary.

The talks were part of the annual **Strings Conference**, held in India after a gap of 14 years, from 22-26 June, 2015. The event, co-organized by ICTS-TIFR and IISc, brought together string theorists from all over the world who presented their latest work. Review talks by leading lights such as Nima Arkani-Hamed of the Institute of Advanced Study, USA were also part of the event.

The general theory of relativity is the theory of gravity that physicists use to describe the universe. The framework that describes the other three forces of nature—electromagnetic, weak and strong forces—are described by the standard model of particle physics which is based on quantum mechanics, a no less successful theory that describes the subatomic realm. In situations where these two theories have to be combined, however, they give nonsensical answers. This happens when physicists try to explore phenomena at exceedingly tiny length scales, such as inside a black hole or in the earliest instants after the Big Bang.

This is because general relativity does not take into account the quantum nature of the world while quantum mechanics still pictures space-time as static. "This means we will have to go beyond Einstein's theory. That's what string theory is all about," said Gross during his lecture.

String theory posits the existence of tiny strings, vibrating in more dimensions than the three which we can observe, that form the fundamental constituents of matter. Direct experimental proof is beyond the reach of technology, but the theory may receive support from the experiments underway at the second run of the Large Hadron Collider at CERN.

✍ **NITHYANAND RAO**

THE NATIONAL CLIMATE SCIENCE CONFERENCE

It is not unusual for academic conferences to have leading researchers give review talks about their own research or their broad areas of work, and also to arrange for students and younger researchers to make poster presentations about their work. **The National Climate Science Conference** organized by the Divecha Centre for Climate Change from 2-3 July, 2015, however, went further. Participating students also had the opportunity to give brief presentations about their work and to summarize their posters which were displayed on the rooftop of the Divecha Centre building.

"It's like the advertisements you see on TV," said G Bala, professor at the Centre and one of the organizers of the conference.

Courtesy: NCS CONFERENCE

Ample time was scheduled for viewing the posters, both in the morning and the afternoon sessions on both days; the last session was devoted entirely to work done by students at IISc. What's more, the faculty members from the Centre for Atmospheric and Oceanic Sciences, closely associated with the Divecha Centre, took a keen interest in the work presented by students from all over the country. The

level of interaction was a refreshing change from what happens at most conferences, and this was made more remarkable by the fact that there were more than 100 posters presented over the two days of the conference.

Much of the research presented, including in the plenary talks, addressed the changing nature of the monsoon due to factors as varied as aerosols, urbanization and the El Nino Southern Oscillation. Understanding the dynamics of the monsoon is important because it is an integral part of any climate model, including the one developed at the Indian Institute of Tropical Meteorology in Pune. Other talks, such as the one on work done by scientists at the Indian research stations in Antarctica, aimed at giving students an overview of the work in a particular area.

✍ **NITHYANAND RAO**

AUTHORS RECEPTION

If there's a book inside you, let it come out. And give it to IIScPress. This was the message that Anurag Kumar, Director of IISc, conveyed during his address as part of the **Authors Reception** held on 20 July, 2015.

Four books were released on the occasion: *Continuum Mechanics* and *Fluid Mechanics* both authored by CS Jog, Professor, Department of Mechanical Engineering; *Design for Sustainable Well-Being and Empowerment* by Monto Mani, Professor, Centre for Sustainable Technologies; *Pattern Recognition and Machine Learning* co-authored by M Narasimha Murthy, Professor, Department of Computer Science and Automation and Susheela Devi, Principal Research Scientist from the same department.

IIScPress, established in 2008, has published more than 20 books in the last five years, many of them in collaboration with the World Scientific Publishing Company and Cambridge University Press. However, GK Ananthasuresh, its Chair, lamented that many faculty members remain unaware of this opportunity.

Although IIScPress is only a few years old, the *Journal of the Indian Institute of Science* has been in existence for a century now, and to celebrate this occasion, a special commemorative centenary issue. Recalling its history, TN Guru Row, Professor at the Solid State and Structural Chemistry and the present Editor of the *Journal*, said it began with an initial grant of Rs.

Courtesy: GEETHA SN

Launch of the special centenary issue of the *Journal of the Indian Institute of Science* by (L to R) Raghavendra Gadagkar, G Padmanaban, Anurag Kumar and TN Guru Row

1000 in 1914. It grew over the years but to ensure its relevance in this digital era, it underwent a change of format in 2007 when it became a quarterly journal publishing only review articles. Each topical issue since then has had a Guest Editor who is an eminent researcher in that particular area.

G Padmanaban, former Director of IISc, pointed out that the history of the *Journal* is closely intertwined with the history of the Institute. He said that in its first 50 years, IISc's emphasis was on applied research. He gave the examples of the many manufacturing factories set-up based on research done at the Institute. "Somewhere we lost the plot in the next 50 years, during which period applied science was not considered very fashionable," said Padmanaban. He felt that in the half-century since then, the Institute had moved on to basic research, which "continued to be good research but it was not good enough." The centenary of the *Journal*, he said, "is a time for us to introspect—where we were, where we are and where we should be."

This was followed by an engaging talk by Raghavendra Gadagkar, Professor, Centre for Ecological Sciences and Chair of the Centre for Contemporary Studies, on the "Dying Art of Writing and Reading Books." Among other things, he observed how writing books was not considered a part of the creative process of enquiry and discovery in the natural sciences and engineering, unlike in the social sciences and humanities. The event concluded with remarks by the Director and a Vote of Thanks by TA Abinandanan, Professor, Department of Materials Engineering and the Chair of the Archives and Publications Cell.

✍ **NITHYANAND RAO**

BEST 2015

This year saw a new initiative by IISc's Centre for BioSystems, Science and Engineering, a programme called the **BioEngineering Summer Training (BEST)** for undergraduate students from across India.

According to its organizers, the objective of starting this programme was to nurture the imagination of young minds and motivate them to develop an appetite for research. Since bioengineering is a rapidly evolving field and is comparatively new, it is therefore important to introduce the undergraduates to the opportunities and challenges that bioengineering research offers.

Over 200 applications were received for admission to this 8-week long programme. A panel comprising bioengineering faculty members selected applicants based on their academic record and their statement of interest.

During the programme, students were not only exposed to hands-on training as part of their research projects, but were also introduced to the art of scientific writing, publishing and IP ethics. Lecture modules on emerging topics like biomechanics, tissue engineering, systems biology and neural engineering were also organized. After the completion of their research projects, the BEST fellows were encouraged to present their research projects towards the end of the programme. In between learning and lecture sessions, the participants got an opportunity to interact with

Courtesy: : BEST 2015

GK Ananthasuresh with students during a tour organized as part of the event

PhD students, and faculty members of IISc. The programme also included an outdoor tour.

Speaking about the benefits of hosting such an event, GK Ananthasuresh (Professor, Department of Mechanical Engineering) and a Co-Chair of the Centre told CONNECT, "An undergraduate summer internship programme is mutually beneficial. Undergraduate trainees get exposed to research environment and get a flavour of research. On the other hand, we—the faculty and graduate students—get to test our little ideas, the so-called 'small bets', while also publicizing our interdisciplinary PhD programme."

✍ **SHILPEE JAIN**
(with inputs from RAHUL ROY)

LOOK WHO'S TALKING

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

INSTITUTE LECTURE: MICHAEL L NORMAN

Courtesy: MICHAEL L NORMAN

Recently, the first generation of stars formed after the Big Bang was discovered using ground-based telescopes. However, detailed numerical simulations that predicted the properties of such stars were published in 2002 by a research group led by Michael L Norman—Distinguished Professor of Physics at the University of California San Diego, and Director of the San Diego Supercomputer Centre—who gave the Institute lecture at IISc on ***Discovering the first stars and galaxies in a supercomputer*** on 29 June, 2015. He is also the first Smt. Rukmini and Shri Gopalakrishnachar Distinguished Visiting Professor of IISc, a visiting chair instituted by an alumnus of the Institute, Prahlad DN in 2007.

"I've always felt that one can legitimately discover something in a supercomputer just as well as in the experimental laboratory or observationally or theoretically," Norman said during his talk.

The earliest stars, composed almost entirely of hydrogen, were hundreds or thousands of times more massive than the sun. The heavier elements, including the ones necessary for life such as carbon and oxygen, were manufactured in their cores which later seeded the formation of the next generation of stars—and planets—when they ended their short lives in supernova explosions. Norman's group pioneered a technique called adaptive-mesh refinement, using recursive algorithms that covered scales from the cosmic down to the stellar, to simulate the formation of the first stars and galaxies.

✍ **NITHYANAND RAO**

MJ THIRUMALACHAR AND MJ NARASIMHAN ENDOWMENT LECTURE: SHANKAR BALASUBRAMANIAN

Courtesy: PUBLIC RELATIONS OFFICE

To honour the memory of her well-known mycologist husband, MJ Thirumalachar, and their son, MJ Narasimhan, M Jeerasannidhi Kasthuri endowed a lecture series in 2007.

On 18 June this year, the endowment lecture was given by Shankar Balasubramanian—the Herchel Smith Professor of Medicinal Chemistry in the Department of Chemistry at the University of Cambridge (he is also the Senior Group Leader at the Cancer Research UK Cambridge Institute (CI) and Fellow of the Trinity College, Cambridge).

In his talk, ***Decoding Human Genomes on a Population Scale***, he traced the scientific developments that happened over 20 years after the discovery of DNA—the code of life—and how the chemists at Cambridge University were able to elucidate its structure which surprisingly precedes the proposal of the double helical

structure by James Watson and Francis Crick. He also discussed how basic sequencing techniques like the one invented by F Sanger, Allan Maxam and Walter Gilbert were becoming useful for large scale human population sequencing. "You cannot define the structure of a biopolymer unless you know the sequence", he said.

✍ **DISHA MOHAN**

AMULYA AND VIMALA REDDY AWARD LECTURES: TG SITHARAM AND HN CHANAKYA

Courtesy: PUBLIC RELATIONS OFFICE

The Amulya Reddy and Vimala Reddy Award Lecture was instituted in 1998 by B Chandrasekaran, an emeritus professor from Ohio State University, USA, in honor of Amulya Reddy, founder of the Centre for Sustainable Technologies (CST), previously known as the Application of Science & Technology to Rural Areas (ASTRA).

The award lecture is bestowed on Institute's faculty members to recognize their contributions in the field of sustainable development, preferably in the rural sector. This year, **TG Sitharam** (Professor, Department of Civil Engineering) and **HN Chanakya** (Professor, Centre for Sustainable Technology) were the recipients of this honour, and they gave their award lectures on 9 June, 2015.

Courtesy: PUBLIC RELATIONS OFFICE

Giving a talk on ***Sustainable Development Issues and Directions in Urban Science and Engineering: Recent Studies***, Sitharam spoke about his work on urban planning and the issues that haunt urban planners with a focus on managing urban transport. He said, "Experts in the field of transport from academic institutions are miniscule in number." To address this issue, CiSTUP was founded in 2009 with a generous help from the state government. Taking example of a few case studies, Sitharam highlighted his student's thesis on a future proof design of transportation system—to optimize movement of KSRTC buses in the city.

In his talk, ***Bioenergy Conversion—Meeting the Challenges of Science, Society and Sustainability,*** Chanakya gave an overview of his research on bio-methanation and waste water management. His work has found use in treating agro-industry waste (coffee waste water) in rural Karnataka and urban solid waste treatment in Sadashivnagar Residents' Association in Bangalore, among several others.

✍ **MEGHA PRAKASH**

CBR INAUGURAL LECTURES: DILIP JESTE AND AVINDRA NATH

To understand brain function, especially in the realm of aging and dementia, a new lecture series has been instituted by the Centre for Brain Research (CBR), a recently setup autonomous facility at the Indian Institute of Science (IISc). On 24 June, 2015, the inaugural talk was given by renowned geriatric psychiatrist **Dilip Jeste**, who holds several distinguished teaching and research titles at the University of California San Diego, USA. The second talk in the series was given by **Avindra Nath**, Chief, Section of Infections of the Nervous System & Clinical Director, National Institute of Neurological, Disorders and Stroke, National Institutes of Health, USA, on 7 July, 2015.


Courtesy: CNS

Jeste, in his talk titled ***Neuroscience of Wisdom, Resilience and Well Being***, explained how some large scale studies indicate that despite deteriorating physical health, the elderly are wise, have better emotional regulation and social decision making skills compared to the younger population. Talking about what he called the 'paradox of ageing', he raised questions like: why do humans live beyond the age of reproductive fertility? What role does ageing play if it provides no evolutionary advantage?

He argued that as one gets older, one gets wiser, which in turn can benefit one's own kin and even the larger community. *Wisdom*, he said, constitutes higher levels of compassion, empathy, altruism, self-understanding, emotional stability and pro-social attitudes with lower levels of stress and depression. Scientific evidence from fMRI studies point towards several brain regions being involved in different components of wisdom. While there is age-related structural degeneration of the brain, it appears that the elderly make up for it by recruiting more brain areas and networks to successfully execute tasks, he suggested. He also delved into how aging brains use compensatory mechanisms to prevent impairment.

Concluding the talk, Jeste said that much work is being done to explore the neuroscience of wisdom, resilience and well-being and that research in geriatric psychiatry is still in its infancy.

Avindra Nath in his talk, ***Recent progress and future challenges posed by neurological diseases***, emphasized the need for having an interdisciplinary approach to ease the increasing neurological burden of an ageing society. Having worked at a research hospital, Nath said that many disorders, particularly neurological disorders, go undiagnosed among the elderly. Currently, most of these disorders are symptomatically treated, he remarked. It is imperative that major efforts are undertaken to understand the disease mechanisms and develop disease-modifying therapies, he added.


Courtesy: PUBLIC RELATIONS OFFICE

Advancements in medical science owe a lot to developments in physics and technological breakthroughs, Nath said. The kernel of the now-widespread imaging tools emerged from research in the physical sciences; brain imaging tools like Magnetic Resonance Imaging (MRI), Computerized Tomography (CT) scan, etc. have contributed immensely in improving diagnostic abilities and accurate monitoring of multiple diseases, he said. He also said that without similar breakthroughs in engineering, physical and chemical sciences, medical tools like Deep Brain Stimulation (DBS), Transcranial Magnetic Stimulation (TMS), and improved drug-delivery compounds would not have existed.

But, according to Nath, we still face many challenges. Medical sciences have not been able to keep pace with developments in other fields. Other challenges include the exorbitant cost of validating a potential drug, diseases going undiagnosed and a lack of good animal models.

In the face of such adverse factors, Nath argued that we need to have more interfacing of applied physics with neurosciences and this could potentially fuel a new age of medical discoveries which can steer new diagnostic and therapeutic approaches in medical science.

✍ **DEEBALEENA BASU**

A NEW BLOOM

Courtesy: UNDERGRADUATE PROGRAMME, IISC

In July this year, the first batch of young men and women graduated from the four-year Bachelor of Science programme which was started by the Indian Institute of Science (IISc) in 2011. Their graduation provides CONNECT ***with an opportunity to reflect on the path traversed by this unique initiative and to also look ahead.***

✍ **BITASTA DAS**

"The training in the undergraduate (UG) programme in IISc has made me more open to new ideas, helped me appreciate the importance of several research areas. And it has made me a well-rounded person," says Neha Kondekar, one of the students from the first batch of young men and women who graduated in July this year from the four-year Bachelor of Science programme, which started in 2011.

Sowing the Seeds

The seeds of this programme were, however, sown a few years earlier. The three national science academies in India—Indian Academy of Sciences, Indian National Science Academy and the National Academy of Sciences—have been working together to find ways of improving science education in India. In 2008, following several discussions and meetings, they jointly wrote a position paper titled *Restructuring Post-School Science Teaching Programmes*. Its recommendations included a strong pitch for a composite four-year UG programme in select institutions in the country. The proposal resonated with IISc whose then Director P Balaram had always felt that studying basic sciences should be made attractive to bright young students who might otherwise choose a professional course. He also believed that a good UG programme is essential for any research institution to flourish. It was then that, under Balaram's leadership, the idea of starting a four-year, research-oriented Bachelor of Science programme began to take shape at IISc. The groundwork for its implementation was carried out by a small group of dedicated faculty members and the initiative was supported financially by the Ministry of Human Resource Development (MHRD). In 2010, the programme got its own Dean—Chandan Dasgupta, a professor in the Department of Physics. It finally came into existence in 2011, exactly a century after the Institute admitted its first

batch of post-graduate students.

Observers of higher education in India have lamented for years that our system relies too much on bookish information and have instead advocated a curriculum that is more hands-on and treats knowledge holistically. The approach would not just make learning more effective, but would also help in addressing complex problems in a rapidly changing world. This view has influenced the structure and curriculum of the UG programme at IISc.

The Chosen Ones

The UG programme at IISc has already become popular. It receives more than 10,000 applications every year. But only 120 students are selected. The successful applicants need to have cleared one of the following: the Kishore Vaigyanik Protsahan Yojana (KVPY), the Joint Entrance Examination (JEE) or the National Eligibility cum Entrance Test (NEET). All the students who are enrolled receive a fellowship besides accommodation on campus and subsidized food.

SIDDHARTH KANKARIA

The Programme

Each student is assigned a faculty advisor who mentors them throughout their programme of study. Students major in any one of the following subjects: physics, chemistry, biology, mathematics, environmental science, and materials science. But until their third semester, students take foundational courses—compulsory for all students—in all these subjects besides engineering and humanities courses. These courses help the students master the fundamentals in all subjects as well as see the interconnectedness of different fields of study. It also gives them an opportunity to discover their

ABHINAV JAIN

own interests, what they are good at and to make informed choices about their major and minor fields of study.

All classes are taught by faculty members of the Institute who are among the best researchers in their own fields. Learning, however, does not happen in classrooms alone. The curriculum emphasizes active learning in labs that are equipped with world class facilities. Many of the experiments that these students do led to crucial scientific discoveries and even won Nobel prizes.

Once the students have completed their foundational course requirements, they get to choose the subject in which they'd like to major in (as well as minor in); they have more flexibility to design their coursework from here on. The seventh and eighth semesters are devoted entirely to

SIDDHARTH KANKARIA

Mendel's law of inheritance represented in Madhubani folk art done as part of a humanities course

research projects which they do with one of the faculty members.

During their course of study, students are required to earn 131 credits in four years, of which the core courses constitute 65 credits. The major subject counts towards 35 credits, the minor towards 16 credits, and the project towards 15 credits.

The core courses also comprise engineering and humanities courses. Engineering courses include electronics, computation and statistics. Students can also opt for additional engineering courses as electives in the following semesters and choose a total of 19 credits.

Humanities is an integral component of student learning in this programme. At IISc, it is not taught as an isolated discipline; here, the goal is to help students understand the socio-cultural context in which science is done. These courses, which are compulsory for the first 6 semesters of the programme, are conducted by the Centre for Contemporary Studies.

Braving the Storm

The growth of this nascent programme has not been without challenges. In 2014, the University Grants Commission (UGC) under the aegis of Ministry of Human Resource Development (MHRD), the body responsible for higher education in India, insisted that all four-year undergraduate programmes should revert to the traditional three-year programme. UG programmes in universities like

GEETA SN

UG office staff responsible for the smooth functioning of the programme along with Chandan Dasgupta, the outgoing Dean

SIDDHARTH KANKARIA

A student demonstrating a scientific principle to curious school students

Delhi were forced to follow this stricture. The possibility that IISc too may have to review its own four-year initiative caused a clamour amongst students, administrators and academicians. Balaram, however, says that the four-year programme was initiated for purely academic reasons and that he never felt intimidated by UGC's move. Eminent scientists like CNR Rao also stood by the IISc's UG programme and insisted that it should continue in its current avatar given its popularity and obvious benefits. Eventually, an additional year was introduced for students who wish to continue and graduate with an MSc degree and the four-year BS programme is now called BSc (Research).

The New Graduates

More than half of the students who graduated this year have decided to continue with their Master's in IISc itself. One of them, Amogh Kinikar, says that he is doing so because his final year project was at an interesting stage and he wanted to see it fructify. Twenty seven students have joined PhD programmes at premier universities abroad and two students have taken up jobs in reputed organizations. Himani Galagali, who will be joining Johns Hopkins University, USA, for her PhD in biology says that her experience over the last four years has been terrific, having been taught by distinguished faculty who made the subjects all the more interesting.

A Breath of Fresh Air

Dasgupta recalls that when the UG programme started, a few faculty members had their reservations. But it did not take long for them to be convinced of the utility of the programme; they may have also been influenced by the cheery hue that these students brought to the campus.

The UG students have more than just repaid the faith that was shown on them when the programme started four years ago. They have excelled in academics as well as in numerous extracurricular activities. At least 20% of the students have secured CGPA (Cumulative Grade Point Average) of 7 or more out of 8. They have been selected by reputed national and international organizations and universities for their summer and final projects.

UG students have also been doing extremely well in student festivals in other universities and colleges. At the inter-college quiz competition at *Mimamsa*, the student festival organized by IISER Pune, IISc, represented by its UG students, has received the first place in each of the last four editions, giving rise to a running joke that all other colleges compete for second position. Beginning 2014, the students have also been organizing *Pravega*, an annual science-tech-cultural fest. This unique inter-college event which has seen only two editions thus far has already become enormously popular. The UG students also bring out an annual magazine called *Quarks* that showcases their multifaceted talents.

The Road Ahead

Chandan Dasgupta has just completed his term as the first Dean of the UG. His shoes will now be filled by Umesh Varshney, Professor, Department of Microbiology and Cell Biology. The Institute recognizing the importance of the programme has also appointed more people to oversee it. PS Anil Kumar, an associate professor from the Physics Department, and Balaji Jagirdar, a professor from the Department of Inorganic and Physical Chemistry, have been appointed as Associate Deans. An Assistant Registrar, Veeranna Kammar, will be in charge of administrative issues. Anil Kumar says these structural changes were necessary to give more attention to the students and monitor their progress as the programme expands. The new Dean, Umesh Varshney, reinforces this point by saying that one of his immediate tasks would be to attend to the students' needs more closely. One area of concern has been the skewed ratio of boys and girls in the programme. While he expresses satisfaction that the number of girl students has been increasing, he says that we need to do more to encourage more young women to take up sciences. He also says that it is now imperative to also encourage students from remote areas to join this programme.

The UG programme, started a few years ago as an experiment in a research institution that only had postgraduate students, has now yielded remarkably satisfying results. In the coming years, there will be more challenges to confront, but with careful nurturing, it will take deep roots and flourish.

ABHINAV JAIN

A performance at *Pravega*

AND THE WINNERS ARE...

Members of the Indian Institute of Science (IISc) community were honoured with awards recently

✍ **MANU RAJAN AND IPSITA HERLEKAR**

Courtesy: SANTANU MUKHERJEE

Santanu Mukherjee

Santanu Mukherjee (Assistant Professor, Department of Organic Chemistry) won the **Prof. Priti Shankar Teaching Award** (2014). He works in the area of asymmetric synthesis, applying purely organic small molecules as catalysts for achieving enantioselective organic transformations. His research interests revolve around the creation and control of stereochemistry at quaternary stereogenic centers.

Balaji Jagirdar

Balaji Jagirdar (Professor, Department of Inorganic and Physical Chemistry) was awarded the **CNR Rao National Prize for Chemical Research** of the Chemical Research Society of India. He investigates the activation of unreactive chemical bonds aimed at realizing catalysts for methane to methanol transformation. His work also involves development of materials for hydrogen storage and generation.

Courtesy: KR PRABHU

KR Prabhu

KR Prabhu (Associate Professor, Department of Organic Chemistry) won the **CRSI Bronze Medal** (2015) of the Chemical Research Society of India. He studies selective oxidative chemistry and has contributed to the design, discovery and development of novel synthetic strategies for C-H activation and C-H functionalization reactions.

Courtesy: MRINAL KANTI GHOSH

Mrinal Kanti Ghosh

Mrinal Kanti Ghosh (Professor, Department of Mathematics) won the **Prof. Rustom Choksi Award for Excellence in Research** (2014). He studies stochastic control, stochastic dynamic games, stochastic differential games and its applications to mathematical finance including derivative pricing, interest rate models and credit risk.

Courtesy: SATISH PATIL

Satish Patil

Satish Patil (Associate Professor, Solid State and Structural Chemistry Unit) won the **Kaushal Kishore Memorial Award** (2014) of the Society for Polymer Science. His group works on the design and synthesis of π conjugated functional materials for optoelectronics devices and developing novel diketopyrrolopyrrole-based alternating copolymers in the pursuit of better n-type materials.

BITASTA DAS

Raghavendra Gadagkar

Raghavendra Gadagkar (Professor, Centre for Ecological Sciences and Chair, Centre for Contemporary Studies) has received the **Cross of the Order of Merit** of the Federal Republic of Germany, Germany's highest civilian award. Also the President of the Indian National Science Academy, he studies the origin and evolution of cooperation in social insects.

CONNECT

Aditya Kanade

Aditya Kanade (Assistant Professor, Department of Computer Science and Automation) won the **Prof. Priti Shankar Teaching Award** (2014). He specializes in programming languages, program analysis and machine learning applied to programming and software engineering. He is also in interested in pedagogy and is developing tools for automated grading and feedback generation on assignments.

CONNECT

Jayant Haritsa

Jayant Haritsa (Professor, Department of Computer Science and Automation) won the **IISc Alumni Award for Excellence in Research (Engineering)** (2015). His group works on database systems and has designed a radically different query execution mechanism that delivers proven and competitive performance bounds.

Courtesy: USHA VIJAY-RAGHAVAN

Usha Vijayraghavan

Usha Vijayraghavan (Professor, Department of Microbiology and Cell Biology) received the **IS Bhatia Award** of the Society of Biological Chemists (India) (2014). Her work involves understanding the growth of stems and flowers in plants. She has been addressing fundamental questions in plant developmental biology using rice and *Arabidopsis* as model systems.

CONNECT

B Ananthanarayan

B Ananthanarayan (Professor, Centre for High Energy Physics) won the **Prof. Rustom Choksi Award for Excellence in Research** (2014). He works on elementary particle physics and field theory to uncover basic interactions of nature at high precision using a variety of mathematical and computational techniques.

Courtesy: ANWESHA MUKHERJEE

Anwesha Mukherjee

Anwesha Mukherjee, a PhD student with Abha Misra (Assistant Professor, Department of Instrumentation and Applied Physics) received the **Gandhian Young Technological Innovation Award** (2015) of SRISTI for developing a prototype of a carbon nanotube based sensor to detect trace amounts of methane at room temperature.

CONNECT

S Vasudevan

S Vasudevan (Professor, Department of Inorganic and Physical Chemistry) won the **IISc Alumni Award for Excellence in Research (Science)** (2015). He works on the physical chemistry of materials, focusing on functionalized layered and nanostructures.

Courtesy: DIPANKAR CHATTERJI

Dipankar Chatterji

Dipankar Chatterji (Professor, Molecular Biophysics Unit) is a recipient of the **IISc Alumni Award for Excellence in Research (Science)** (2015). His research focuses on studying how bacteria react to different levels of stress.

Courtesy: AJAY SOOD

AJAY SOOD ELECTED TO ROYAL SOCIETY

Ajay Sood (Professor, Department of Physics) has been elected a Fellow of the prestigious Royal Society of London. He is among the 57 new Fellows elected to the Society in 2015. Ten of these new fellows including Sood are Foreign Members. Founded in 1660, under the patronage of King Charles II, the Royal Society is among the oldest scientific communities in the world. The most eminent scientists from the UK and Commonwealth of Nations are elected each year by the Society's council members as its Fellows. The Society currently includes 80 Nobel laureates and previously had legendary scientists like Isaac Newton, Alexander Fleming and Charles Darwin as its Fellows. Apart from promoting and supporting excellence in the field of science, the Society promotes the use of science for the benefit of humanity and to foster international and global cooperation.

Sood is an experimental researcher who works on several areas of physics including soft condensed matter and hard matter. His previous work on carbon nanotubes revealed that voltage is generated when water is made to flow over graphene nanotubes. This effect, now called the "Sood effect", has potential applications in the manufacture of various electronic devices including pacemakers. Sood's experiments with colloidal matter, where he uses electric current to change the structural properties and induce crystallization, has helped in developing a diagnostic test kit for typhoid. This kit works a thousand times faster than conventional tests and is able to give results in just half a day (as compared to commercially available tests that can take as long as a week). He is at present studying the phenomenon of "flocking", using small metal spheres and brass bits. This study would help in understanding how organisms like microbes, ants, birds, etc aggregate together; this, in turn, may also help in evolving more effective protocols in managing crowds and traffic which are also self-organizing phenomena.

Sood's long list of honours includes the Shanti Swarup Bhatnagar Prize given by CSIR and the Padma Shri given by the Government of India. The Royal Society Fellowship is a new feather in his cap and puts him in the league of celebrated and well-known scientists like Stephen Hawking and Richard Dawkins. Speaking to CONNECT, Sood described receiving the Royal Society Fellowship as "an overwhelming and humbling experience".

✍ **IPSITA HERLEKAR**

Campus Critters

A newly molted scarab beetle

Supercomputer Education and Research Centre