ISSN 2454-6232

CONNECT

WITH THE INDIAN INSTITUTE OF SCIENCE

Startups
Entrepreneurship at IISc

Aerospace Engineering
Origins and growth

SID
Nurturing innovation

September 2016
Volume 3 • Issue 3

CONTRIBUTORS

Suhas Mahesh is a recent graduate of the undergraduate programme

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

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

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

Sudhi Oberoi is a Project Trainee at the Archives and Publications Cell

Navin S is Master's student in the Department of Electrical Engineering

Ramya Bala is a Research Associate at the Centre for Ecological Sciences

Gaurav Govardhan is a PhD student at the Centre for Atmospheric and Oceanic Sciences

G Mugesh is a professor in the Department of Inorganic and Physical Chemistry

Shishir G Patil is a Research Intern at the Centre for Nano Science and Engineering

Raghu Menon is a PhD student at the Centre for Product Design and Manufacturing

Punit Kumar is a PhD student in the Department of Materials Engineering

Gyan Shankar is a PhD student in the Department of Materials Engineering

Sweety Arora is a PhD student in the Department of Materials Engineering

Akanksha Dixit is a PhD student in the Department of Biochemistry

Sakshi Gera is a PhD student in the Department of Molecular Development, Reproduction and Genetics

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

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

Kavitha Harish is with the Archives and Publications Cell

Narmada Khare teaches biology at IISc

Amogh Kinikar is a Master's student at the Department of Physics

Sowmithri Ranganathan is with the Archives and Publications Cell

Karthik Ramaswamy is the Editor of CONNECT

Manbeena Chawla is a Research Associate at the Centre for Infectious Disease Research

FRONT COVER: 'Startups' Acrylic painting (TEJESWINI PADMA)

FRONT INSIDE COVER: 'The Tree' (IISc PHOTOGRAPHY CLUB)

BACK INSIDE COVER: Hawk Moth (NATASHA MHATRE)

BACK COVER: Watercolour of the Society for Innovation and Development (BHAMA SRIDHARAN)

CONNECT TEAM

Karthik Ramaswamy (Editor, CONNECT, Archives and Publications Cell)
Megha Prakash (Consultant Editor, Archives and Publications Cell)
Nithyanand Rao (Consultant Editor, Archives and Publications Cell)
Sudhi Oberoi (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)

Photography: IISc Photography Club (unless otherwise mentioned)

Published by

IISc Press

CONTACT

Email: newsletter@apc.iisc.ernet.in
Phone: 91-080-2293 2066
Address: Archives and Publications Cell
Indian Institute of Science, Bangalore 560 012, India

QUICK LINK **http://www.iisc.ac.in/iisc-connect/all-issues/**

Design: SaiMaa | Printer: Sri Sudhindra Offset Process

FROM THE CONNECT TEAM

Greetings!

In the course of their scientific explorations, many researchers get bitten by the entrepreneurial bug. And those from the Indian Institute of Science (IISc) are no exception. IISc, however, may be more of a fertile breeding ground for startups. Its researchers—many of whom are driven by the desire to innovate or are motivated by social challenges—work on a diversity of problems in both science and engineering, often in interdisciplinary collaborations, and have access to cutting-edge facilities. But just possessing these attributes will by no means ensure that IISc will become the epicentre of translational research.

The recipe for entrepreneurial success includes several other ingredients: sufficient funding to kick start an idea, a long term business plan, and a nurturing environment that is open to innovation. In order to help its researchers take a plunge into the uncharted waters of entrepreneurship, the Institute has created an Entrepreneurship Cell under the auspices of the Society for Innovation and Development (SID), and is revising its policies to ensure that research from the Institute impacts society more directly. In this issue of CONNECT, Suhas Mahesh takes a closer look at the spread of the startup culture at IISc.

In an article that complements this feature, Navin S discusses the activities of SID, a body that not only helps nurture startups, but also facilitates other forms of engagement between researchers and industry. SID, by any definition, is a unique experiment. In the words of its Chief Executive, B Gurumoorthy, it is the "first ever research park set up in the country and pioneered the framework for faculty entrepreneurship in India."

This issue also includes the story of the origins and growth of the Department of Aeronautical Engineering, later rechristened as the Department of Aerospace Engineering, as well as its close association, particularly in its early years, with the Hindustan Aeronautics Limited (HAL).

As always, there is much more for the reader to chew on.

Happy reading!

In This Issue...

THE RISE OF STARTUPS

All across the campus, academics are prodding awake their entrepreneurial alter egos. IISc is making its mark on India's startup scene

Courtesy: SANJIV SAMBANDAN'S LAB

✍ **SUHAS MAHESH**

The night falls upon the campus as the end of the semester looms ominously. Every lit window in hostel N-Block betrays an unmoving silhouette hunched over a pile of books. Pranav Mundada, however, is busy debugging the image processing algorithm for the microscope he is helping build. The brainchild of Satya Tapas, a former IISc postdoctoral fellow, the automated microscope can diagnose malaria from just a blood smear, eliminating the need for costly laboratory tests. "The device holds great promise for rural India, where both money and expertise are scarce," says Satya. Just down a flight of stairs, Shayan Banerjee, a student of IISc, is inspecting the application for the patent that he intends to file soon. His discovery—a chemical—is already in commercial production in his Surat-based company. Banerjee and Satya are not alone. All across the campus, academics are prodding awake their entrepreneurial alter egos. The Indian Institute of Science is making its mark on India's startup scene.

IISc and Entrepreneurship

The alumni of IISc have a long history of founding successful companies. Many distinguished alumni, like Infosys' DN Prahlad, have also played pivotal roles in charting the success stories of companies. Graduates from IISc's BE programme in the 1970s

were particularly prolific, many of them even going on to become serial entrepreneurs. As I sit in the office of one such company—Integra Microsystems—alumnus P Ravi reels off reams and reams of names of companies founded by his classmates from the 1970s. "We received no direct financial or intellectual stimulus from IISc while starting these companies," adds V Gopalakrishna, another alumnus. Neither were these companies truly *startups*, in the sense the word is used today. A startup is typically technology-oriented with a rapidly scalable business model. The startup scene in IISc only truly took off at the turn of the millennium, with the involvement of the Society for Innovation & Development (SID).

The startup scene in IISc only truly took off at the turn of the millennium, with the involvement of the Society for Innovation & Development (SID)

TEJESWINI PADMA

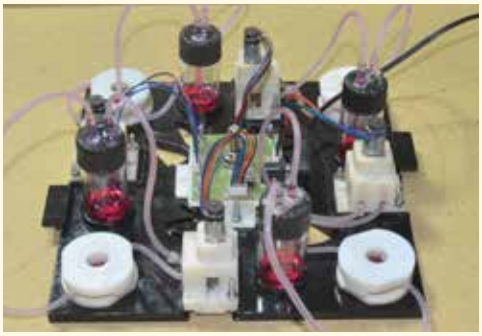
This painting on the front cover has several motifs that reflect the activities and logos of a few startups that have an IISc connection

Making Entrepreneurs of Academics

As India's premier research institute, IISc is uniquely positioned to nurture an R&D startup environment. Its intellectual property pool, amassed over a century, lies unused, waiting to be tapped. The city's technology industry also provides a huge pool of talent. However, it's all easier said than done. "Being an academic and being an entrepreneur are very different things," CS Murali says with a smile. Murali, an industry veteran, is the Chairperson of the Entrepreneurship Cell in SID. "Conceiving and testing ideas in the lab is very different from translating ideas into products," he explains. He later admits that it took even SID some time to arrive at this realization. The Cell serves as an incubation centre and provides seed funding and office space, for up to three years. The biggest challenge lies

BendFlex

BendFlex specialises in developing biomedical devices using compliant mechanisms. The startup has been founded by two former PhD students of GK Ananthasuresh (Professor, Centre for Biosystems Science and Engineering), Ramnath Babu and Santosh Bhargav. "With compliant mechanisms, a medical device that would need 30 components, can be made with just three or four," explains Ramnath. Their current products include a Bioreactor and a compliant mechanism kit.



RAMNATH BABU

in the soft skills, as Ramnath Babu, co-founder of BendFlex, admits: "Managerial and marketing skills are a must. Without it, the startup will sink like a rock." Needless to say, these skills are not common in an academic environment. Murali doubles up as an advisor, drawing on his decades of experience and contacts in the industry to guide the startups. The Cell also welcomes startups from outside IISc. The imprimatur of the Institute is a big attraction for these entrepreneurs. It can serve as the key to open many stubborn locks. But there's a catch: SID only incubates ideas with some "deep science" behind them. This means that the ubiquitous aggregators and social media startups are ruled out. So far, 18 startups have been incubated by SID, with the numbers growing every year.

PathShodh

PathShodh is developing a handheld diagnostic device for diabetics based on research from the lab of Navakanta Bhat (Professor, Centre for Nano Science and Engineering). The phablet-like device is capable of performing eight different tests in a few minutes with a single drop of blood or urine. These tests include blood sugar, HbA1c, haemoglobin, glycated albumin, microalbuminuria, urine ACR, urine creatinine and serum albumin. The technology is minimally-invasive (for blood) or non-invasive (for urine) and doesn't require medical procedures like sample preparation and storage. Using the device is also simple—a prick for a drop of blood that has to be placed on a paper strip, and in less than two minutes, the results flash on the digital monitor.

SUHAS MAHESH

(Credits: Megha Prakash)

How Startups Begin

Most startups in IISc are born as a natural extension of research that happens in the laboratory. BendFlex, a biomedical devices startup, was conceived this way by two students of GK Ananthasuresh, a professor at the Centre for Biosystems Science and Engineering. One of BendFlex's products, developed at IISc, is a force-sensor so sensitive that it allows mechanical properties of individual cells to be monitored. "It will be a big leap for diagnostics if we could monitor the mechanical properties of a cell. For instance, cell stiffness can tell us if a cell is diseased," explains Ramnath.

Most startups in IISc are born as a natural extension of research that happens in the laboratory

Some startups have also been born out of the founders' social concerns. Sanjiv Sambandan, an assistant professor at the Department of Instrumentation and Applied Physics, once saw army personnel drinking what seemed like non-potable water and set out to find a solution to the problem. Three years later, he boasts of a device capable of purifying 1000 liters of water every day, without any membranes or chemicals. With his device, Sambandan and his team romped home to victory in the Google PitchFest in Zurich last year. His startup openwater.in, seeks to make clean water accessible to all, i.e. *open*.

Even more fascinating is the story behind the startup PathShodh, whose product could revolutionize the diagnosis of diabetes. Vinay Kumar, who has insulin-dependent diabetes, contacted Navakanta

SciDogma Research

SciDogma Research has developed an automated microscope that is capable of detecting the malaria parasite from a blood smear. The invention is the brainchild of Satya Tapas, a former postdoctoral fellow in the lab of MRN Murthy (Professor, Molecular Biophysics Unit). In diagnostic labs, parasite counts are obtained by manually counting them under a microscope. This can potentially lead to human error, and result in misdiagnosis. Diagnostic procedures are also costly and time consuming. This

SATYA TAPAS

portable microscope performs the entire test automatically from just a blood smear. The device was the runner-up at Stanford Medicine X Health Care Design Competition in 2016.

Bhat, a professor at the Centre for Nano Science and Engineering (CeNSE), asking if he could contribute to Bhat's efforts in building biosensors for diabetes management. Soon Vinay joined Bhat's lab for a PhD which the highly motivated student finished in just two years. But Vinay and Bhat did not stop there. In 2015, they teamed up with Gautam Sharma to start PathShodh. PathShodh's offering is a phablet sized device that can test eight parameters critical for diabetics.

Challenges

Being an entrepreneur is tough. Being an academic *and* an entrepreneur doubly so. In 2000, when some IISc professors decided to found startups, they were asked by the administration to choose between the two. They chose entrepreneurship. "It was a loss for us, in some sense," remarks Anurag Kumar, the Director of the Institute. Since then, however, IISc has considerably loosened its rules to promote the spirit of entrepreneurship. Professors are even allowed to take sabbaticals to focus their energies on their startups. Bhat is currently on a sabbatical, overseeing PathShodh. All the entrepreneurs seem to generally agree on another big challenge: investors are suspicious about ideas fresh out of the laboratory. Besides, many entrepreneurs face problems that are unique to their startups. "People lose interest the minute they hear the word *space*. I suspect it has to do with the ignorance surrounding the term," regrets HL Prasad, who co-founded Astrome which seeks to deliver high-speed internet using satellites. And some have to constantly juggle their startup work with their day jobs. Or in the case of fifth year undergraduate Shayan Banerjee, his course work. "I don't even have the luxury of a flexible schedule like a grad student does," he sighs.

To overcome such challenges, Ramnath offers us a final nugget of wisdom: "The biggest challenge is to not become too attached to your idea. Startups fail when entrepreneurs fool themselves into believing the public wants their product," echoing Richard Feynman who said: *the first principle is that you must not fool yourself—and you are the easiest person to fool*.

"The biggest challenge is to not become too attached to your idea. Startups fail when entrepreneurs fool themselves into believing the public wants their product"

Looking Ahead

In spite of the many challenges, the startup scene in IISc seems well poised to take off in a serious way, especially with the support of the management. "Now we have time tested policies for all sorts of entrepreneurship," says Anurag Kumar. The Institute also constantly revises its policies on entrepreneurship to keep abreast of changing trends. "In fact, the Governing Council approved a revised policy on IP and entrepreneurship when it met in June," he adds.

In spite of the many challenges, the startup scene in IISc seems well poised to take off in a serious way, especially with the support of the management.

Existing startups are ready to scale it up in a big way in the coming years. Astrome is on track to launch its first set of satellites in 2019, providing cheap satellite-streamed internet. PathShodh's device, if successful, will usher in a big revolution in diabetes management. Historically, a number of companies which today are highly influential have all had humble beginnings in universities. From Facebook (Harvard) to Google (Stanford) to Dell (UT Austin), they can all be traced back to university dorms. Some say it is the combination of ambition and intellect that universities foster. Some call it the multidisciplinary atmosphere that allows cross-pollination of ideas. Whatever the reason, it is clear that universities are where entrepreneurial magic happens. We can only wait and watch what magic IISc's startups manage to weave in the coming years.

(The author thanks Navin S, Megha Prakash and Aravind Rao for their help)

openwater.in

openwater.in's offering is a new water purifying system, which can effectively convert sewage into potable water. Created by Sanjiv Sambandan (Assistant Professor, Department of Instrumentation and Applied Physics), Karthik Raghunandan and his team, the device uses field effect technology, removing the necessity for any chemicals or membranes. openwater.in is also involved in *Shukla Ganga,* an ambitious project to map pollutant concentrations across the Ganga river basin.

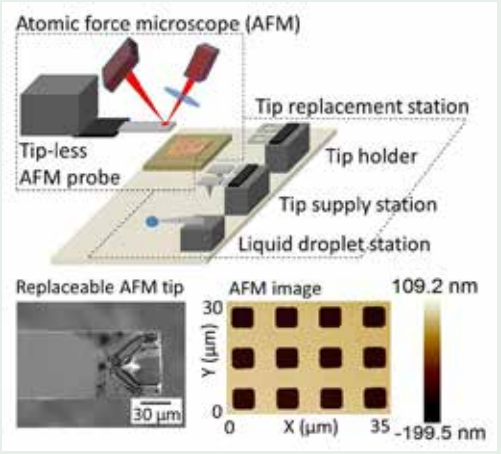
KARTHIK RAGHUNANDAN

HOT OFF THE PRESS

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

MICROSCOPY

A system to reuse the tips of an AFM probe



Courtesy: R SRI MUTHU MRINALINI AND GR JAYANTH

An Atomic Force Microscope (AFM) uses a sharp tip permanently attached to a cantilever to image objects at nanometre scale. The AFM tips, however, wear out when repeatedly used for scanning, requiring the entire probe to be replaced. Besides, the new probe then has to be recalibrated for sensitivity.

Now, researchers in the Department of Instrumentation and Applied Physics have devised a system to quickly replace and re-use only the tips of the AFM probe. The new system employs a liquid meniscus-based microgripper at the end of the AFM cantilever to pick up a new tip, grip it during imaging and then drop it off after use.

Published in: *IEEE/ASME Transactions on Mechatronics*

Read more at: http://dx.doi.org/10.1109/TMECH.2016.2544401

NEURODEGENERATIVE DISEASES

New genetic mutations found for neurodegenerative diseases

Researchers at the Department of Molecular Reproduction, Development and Genetics, working with collaborators, have identified five new genetic mutations in individuals suffering from a group of related neurodegenerative diseases.

The researchers analyzed DNA samples from families of 22 Indian individuals who suffer from disorders caused by alterations in a gene called PLA26G. This gene provides instructions for making an enzyme that helps break down fats called phospholipids in our body. Mutations in this gene cause neurological disorders which lead to slower body movements, tremors, and problems with vision and brain function. The five new mutations add to the 124 already identified across the world.

Published in: *PLoS ONE*

Read more at: http://dx.doi.org/10.1371/journal.pone.0155605

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

HYPERSONICS

A better way to study heat transfer at hypersonic speeds

Courtesy: S SRINATH AND KPJ REDDY

Hypersonics is the study of objects moving at speeds greater than five times the speed of sound, or Mach 5. Heat transfer rates in a material travelling at such speeds is typically measured using thin films of metals such as platinum or nickel, which are expensive. The thin films have to be able to respond quickly to enable such measurements during experiments in a hypersonic shock tunnel.

Researchers in the Department of Aerospace Engineering replaced the thin films of metal with those of large carbon clusters (LCC), cutting the costs and improving the response times of these measurements. When they used the LCC thin films on models that replicate entry into the atmospheres of Earth and Mars, they found it outperformed the platinum thin films.

Published in: *Measurement Science and Technology*

Read more at: http://dx.doi.org/10.1088/0957-0233/26/2/025901

GREEN TECHNOLOGY

An alternative to plastic packaging for organic electronics

Researchers from the Centre for Nano Science and Engineering and the Department of Materials Engineering have developed a moisture-impermeable graphene-polymer composite film suitable for packaging organic electronic devices.

They first obtained a uniform graphene monolayer over large area copper foils using chemical vapour deposition. Polymers were then melt-casted on the graphene-copper foil substrates and the copper foils etched away, thus obtaining the graphene-polymer composite films. This composite film can protect organic electronic devices from atmospheric water vapour, while retaining the transparent and flexible nature of presently available polymer packaging. In a similar way, graphene could be potentially used to make paper impermeable, saving much plastic packaging waste.

Published in: *ACS Nano*

Read more at: http://dx.doi.org/10.1021/acsnano.6b02588

SOLAR ENERGY

Study of solar power panels inside IISc campus

In an effort to understand the performance of solar photovoltaic systems in Bangalore, researchers at the Divecha Centre for Climate Change monitored the one installed on the roof of the JRD Tata Memorial Library for about three years. They found that its performance parameters were comparable to those of systems elsewhere in the country.

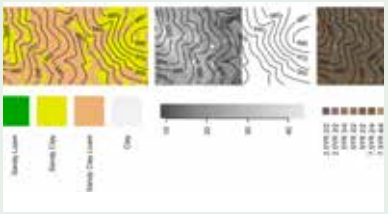
However, as the modules became hot during the summers, their performance suffered. In particular, they found that the performance ratio, a measure of the energy that is actually available for export to the grid after deducting various energy losses and the energy required for operation of the system, was inversely proportional to the module temperature.

Published in: *Solar Energy*

Read more at: http://dx.doi.org/10.1016/j.solener.2016.02.013

ECOLOGY

Soil variability in a dry tropical forest


Courtesy: R SUKUMAR'S LAB

A team at the Centre for Ecological Sciences studied how soil characteristics in the Mudumalai Wildlife Sanctuary, a seasonally dry tropical forest, depend on lithology (characteristics of rock), topography, vegetation and fires.

They found the chemical composition of the parent rock to be the most important factor influencing soil variability, followed by the topography of the region. Contrary to the general observation that lower elevation soils are richer in nutrients, the study found that higher elevation soils had greater stocks of several plant nutrients, moisture, organic matter and clay. This finding could be an important tool in determining soil quality for future restoration projects.

Published in: *PLoS ONE*

Read more at: http://dx.doi.org/10.1371/journal.pone.0153212

NANOSENSORS

A better sensor for atmospheric CO_2

Sensors for CO_2 based on absorption spectroscopy are not very sensitive to lower concentrations of CO_2 and are expensive and bulky, precluding large scale deployment. Now, researchers at the Centre for Nano Science and Engineering have developed a low-cost sensor that can detect CO_2 in concentrations as low as 400 parts per million.

The new sensor is a heterojunction diode, with the interface between thin layers of barium-titanium oxide and copper oxide forming the heterojunction. The addition of silver on metal oxide catalyzes the detection process. When CO_2 comes into contact with the sensor, a chemical reaction ensues, changing the electrical properties of the diode junction. This changes its resistance value which corresponds to the CO_2 concentration.

Published in: *IEEE Sensors Journal*

Read more at: http://dx.doi.org/10.1109/JSEN.2016.2567220

CLIMATE SCIENCE

Why CO_2 is more efficient at warming the Earth than sunlight

Although increasing levels of CO_2 in the atmosphere is the major culprit in global warming, an increase in solar radiation can also contribute to this problem—but it is not as effective as CO_2 in warming up the atmosphere. Scientists from the Divecha Centre for Climate Change, working with collaborators abroad, have proposed climate models and simulations to explain this puzzle.

The study will allow scientists to make improved predictions of how the climate would respond to changes in the amount of sunlight on long time scales and also to events such as volcanic eruptions and changes in glacial cycles. It could also help scientists interpret past climatic changes.

Published in: *Environmental Research Letters*

Read more at: http://dx.doi.org/10.1088/1748-9326/11/4/044013

DISPATCHES FROM THE LAB

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

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

AJAY SOOD

(HONORARY PROFESSOR, DEPARTMENT OF PHYSICS)

MANOJ SUDHAKARAN

GLASS, GRAPHENE AND MORE

In 2015, in recognition of his significant contributions to diverse areas of physics, Ajay Sood was elected as a Fellow of The Royal Society, the most prestigious scientific body in the world. Much like his previous work, Sood's recent research—ranging from flocking behavior to the formation of glass—reflects the diversity and the interdisciplinary nature of his interests.

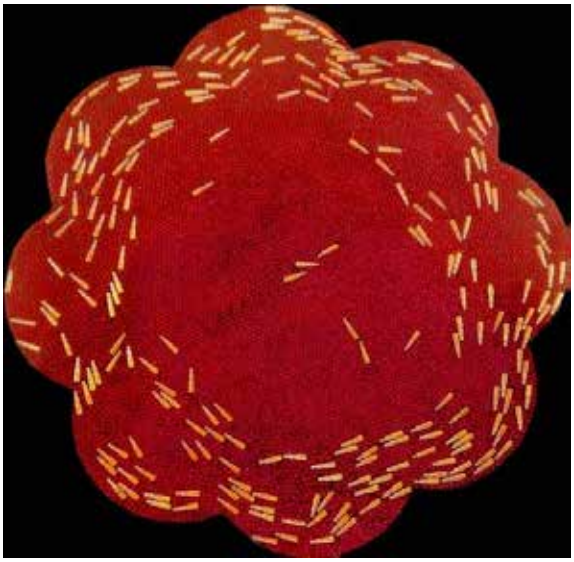
Flocking is a collective motion of self-propelled entities, an example of how complex group behaviour can emerge from simple rules followed by individuals with no central coordination. Sood and his group are studying this phenomenon using small metal spheres and brass bits. This study would help in understanding how organisms like microbes, ants, birds, etc., aggregate and move together; this,

in turn, may also help in evolving more effective protocols in managing crowds and traffic which are also self-organizing phenomena.

Much like his previous work, Sood's recent research—ranging from flocking behavior to the formation of glass—reflects the diversity and the interdisciplinary nature of his interests

Towards ultrafast optoelectronic applications of graphene, Sood's experiments on optical pumps—terahertz probes—using femtosecond laser pulses have provided insights into the microscopic behaviour of photoexcited electronic carriers in graphene. The dominant processes contributing to the photo-conductivity have been delineated for the first time in a quantitative way.

Sood's team has also developed a new sensitive and accurate platform for biosensors using nanomaterials like graphene and etched Fibre Bragg Grating (eFBG) in collaboration with S Asokan, a Professor at the Department of Instrumentation and Applied Physics. This has been used to detect C-reactive protein (CRP), a biomarker to indicate inflammation in the body. The CRP detection has been carried out by monitoring the shift in Bragg wavelength of an eFBG.



Courtesy: SOOD'S LAB

Flocking in active granular media

Most recently, Sood's lab, working with Dipankar Chatterji of the Molecular Biophysics Unit and R Ganapathy of the Jawaharlal Nehru Centre for Advanced Scientific Research, has developed a micro heat engine powered by changes in bacterial activity. The engine can run at an efficiency of 50-60 percent.

Sood is also collaborating with Ganapathy to address a long-standing unsolved problem of how glass is formed using colloidal systems and experimental probes of confocal microscopy and holographic optical tweezers.

MANOJ SUDHAKARAN

Sood with his team

PRADIP DUTTA
(PROFESSOR, DEPARTMENT OF MECHANICAL ENGINEERING)
AND
PRAMOD KUMAR (PROFESSOR, DEPARTMENT OF MECHANICAL ENGINEERING)

MANOJ SUDHAKARAN

TOWARDS CLEANER, CHEAPER AND MORE EFFICIENT POWER GENERATION

Today's thermal power plants use steam to carry heat away from the source and turn a turbine to generate power. However, one could generate more power if, instead of steam, supercritical carbon dioxide (S-CO_2) is used. The term "supercritical" describes the state of carbon dioxide above its critical temperature of 31°C and critical pressure of 73 atmospheres, making it twice as dense as steam.

The efficiency of energy conversion could also be significantly increased—by as much as 50 percent or more—if S-CO_2 is operated in a *closed loop Brayton cycle*. Besides increasing power generation and making the process more efficient, there are other advantages of using this new technology. Smaller turbines and power blocks can make the power plant cheaper, while higher efficiency would significantly reduce CO_2 emissions for fossil fuel based plants. Moreover, if the power plant used solar or nuclear heat source, it would mean higher capacity at lower operating costs.

In order to help make this technology a reality, a research group led jointly by Pramod Kumar and Pradip Dutta is setting up the world's first S-CO_2

based solar thermal test loop at the laboratory scale at the Interdisciplinary Centre for Energy Research in the Institute. This test loop is designed to generate the necessary data for future development of scaled up S-CO_2 power plants. But this would require overcoming several technological challenges– developing critical components such as the turbine, compressor and heat exchangers that can work at the desired pressure and temperature ranges, and using materials that can withstand these conditions.

In order to help make this technology a reality, a research group led jointly by Pramod Kumar and Pradip Dutta is setting up the world's first S-CO2 based solar thermal test loop at the laboratory scale at the Interdisciplinary Centre for Energy Research in the Institute

In spite of these challenges, the group has made tremendous progress over the past three years. They have developed optimized thermodynamic cycle designs, heat transfer and fluid flow codes for designing the test loop, critical components such as compact heat exchangers and solar receivers, and

Courtesy: PRADEEP DUTTA

A model of the S-CO_2 Test Loop Facility at ICER

state-of-the-art instrumentation along with loop control sequence algorithm.

This effort is part of an Indo-US project, which has already been identified as a possible national initiative for the next generation of solar thermal power plants. This gives India an opportunity to become a world leader in this technology and fulfill a major objective of the National Solar Mission which emphasizes indigenous manufacturing.

KG HARIDASAN

Dutta and Kumar with their team

KAMANIO CHATTOPADHYAY
(HONORARY PROFESSOR, DEPARTMENT OF MATERIALS ENGINEERING) AND
DEBIPROSAD ROY MAHAPATRA
(PROFESSOR, DEPARTMENT OF AEROSPACE ENGINEERING)

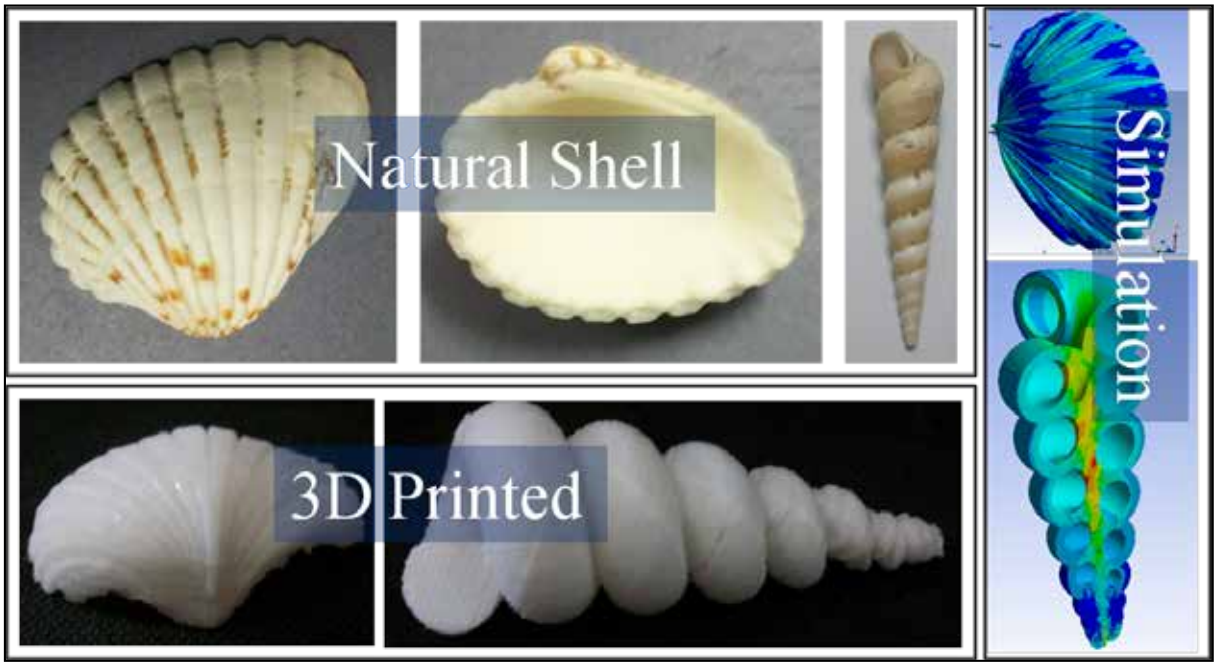
MANOJ SUDHAKARAN

DESIGN INSPIRED BY NATURE

Kamonio Chattopadhyay, a materials engineer who has done pioneering work in the field of crystal structures, and Debiprosad Roy Mahapatra, an aeronautical engineer who works on engineering mechanics, were brought together by a mutual interest in designing futuristic materials inspired by nature.

By a process of trial and error over millions of years, natural selection has shaped evolutionary traits that help animals and plants survive, often in adverse environmental conditions. One such example is the shell of the mollusk. Many of these marine animals live in the deep seas and have to withstand enormous pressure. How these animals protect themselves from stress and fracture was a question that intrigued Chandrasekhar Tiwary— a former PhD student with Chattopadhyay—when he stumbled upon them as he took a stroll on a beach in Pondicherry.

Chattopadhyay and Mahapatra decided to investigate this question with Tiwari and his new postdoctoral advisor, Pulickel Ajayan, a professor at Rice University in the US. With the help of mechanics theory and experiments, they found that these animals secrete shells with an optimal thickness to deal with their marine lifestyle. Also, they have



Courtesy: K CHATTOPADHYAY AND DR MOHAPATRA

complex shapes that enable them to transfer stress from the outer surface to particular locations of geometric concentrations. At great pressures deep in the sea, this design of the outer shell allows the soft-bodied animal inside to survive because even if there is a fracture, it occurs in these sturdy parts. Their hypothesis was confirmed by mechanical tests performed on models created using 3D printing.

Besides helping us understand how nature has driven the evolution of life forms, this study could have a wide range of implications in many diverse fields, from designing aircrafts that are safer and more damage tolerant to constructing buildings that protect against environmental calamities.

Besides helping us understand how nature has driven the evolution of life forms, this study could have a wide range of implications in many diverse fields, from designing aircrafts that are safer and more damage tolerant to constructing buildings that protect against environmental calamities. Chattopadhyay and Mahapatra hope that their findings, along with information emerging from other such studies, could help us design and engineer a new generation of materials.

Other collaborators who participated in the research

ON CAMPUS

In conversation with guests of the Institute

HASSAN ANNEGOWDA RANGANATH: A BIOLOGIST WHO HAS WORN MANY HATS

✍ **MEGHA PRAKASH**

CONNECT

Though Hassan Annegowda Ranganath has been a researcher, administrator, and an accreditator of higher education, he has always been a teacher at heart. After a long journey in academics, he now teaches undergraduate students biology at IISc. CONNECT *takes a closer look at his illustrious journey.*

Research and Teaching: University of Mysore

After getting his PhD from the University of Mysore, Ranganath began his scientific career as a researcher and teacher at his alma mater. For his research, he studied how new species evolve using the fruit fly (*Drosophila*) as a model system. Ranganath carried on the rich tradition of studying evolutionary genetics at the University of Mysore. Here, he worked in the Department of Studies in Zoology which was founded by MR Rajasekarasetty, a *Drosophila* researcher himself, who was greatly influenced by pioneers in the field, including Theodosius Dobzhansky.

What made the Department unique was not just the quality of research it produced in evolutionary genetics, but also the training and education it imparted. Ranganath played a crucial role in advancing this tradition too. He was instrumental in setting up a national facility called the *Drosophila* Stock Centre which maintains over 40 species and 2000 genetic stocks of *Drosophila*, collected from different laboratories from across the globe and also from other Indian research institutions. The Centre, initially funded by a generous grant provided by the Department of Biotechnology (DBT), does more than just provide stocks of flies to colleges and universities.

Courtesy: HA RANGANATH

***Drosophila* Stock Centre**

Experiments using *Drosophila* have been vital to the growth of genetics, especially developmental and evolutionary genetics. Students of genetics

ANDRÉ KARWATH/CREATIVE COMMONS LICENCE/WIKIMEDIA COMMONS

Drosophila melanogaster **(Fruit fly)**

the world over are trained in handling and experimenting with these flies. However, in many colleges and universities in India, teaching genetics was, and sometimes still is, restricted to using blackboards in the classroom. The *Drosophila* Stock Centre at Mysore University not only serves as a stock centre (more than 400 institutions from all over India use this facility), but also conducts workshops, where teachers and students learn how to carry out experiments in genetics using *Drosophila*. What's more, the Centre supports short term research projects of students from across the country. At the University of Mysore, Ranganath also helped in setting up of the Unit on Evolution and Genetics funded by the Department of Science and Technology (DST).

Ranganath, who is an elected fellow of all the three science academies of India, has conducted several lecture workshops and refresher courses as part of the outreach activities of the academies. His election to all the three science academies of the country is a testimony of his three-decade long scientific journey and contributions he has made to the field of genetics.

Donning the Role of an Administrator: Bangalore University

After an illustrious career at the University of Mysore, Ranganath moved to Bangalore in 2006, when he was appointed as the Vice-Chancellor of Bangalore University (BU). Here, though he was preoccupied by his duties as the Vice Chancellor, he ensured that he made time to teach and be with students. "Amidst all the administrative responsibilities, I was happy to take an hour-long class on genetics, the first class in the morning. You will not believe it, but it also helped me as an administrator. This made other teachers come on time and take regular classes [smiles]," he says.

Ensuring Quality in Education: National Assessment and Accreditation Council

At the end of his tenure as Vice-Chancellor of BU in 2008, Ranganath was chosen to head the Bangalore-based National Assessment and Accreditation Council (NAAC), a statutory body established by the University Grants Commission (UGC), responsible for quality assessment of higher education in India. Ranganath says that an institution becomes eligible for accreditation only after a minimum of 5 years after it has started functioning or after 2-3 batches of students have graduated. This, he explains, gives the institution an opportunity to be equipped with basic infrastructure such as trained faculty and staff, land, staff room, library, etc.

Ranganath argues that though some people perceive accrediting bodies as fault-finding machines, accreditation has many benefits. He compares accreditation to a 'health check-up', a process which helps identify the strengths and weaknesses of an institution, as well as the administrative and academic gaps that need to be plugged. He says that accreditation also lets the public become aware of the quality of an institution and aids policy makers take funding decisions. Though he is a proponent of accreditation for institutions of higher education, Ranganath warns that focusing on accreditation alone cannot improve the quality of higher education in India.

He [Ranganath] compares accreditation to a 'health check-up', a process which helps identify the strengths and weaknesses of an institution, as well as administrative and academic gaps that need to be plugged.

One other related issue that Ranganath highlights is that higher education in India—which he is passionate about—is regulated by too many bodies, including UGC, National Council for Teacher Education (NCTE), All India Council for Technical Education (AICTE) etc. While acknowledging that they all have their roles to play, he suggests setting up of a single overarching body to regulate, control, interact and synchronize the activities of these bodies. Ranganath, however, feels that there have been moves afoot towards more coordination between the different bodies involved in higher education.

The other issue that ails higher education in the country, according to Ranganath, is the lack of trained manpower. He points out that the reason why we do not always get qualified and experienced faculty is because higher education in our country is just not a priority for policy-makers. For example, he says, when an Election Commissioner or a Chief Justice or for that matter any government official is about to retire, the government is proactive in announcing their successor immediately. He contrasts this with an academic set up, where a committee is formed only in the last minute, even for an important appointment like that of a Vice-Chancellor. This is why many administrative positions lie vacant in Indian institutions, Ranganath explains. He feels that the country needs an autonomous 'Commission for Higher Education and Research' to "mentor this domain".

Teaching Undergraduates: IISc

Ranganath says that the day he stepped down as the Director of NAAC in 2014, he wanted to get back to his first love—teaching. When the opportunity arose to teach in IISc's undergraduate programme, he immediately jumped at it. Though it was the beginning of new chapter in his life, the Institute was not new to him. His association with IISc dates back to his days as a researcher at the University of Mysore. "Back then, I had the fortune to interact with Raghavendra Gadagkar (Professor, Centre for Ecological Sciences) who is also interested in biological diversity, speciation, genetics, etc.," he recalls.

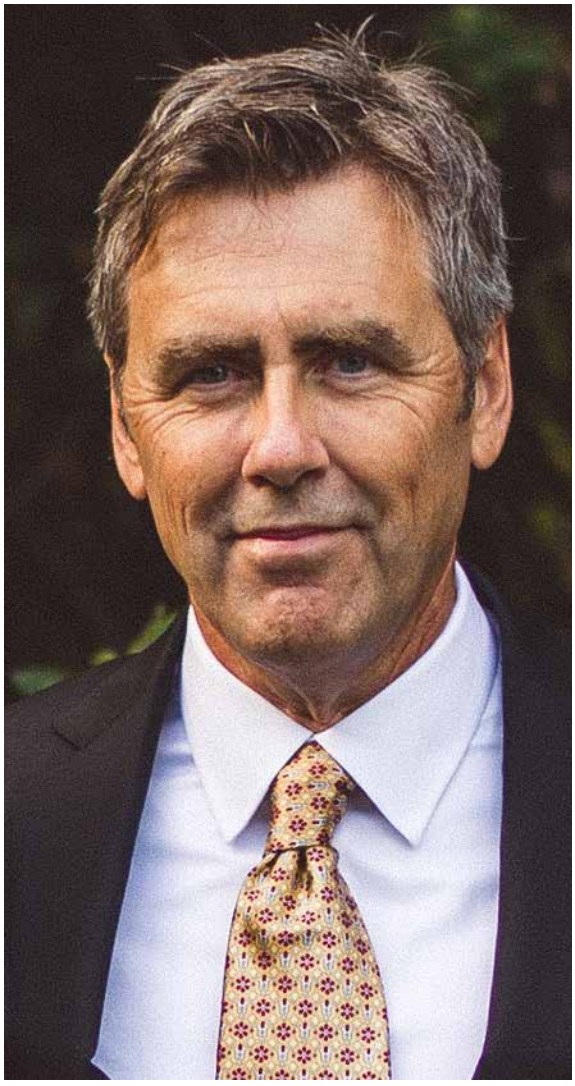
At IISc, Ranganath is delighted with the performance of the undergraduate students. He says, "Their performance is almost equivalent to that of PhD students—the way they interact, conduct their projects and give project presentations. Within 2-3 years of joining IISc, these students undergo a complete transformation. Their outlook changes, they mature and performance is fine-tuned."

Ranganath believes that the undergraduate (UG) programme initiated by IISc should be replicated across the country. "It is an excellent strategy by IISc to start the BSc (Research) and MSc (Research) programmes which is helping in preparing the next generation of potential teachers and researchers. There may be defects or drawbacks, but it is an excellent idea by the Institute to embark on this programme. Such training was not seen in any other traditional university which I visited as the Director of NAAC. I could say that the facilities provided at IISc are distinct and unique. Moreover, a striking feature of the UG programme at IISc is its focus on student-teacher interaction supplemented with a well-crafted curriculum. This makes it unique," he adds.

Finally, Ranganath wishes that IISc, with its expertise in almost all disciplines of basic sciences and modern laboratory infrastructure conducts refresher courses regularly for college teachers to empower them and also expose them to new methods in teaching and the research ambience of the Institute. This will add to its "Institutional Social Responsibility", he says.

THOMAS D ALBRIGHT: NEUROSCIENCE AND BEYOND

✍ **SUDHI OBEROI**



Courtesy: THOMAS ALBRIGHT

Thomas D Albright is the Director of the Vision Research Center at The Salk Institute for Biological Studies. He is a pioneer in the study of visual perception and memory in primates. Albright, a former DST-IISc Chair Professor, is also among the board of directors of the Academy of Neuroscience for Architecture. He spoke with CONNECT *during his visit to the Institute to attend the 4th Bangalore Cognition Workshop organized by the Centre for Neuroscience.*

Q You have a close association with India. Tell us more about it.

My first wife was Indian and I travelled to India with her for the first time in 1983. I fell in love with the country. I had read everything there was to read—travel books, novels and history books; I even saw films by Satyajit Ray. But nothing prepared me for India completely. It was the rich sensory experience that I had never had before. After that first visit I decided that I would like to spend a year in India. My wife's family knew people in academia and I asked them if there was any possibility for me to do a postdoctoral fellowship in India. This was back in 1983 and I was told that there was no neuroscience in India, and even if there were, there wouldn't be any money to pay an American. So I came back to India in 2003 after a long hiatus of 20 years. The people here are so wonderful and now after many visits I still feel that way about India. It is a very welcoming country.

Q How did you get interested in neuroscience?

I was always interested in human behavior and also fascinated by the sense of sight. But I had no idea how visual perception worked. So when I went to University of Maryland as an undergraduate, I had an opportunity to work with a distinguished neuroscientist, Bill Hodos, who was studying visual perception in birds. At around the same time in late 1970s, [David] Hubel and [Torsten] Wiesel had just done their pioneering work on information processing in visual system. Bill suggested that this was the future of neuroscience and encouraged me to go in that direction. So I went to Princeton University for my graduate studies where I worked under the guidance of Charlie Gross who was studying the inferotemporal

cortex to answer similar questions. There had been neuropsychological studies showing that damage to the inferotemporal cortex leads to impairment in visual object recognition, suggesting that it had both role in vision and memory because you cannot recognize objects as you do not have a memory of it. For my PhD, I studied motion sensitive cells in the middle temporal area (area MT) of primate visual cortex. I continued as a postdoctoral fellow in the same lab for a few more years. When Charlie was away on sabbatical, I was more or less running the lab, and had the opportunity to set up some very promising experiments. But after 8 years, I was tired of Princeton, and so when I was offered a job at The Salk Institute for Biological Studies in San Diego, I jumped at the opportunity.

Q What does your lab study?

While setting up my lab, I became increasingly interested in neural responses that correlate with perceptual experience rather than simply correlating with the properties of the retinal stimulus. To get at this we started doing experiments in which we would manipulate context to understand the neuronal basis of perceptional experience, since context can determine the specific percept elicited by a particular stimulus. For instance, the perceived colour of a stimulus depends very heavily on the surrounding colour. So we would look at whether colour coding cells in the visual cortex responded to physical colour (the wavelength of light on the retina) or whether the response was correlated with the perceived colour. We found that the responses of many cells were correlated with perceived colour. So contextual manipulations gave us the means to identify neuronal correlates of perception. We pioneered a lot of these studies and the results were really striking. Then at some point my interests expanded to the topic of memory. Memory is of course another form of context—temporal context—and we've since made a number of discoveries about how memory signals interact with visual signals ascending from the retina, yielding coherent perceptual experience.

"Memory is of course another form of context—temporal context—and we've since made a number of discoveries about how memory signals interact with visual signals ascending from the retina, yielding coherent perceptual experience"

Q Are there any practical applications of your research?

I think they are pretty profound. I was asked a couple of years ago to chair a committee for the US National Academy of Science (NAS) to look at the validity of eyewitness identification testimony, a very common form of evidence in the court for police investigations. We tend to believe people when they say that, "I saw this with my own two eyes!" But in fact, if you think about the role of context in visual processing you will realize that in many cases, the thing that you expect to see, given the context you are in, has the potential to bias your perceptual experience. Similarly, people commonly believe that if information about visual experience is placed into memory it remains there in original form, much like a videotape recording. But that's not how memory works; it is a constantly evolving representation of your experience, and so it can be modified—indeed, contaminated—if you are exposed to new information, which happens very commonly in eyewitness identification. So our NAS committee made a number of recommendations for the procedures that can be used by law enforcement to gauge the quality of eyewitness identification along with suggestions for how the process can be improved.

"Our NAS committee made a number of recommendations for the procedures that can be used by law enforcement to gauge the quality of eyewitness identification along with suggestions for how the process can be improved"

Q You are a member of the Academy of Neuroscience for Architecture. Could you tell us more about it?

Yes, I have a big interest in architecture and I have been a member of the governing board of this academy for the past 12 years. It's a growing enterprise involving neuroscientists and architects, the goal of which is to bring our expanding knowledge of brain organization, function and plasticity to bear on architectural design. It is encouraging to see that neuroscience is willing to think outside the medicine box.

"It is encouraging to see that neuroscience is willing to think outside the medicine box"

Q Could you tell us a bit about your relationship with the neuroscientists here at IISc and the growth of the field in India?

Back in 2003, I was invited to a meeting in Delhi which was hosted by the National Brain Research Centre (NBRC). I met many Indian scientists including Aditya Murthy, Shyamala Mani and Vijayalakshmi Ravindranath who were then at NBRC. That was my re-connection to India through neuroscience and eventually to IISc, where we started hosting the Brain and Cognition Workshop.

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Indian neuroscience has grown so much and neuroscience here at IISc is now world class. It has become more sophisticated. Indian investigators have access to strong funding sources and to the same equipment and resources we use for research in the US. They are now able to compete with scientists from Europe and the US, and institutions like IISc are increasingly successful at recruiting top Indian neuroscientists. I'm also delighted by the growth and continued success of the Bangalore Cognition Workshop. The organizers of this workshop now have a reputation with major funding agencies that support the programme, and I think it is a really valuable thing for neuroscience research and training in India.

"Indian neuroscience has grown so much and neuroscience here at IISc is now world class"

Q What in your opinion are the interesting areas in neuroscience that we should look out for in the next couple of years?

In my own field of information processing in the cerebral cortex—which is three quarters of the human brain—there are many things that we don't know, including how information is communicated up through the visual processing hierarchy and what is the nature of the computation at each successive stage of processing the transfer function. We are at a period in the evolution of the field of neuroscience where a lot of research is driven by new technologies. The *Obama Brain Initiative* illustrates this point. The focus of the brain initiative from the beginning has been on technology development, but powerful new technologies that emerge will eventually lead to sensational new discoveries. For example, I recently attended a talk by Ed Boyden from MIT who spoke on developments in optical microscopy in the past decade and efforts underway to overcome diffraction limits in imaging. The idea is that rather than making microscopes stronger, we should think about making the tissue bigger. This effective imaging technique called expansion microscopy and other such out-of-the-box ideas are transforming the field.

TRANSLATING RESEARCH INTO PRODUCTS

The Society for Innovation and Development (SID) serves as a bridge between research labs and the marketplace

✍ **NAVIN S**

"Freedom without the strength to support it and, if need be, defend it, would be a cruel delusion. And the strength to defend freedom can itself only come from widespread industrialization and the infusion of modern science and technology into the country's economic life."
— JN Tata

Tucked away in a quiet corner of the IISc campus, lies a rather nondescript building, with the Mariamma Temple on one side and the National Science Seminar Complex on the other. The building, obscured by the colourful foliage surrounding a lively pond at its entrance, houses the office of SID. However, the relaxed ambience that pervades this building stands in stark contrast to the entrepreneurial energy of the place.

SID is a novel experiment. "It *is* the first ever research park set up in the country and pioneered the framework for faculty entrepreneurship in India," beams B Gurumoorthy, its Chief Executive (and a professor at the Mechanical Engineering department and the Centre for Product Design and Manufacturing), when queried about what renders SID unique. "Even within the Institute, SID enjoys a special status. It pays its own taxes, files its own returns and even has its own Board of Governors, of which the Director of IISc is the ex-officio Chairman," he adds.

Early Years

SID was registered as a society under the Karnataka Societies Act in 1991. "It was set up to partner with industry for creating new knowledge, to monetise the Institute's intellectual properties

and also to encourage entrepreneurship," explains Gurumoorthy. To draw from, and provide access to, the intellectual and infrastructural resources of IISc, SID facilitates three modes of engagement with industry—agreements where a faculty and a firm collaborate on a particular research project; "umbrella agreements" with companies that wish to engage with a large number of faculty from several departments, covering the intellectual property (IP) exchange and other issues for different projects; and agreements with companies for "co-locating" their research labs in the IISc campus, enabling them to engage with the Institute's faculty and students while executing their projects. "The projects involving dissemination of know-how, or advisory interaction with industry, are handled by the Centre for Scientific and Industrial Consultancy," says Gurumoorthy.

The Startup Phenomenon

At the turn of the century, a group of four faculty at the Department of Computer Science and Automation—Swami Manohar, Ramesh Hariharan, Vijay Chandru and V Vinay—who were working on two ambitious projects in their Perceptual Computing Laboratory (PerCoLat), decided to commercialize their ventures. These projects went on to become path-breaking companies—Strand Life Sciences (originally Strand Genomics) and PicoPeta Simputers—setting the stage for the rise of entrepreneurship and startups at IISc. But not before SID's policies underwent a sea change to accommodate this new phenomenon.

"Back then at SID, faculty could do a research-oriented project with the industry, but, being government employees, there was no provision for them to start companies and hold equity," recalls Swami Manohar. "The very concept of faculty entrepreneurship did not exist in India at that point." Manohar and colleagues, therefore, pushed for creating a mechanism to facilitate technology translation through the startup route.

"The very concept of faculty entrepreneurship did not exist in India at that point"

Creating these rules was not easy, though. "We had to do significant groundwork to create a framework suited to India," he says. In particular, they had to ensure that, while the technology transfer happened and the startup founders reaped their due rewards, the Institute also benefitted. Manohar and his partners offered to be the guinea pigs for this model, under which Strand and PicoPeta were started.

In fact, when Ratan Tata visited SID in 2005 he remarked that he was "impressed with the calibre of the work being done to foster a greater spirit of innovation and creativity."

Impact on Innovation

Manohar believes that SID's foremost and unique contribution has been to create and formalize a faculty entrepreneurship policy that has enabled faculty to be involved in startups without relinquishing their positions at IISc. "This was the first such model in the country, which was later replicated in other government-funded institutions," he says. Once this policy was established, the grant for Technology Incubation and Development of Entrepreneurs (TIDE) from the Department of Electronics and Information Technology (in 2005-06), meant for investment in IT companies, and timely assistance from IISc's seasoned alumni, helped spawn a number of ventures in a short span of time, generating more requests for incubation from faculty and students.

However, the strict criteria for evaluation—the offering must be based on "deep science and technology (S&T)" and have the potential for a strong impact on society—ensures that run-of-the-mill companies are kept out of SID's ambit. To streamline the process further, a dedicated Entrepreneurship Cell (E-Cell) was started under SID to cater solely to the special needs of startups. In addition, the IP

Cell (now called the Office of Intellectual Property and Technology Licensing) was created to identify various avenues for commercializing IISc's patented technologies and come up with simplified and standardized agreements to serve IISc's needs and interests. These proactive measures have led to a flurry of companies, rooted in cutting-edge research, being incubated at SID in recent years.

Nurturing Entrepreneurship

CS Murali, who heads the E-Cell, and his colleague CV Natraj are the SID representatives who any entrepreneur, from IISc or otherwise, should first meet in order to take their idea or innovation forward. The duo orient aspiring entrepreneurs towards a business mindset—to evaluate if the idea can be taken to the market through a startup, or if it can be licensed-out, or if it is something that has no immediate value.

Entrepreneurship Centre

"That's something first-time entrepreneurs may not have thought much about. They might have a feel for what their technology can do, but it's also important to have a perspective on who's going to pay for it and how it can be sustained," explains Murali. Applicants are then invited to make a formal presentation before a committee comprising domain experts from IISc and the outside world. "Once the proposal gets accepted," says Natraj, "we spend a lot of time and effort with the team subsequently; the engagement is very intense."

"That's something first-time entrepreneurs may not have thought much about. They might have a feel for what their technology can do, but it's also important to have a perspective on who's going to pay for it and how it can be sustained"

In return for some equity (4–12%) in the startup, SID offers entrepreneurs the space to operate for two years, assistance with IPs, investment in the form of seed funding and access to advice and mentoring from alumni, faculty and domain experts with experience in running S&T companies. For all its help, SID expects that the team remains committed, passionate and inventive; there's at least one dedicated, full-time founder; and a thorough evaluation of the technology and the market domain is done. Once SID invests in a project, it does not take a seat on the board of the company; instead it assumes a "Board Observer" position to oversee activities, ensure that IISc's reputation is not jeopardized and make sure that the IPs are not misused and the investment is not frittered away. There are also regular discussions to ensure the teams stay focussed and remain aggressive in spotting business opportunities. At the end of two to three years, SID expects the team to develop a product so that they can find either a paying customer or a venture capitalist to sustain their venture.

SID also has an Entrepreneurship-in-Residence programme to help entrepreneurs validate their ideas and develop business plans. This supports both the serial entrepreneurs, who have experience in monetising IPs but are searching for technologies, and fresh graduates, who have the ideas and technology but are looking for market opportunities.

Policy Making

The representatives of SID also participate regularly in meetings organized by think-tanks associated with various governmental decision making bodies,

including those by the Prime Minister's Principal Scientific Adviser, and actively suggest policy interventions based on SID's experiences.

The Way Forward

Despite these efforts, the general lament is that there haven't yet been a significant number of startups out of IISc. Nevertheless, Manohar is convinced that IISc has great potential for innovation because of the quality of research in both science and engineering being carried out in its campus, and that startups exploiting this synergy can create truly world-class products. But that can happen only if more faculty and students take the startup route.

Echoing these comments, Gurumoorthy says that getting faculty to engage more with industry and improving IISc's record of translating research and ideas into useful products that impact our society are priorities. "We are also looking to focus more on the MSME (Micro, Small and Medium Enterprises) and strategic sectors, including defence. On the other hand, we also want companies to engage more with our students through internship programmes and projects in a structured manner."

Efforts are also on to create a chest of funds to help deserving companies which need a longer incubation time to succeed. Towards this end, SID is vigorously bidding for several avenues of funding support, including government grants and corporate social responsibility funds. "The target," says Gurumoorthy, "is to get 30 companies, up from the current six, to establish research labs, five years from now. We also plan to start supporting at least 8–10 new startups annually and bring in at least four MSMEs into the system every year."

If things proceed according to SID's plan, it would go a long way towards delivering the benefits of academic research to society and fulfilling the vision of the Institute's founder, JN Tata, who had, in the words of his biographer Sir Dinshaw Edulji Wacha, "incessantly striven to promote the greater advancement of Science and Industrialism", more than a century ago.

CAMPUS CHRONICLES

A look at some of the events that took place in IISc in recent weeks

INDIAN WOMEN IN SCIENCE: WIKIPEDIA EDIT-A-THON

Courtesy: INDIABIOSCIENCE

Wikipedia editor L Shyamal guides new editors at the event

A Wikipedia edit-a-thon was organized at IISc on 16 July 2016 by IndiaBioscience to create awareness about the lives, and research by Indian women in science. During the event, participants, some of whom attended online, created new Wikipedia pages on Indian women in science, and also enriched existing pages with additional information and references. Two such edit-a-thons had been held in 2014.

During the event, L Shyamal, an experienced Wikipedia editor, walked the participants through the process of creating and editing Wikipedia pages, highlighting guidelines that would improve the quality of their contributions. In fact, one of the pages was deleted by Wikipedia administrators elsewhere even as it was being created by the participants of the event. This brought their attention to how important it was to insert good references in the new articles they create. Such references, however, are sometimes difficult to insert when many of our women scientists do not have detailed web pages, interviews or news articles in which they are featured.

Though impaired by certain rules on Wikipedia that do not allow a new user to create an article, eight articles were created during the event and at least fifteen existing ones were edited. The pages that were created included those on Sandhya Visweswariah, Chairperson, Department of Molecular Reproduction, Development and Genetics; Kusala Rajendran, Professor, Centre for Earth Sciences; Rohini Balakrishnan, Chairperson, Centre for Ecological Sciences; Sudhira Das, the first female engineer from Odisha; Kamala Krishnaswamy, Director of the National Institute of Nutrition; and Rashna Bhandari, Head, Laboratory of Cell Signalling at the Centre for DNA Fingerprinting and Diagnostics. An article about Renee M Borges, Professor, Centre for Ecological Sciences, was created in Hindi and one on Sudhira Das in Odiya.

✍ **P RAMYA BALA**

ESTABLISHMENT OF *FUTURE EARTH* SOUTH ASIA REGIONAL HUB

Courtesy: THE DIVECHA CENTRE FOR CLIMATE CHANGE

AS Kiran Kumar, Secretary, Department of Space, and Chairman, ISRO, addressing scientists during the inaugural session of the *Future Earth* meeting. Inset, left: SK Satheesh, Chair, Divecha Centre for Climate Change. Inset, right: AS Kiran Kumar, Anurag Kumar (Director, IISc), and M Rajeevan (Secretary, Ministry of Earth Sciences)

The South Asia regional hub of *Future Earth*, an international programme on global environmental change and sustainability supported by agencies including UNESCO and the United Nations Environment Programme, will be set up at the Divecha Centre for Climate Change, IISc. This was announced at an event held at the Centre on 9 July 2016.

Future Earth, which brings under its fold many existing international programmes including the International Geosphere Biosphere Programme and the World Climate Research Programme, has five global hubs, or secretariats, that are located in Canada, France, Japan, Sweden and the United States. These secretariats are complemented by regional hubs spread across the globe. The regional hub for South Asia will now be established at the Divecha Centre. "The South Asia regional hub," SK Satheesh, Chairperson of the Divecha Centre, said, "is an autonomous research platform that promotes scientific cooperation between India and neighbouring countries in *Future Earth* related activities. The regional hub will ensure that regional priorities are made part of the strategic development of *Future Earth* activities."

"The vision of *Future Earth* is 'Science for the People' and requires solutions-oriented research that responds to the challenges faced by the society due to global environmental change in collaboration with various research partners, decision-makers in government, the private sector and civil society," he added. In accordance with this spirit, the event was attended by more than 70 scientists from various government organizations, national laboratories and academic institutions, including Anurag Kumar, Director, IISc; AS Kiran Kumar, Secretary, Department of Space and Chairman, ISRO; and M Rajeevan, Secretary, Ministry of Earth Sciences.

The brainstorming session during the meeting saw discussions on some selected topics which are relevant to the South Asian region, such as the impact of climate change on the monsoon, extreme weather, water security, food security, air quality, and renewable energy. The regional hub will soon organize its first workshop to take this forward. "The mandate of this hub is to integrate the available information and develop strategic knowledge and region-specific strategies to tackle and face consequences of climate change," said Satheesh.

✍ **GAURAV GOVARDHAN**

The 4th Bangalore Cognition Workshop

Courtesy: AGRITA DUBEY

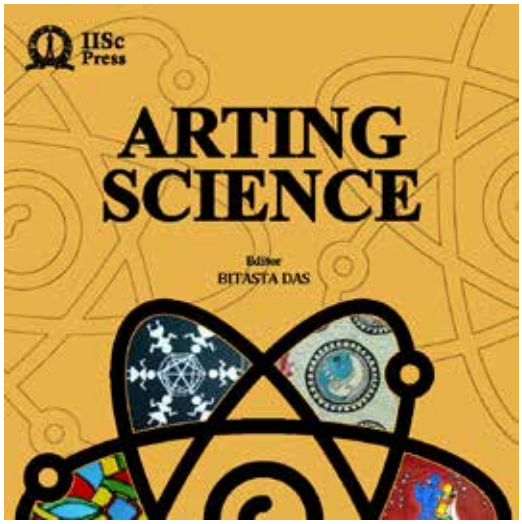
A panel discussion on vision during the Bangalore Cognition Workshop

One of the many open questions in neuroscience is cognition—the brain physiology underlying perception and functions such as vision, attention, movement and memory. To discuss recent developments and familiarize budding neuroscientists with the field, the Centre for Neuroscience (CNS) at IISc organized the Bangalore Cognition Workshop from 19 June to 2 July 2016 in collaboration with the International Brain Research Organization, the Indo-US Science and Technology Forum and the Wellcome Trust-DBT India Alliance.

In recent years, neuroscience has grown by leaps and bounds, mainly because of the interdisciplinary nature of research in the field. The workshop, now in its fourth edition, assembled experts from various disciplines from all over the world together with 40 students from leading institutions around India. "The biggest goal of this workshop," Supratim Ray, one of the organizers from CNS, told CONNECT, "is to bring an elite group of scientists to India and enable an effective discussion that motivates students to pursue neuroscience."

✍ **SUDHI OBEROI**

Book Launch by IIScPress



Courtesy: IIScPRESS

IIScPress organized an Authors' Reception on 16 June 2016, during which two books were released: *Arting Science, edited by Bitasta Das, a compilation of the art work done by students of an undergraduate course taught by Das and Mechanics, Waves and Thermodynamics: An Example-based Approach* by Sudhir Ranjan Jain. The event also featured a special talk by Suhas Mahesh in which he highlighted the versatility of Sanskrit, a language which enables the creation of remarkable patterns in its poetry.

✍ **KAVITHA HARISH**

Asian Science Camp 2016

Courtesy: LOCAL ORGANIZING COMMITTEE, ASC 2016

The 10th edition of the Asian Science Camp (ASC) was held at IISc from 21–27 August 2016. Over 220 students from 23 nations from around Asia, Australia and Oceania participated in the event organized by IISc through the Kishore Vaigyanik Protsahan Yojana (KVPY).

✍ **G MUGESH**

Summer School on Internet of Things

Courtesy: MICROSOFT INDIA

Amarjeet Singh, Chief Technology Officer, Zenatix, addressing the participants at the Summer School

A summer school on Internet of Things was conducted by Microsoft Research India in collaboration with the Department of Computational and Data Sciences (CDS) at IISc from 20–25 June 2016. This was part of an annual series, with a different theme each year, which aims to provide an opportunity for students to learn the fundamentals of a subject as well as state-of-the-art research.

✍ **SHISHIR G PATIL**

Decoding the Design Code

Courtesy: CPDM

Inauguration of DCODE by Anurag Kumar, Director of IISc

DCODE, a series of two-day knowledge and capacity-building workshops on design and development, organized by the Centre for Product Design and Manufacturing (CPDM), IISc, along with the Confederation of Indian Industry (CII) and the World Intellectual Property Organization (WIPO), was launched on 27 July 2016 at IISc. The first workshop took place on 28 and 29 July 2016 at CPDM.

✍ **RAGHU MENON**

ICMR 2016

Courtesy: ORGANIZING COMMITTEE, ICMR 2016

Alok Singh presenting his painting of S Ranganathan

An International Conference on Metals and Materials Research (ICMR) was organized in honour of S Ranganathan, an emeritus professor in the Department of Materials Engineering, on the occasion of his 75th birthday on 20 June 2016. ICMR, held during 20–22 June 2016, was hosted by the Department in association with the Bangalore chapter of the Indian Institute of Metals.

✍ **PUNIT KUMAR, GYAN SHANKAR** AND **SWEETY ARORA**

New Horizons in Biology

Courtesy: THE ORGANIZING COMMITTEE

HS Savithri speaking at the Symposium

The Department of Biochemistry organized the New Horizons in Biology symposium on 16-17 June 2016 to acknowledge the contributions of a distinguished faculty member, HS Savithri, who retired this year. Her students and colleagues, past and present, converged on the campus of IISc to celebrate her contributions to the field of biology over a span of more than three decades.

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

Book Launch: *The Great Derangement* by Amitav Ghosh

Courtesy: PENGUIN INDIA

Release of *The Great Derangement-Climate Change and the Unthinkable*

Amitav Ghosh, a name familiar to many enthusiasts of historical fiction through his novels such as *The Calcutta Chromosome*, was at IISc on 27 July 2016 to release his latest book, *The Great Derangement—Climate Change and the Unthinkable*. The release of his nonfiction book was followed by a panel discussion on climate change. The event was organized by Dakshin Foundation, Penguin Books and IISc.

✍ **ANANYA JANA**

LOOK WHO'S TALKING

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

CBR Lecture: "Why the Brain" and "Research Across Borders"

Courtesy: PRO, IISc

Courtesy: KRIS GOPALAKRISHNAN

"We are at the beginning of the fourth industrial revolution," said Kris Gopalakrishnan, co-founder of Infosys Ltd., addressing a packed Faculty Hall, IISc, on 4 August 2016. He was referring to the emerging technological revolution combining physical, digital and biological systems. "I believe we must take full advantage of it, create capability in India and build an industry around it," he added during the talk organized as part of the Centre for Brain Research (CBR) Lecture Series.

In his talk, Gopalakrishnan, who has, through his Pratiksha Trust, given Rs. 225 crores to set up CBR and an additional Rs. 30 crores to fund three chair professorships in brain research at IISc, focused on why he is supporting research and innovation, and why he believes brain research is important for India.

"We are going to create capabilities in computers which, at some point, exceed human capabilities in certain dimensions at least," he said. He pointed out that understanding how the brain works could also help us build better models of computing.

Gopalakrishnan also highlighted the importance of studying clinical problems such as aging and Alzheimer's disease which are a huge social and economic burden. "Cost is an issue," he said. "If we don't participate in this research, it will be too expensive for us, and we will be 20-30 years behind when that capability comes to India."

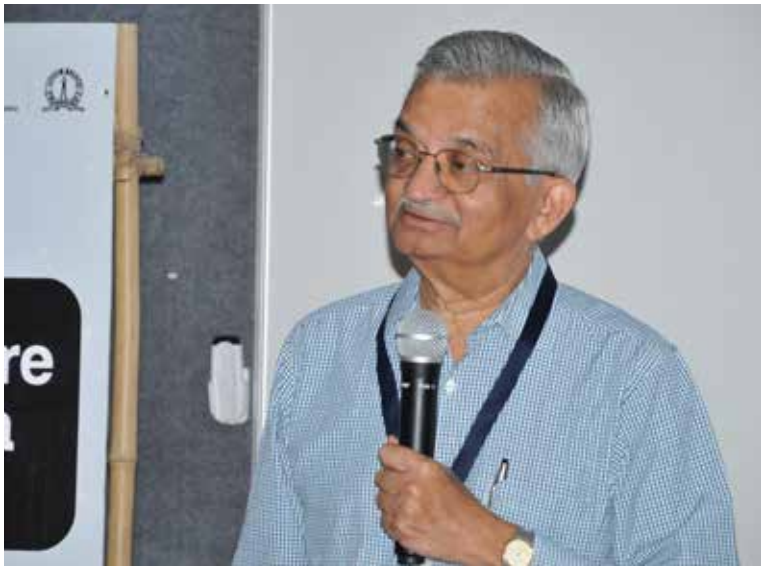
His lecture was followed by a talk on "Research Across Borders" by Subra Suresh, President, Carnegie Mellon University (CMU). Suresh, formerly the Director of the National Science Foundation (NSF), highlighted the funding agency's history and contributions. Echoing Gopalakrishnan's words, he emphasized that innovation and research have a "huge impact on society", citing the example of how educational and medical institutions helped revive the economy of the city of Pittsburgh when its steel industry collapsed.

Drawing from his own research experience, Suresh also described some examples of cross-disciplinary research being carried out at CMU—using sound waves to detect rare cancer cells circulating in the blood, and using microfluidics to detect early-stage malarial infections and to control pain in sickle cell disease by altering the physical state of red blood cells.

Suresh ended his talk with insights into CMU's "BrainHub", a new global research initiative focusing on understanding the brain and behaviour. "One of our aspirations is to connect research at CMU with research that will evolve at CBR," he said.

✍ **RANJINI RAGHUNATH**

R&D Support to Make in India: A Lecture by Anil Kakodkar



Courtesy: CPDM

"There is huge merit in doing things by ourselves to address our problems without worrying about what's happening elsewhere," said Anil Kakodkar, during his talk on *R&D Support to Make in India*, the third CPDM Distinguished Lecture on Advanced Design and Manufacturing, delivered at the Centre for Product Design and Manufacturing, IISc, on 26 July 2016.

As an example from everyday life, he spoke about how the bamboo stick on which the common *agarbathi* is coated, is imported from Vietnam despite India having plenty of bamboo. This is because the tooling for the machines which make those sticks has been designed for Vietnam bamboo—no one has yet adapted it to suit the different cutting characteristics of Indian bamboo.

Kakodkar asserted that though the current growth in the Indian economy comes largely from the service sector, lasting growth should come from the manufacturing and agriculture sectors in order to create the millions of jobs the huge, and growing, population needs. However, he said, "as people in the R&D domain, we should work towards ensuring that 'Make in India' is not restricted to getting technology from somewhere and just manufacturing it here. Rather, it should be 'Make in India' in totality." This, he said, is particularly important in the light of increasing automation in manufacturing in advanced countries. "So there is a big risk of manufacturing moving back to these countries," he observed.

The manufacturing sector today is undergoing other changes too. Giving the example of small, more affordable, medical diagnostic devices that may take the place of larger hospital-based equipment, Kakodkar said that even multinational companies are changing their product profiles to serve such markets. He also emphasized the importance of "ecosystems" that can translate research in the lab into prototypes and, finally, into products.

Kakodkar, a former Secretary of the Department of Atomic Energy (DAE), took the audience through some of his experiences of research and development carried out at various DAE labs. Among them was the work on pressurized heavy water reactors which, he said, was the mainstay of the Indian nuclear power program. The prototypes for the various components were developed in-house, at BARC and elsewhere, to ensure that standards were maintained and that industry partners could be told what to do and how to do it, with stringent specifications.

"Such collaboration between designers and manufacturers is important," he said. "We are all in silos, as it were."

✍ **NITHYANAND RAO**

Turtles as Marine Icons

Courtesy: IISc ALUMNI ASSOCIATION

Kartik Shanker, Director, Ashoka Trust for Research in Ecology and the Environment (ATREE), traced the ups and downs in the story of turtles in India in a talk titled *From Soup to Superstar: The Making of a Marine Icon in India* at IISc on 25 August 2016. The event was organized by the IISc Alumni Association. Shanker, who has published a book of the same title, talked about sea turtles, efforts to conserve them in India, the people involved and how the fishing industry can help.

He expressed hope that sea turtles would be used as flagship species to encourage collaboration between citizens, researchers and the industry. Drawing public interest and attention to the changing ecosystems of sea turtles, he felt, would help build strong collaborations for conservation initiatives in the country.

✍ **NARMADA KHARE**

Impact of IGBT: Golden Jubilee Lecture

Courtesy: PRO, IISc

Anurag Kumar (Director, IISc) presenting Jayant Baliga a memento

Early electrical devices, especially those that had an induction motor at their heart, were inefficient. To save energy, one way to reduce the power output of the motor was to switch it on and off at a suitable rate. However, this was only possible for small currents.

Then, around 1980, Jayant Baliga at General Electric invented the insulated-gate bipolar transistor, or IGBT, a switch which works efficiently at high currents. Baliga, who gave a Golden Jubilee Lecture at IISc on 26 July 2016, discussed his work and its impact on society.

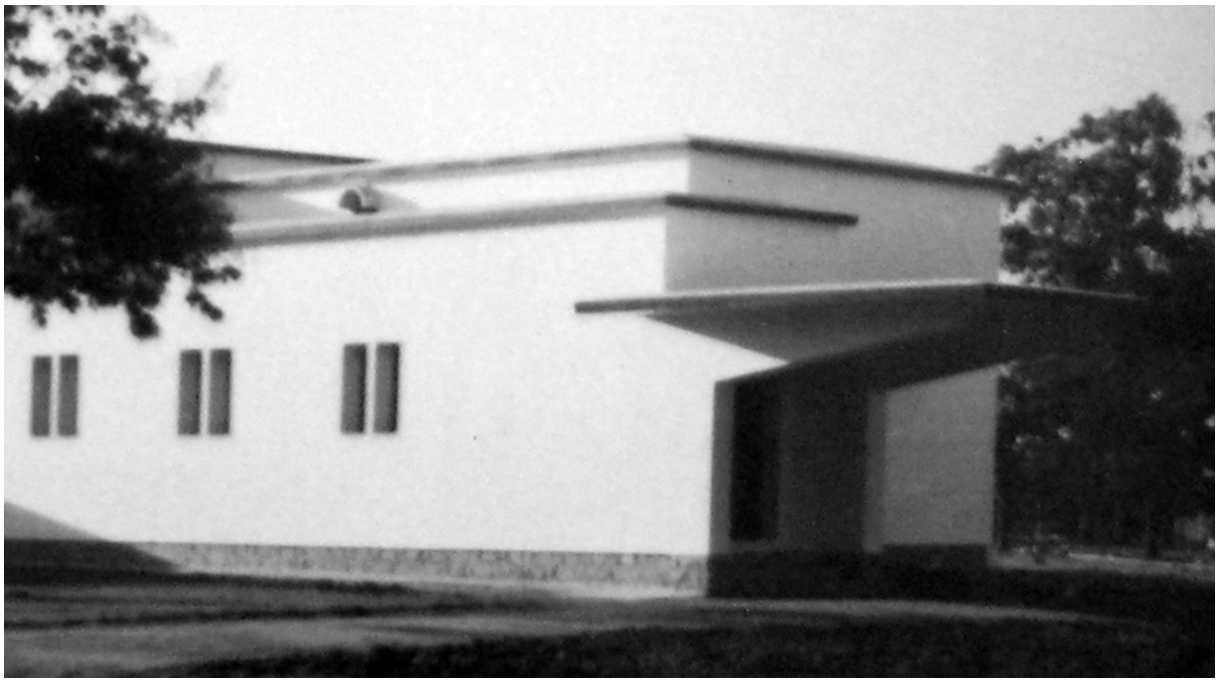
This one invention has, according to Baliga, reduced the global consumption of fossil fuels by an estimated 10% by making automobiles more efficient. Today, the IGBT is used wherever relatively high voltages need quick switching. This includes everything from electrical trains to the mixer grinder on your kitchen top. For his invention, Baliga was awarded the US National Medal of Technology and Invention in 2010.

✍ **AMOGH KINIKAR**

AERONAUTICS TAKES WINGS AT IISc

The article traces the birth of the Department of Aeronautical Engineering, its close association with HAL, and its transformation into the Department of Aerospace Engineering

✍ SOWMITHRI RANGANATHAN



Courtesy: IISc ARCHIVES

The original Aerospace Engineering Building

"That in view of the scientific and practical importance of advanced instruction and research in aeronautical engineering and metallurgical sciences and of research in automobile engineering, the Court recommends to the Council that the Government of India, the Provincial governments, the Indian States and the Industrialists be approached for funds which will enable the Institute to equip itself with facilities for such work[1]." This resolution, passed by the Court of IISc in 1941, then presided over by Sir M Visvesvaraya, led to the founding of the Department of Aeronautical Engineering at the Institute in 1942. Its establishment was part of a wave of expansion of engineering departments in the Institute that began under Sir JC Ghosh who served as IISc's Director from 1939 to 1948.

Bangalore Emerges as an Aeronautical Hub

The introduction of the new Department coincided with another momentous event in the history of Indian aviation. The industrialist Walchand Hirachand, described by Sardar Patel as a "patriotic industrialist"[2] and one "whose life was a triumph of persistence over adversity"[2], was keen to set up an automobile factory, but wartime exigencies made him change his plans. In 1940, with active encouragement of the Mysore State and 700 acres of land provided by it, he set up Hindustan Aircraft Ltd instead. During this period, this company, which later became the Hindustan Aeronautics

Limited (HAL), and the Aeronautical Engineering Department at IISc played a crucial role in the British war effort in Asia. Together, they helped in assembling aircrafts, and in the repair and maintenance of aircrafts damaged in the air attacks. The Institute helped Allied aircrafts in other ways too: it provided support for training the technicians of the British Air Force and set up a unit within the Institute campus for the production of hydrogen gas used as a fuel additive. During this period, Hindustan Aircraft also built India's first aircraft, the Harlow PC-5, which was later deployed in the Indian Air Force.

Courtesy: HAL

VM Ghatage

Aeronautics Takes Root at IISc

When the Aeronautical Engineering Department, the first such academic department in the country, was set up in IISc, education and research in this field was still in its infancy. In its initial years, the focus was on infrastructure development—designing the building to house the Department and labs, procuring equipment for practical training and planning academic courses. The building was designed and constructed by Otto Koenigsberger, a German who served as Chief Architect of the Mysore State[3]. The Department building, along with a few others that he designed and constructed in the Institute, reflect his minimalistic style, marking a clear break from the ostentatious architecture prevalent in Mysore until then.

In January 1943, course work in the Department started when the first batch of 15 students enrolled in the one-year postgraduate diploma programme. Initially, only students with first-class marks in Mechanical or Electrical Engineering were admitted into the programme which focussed on aircraft design and structures. Later additional courses were introduced in several new areas, and students from other disciplines were also admitted. Curriculum for these courses was designed with the help of VM Ghatage, who had a PhD in aerodynamics from Gottingen University, Germany, and was on deputation from HAL. He was assisted in this endeavour by Sir John Higgins, the Chair of the Board of Directors of HAL, WD Pawley, the President of HAL, and LC McCarty, also from HAL[4].

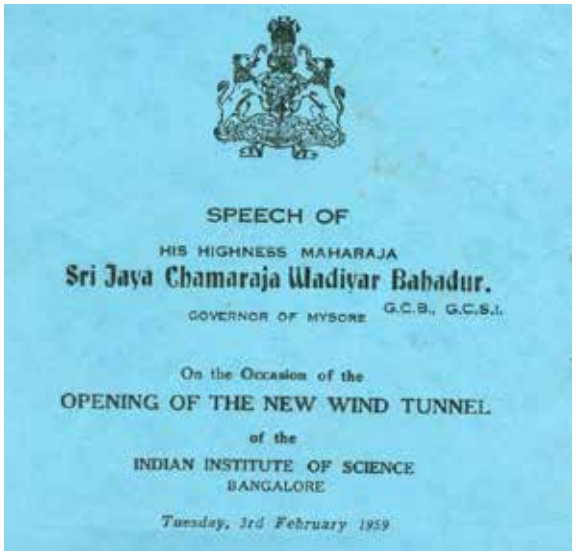
The Department's close association with HAL was also reflected in a short-term course that was offered specially to the employees of HAL. The association benefited the students too—Pawley, in order to encourage research in aeronautical engineering, offered a scholarship of $3000 for a student to work in the field at any American university for four years[4]. Scholarships were also given to promising students by the Maharaja of Mysore and the Dorab Tata Trust.

This period saw many changes in the academic programmes. The one-year Certificate of Proficiency course was converted into a two-year course leading to a Diploma of the Indian Institute of Science (DIISc). After the Institute attained a deemed university status in 1958, ME and PhD programmes were also started.

Facilities at the Department

In its early years, though the Department made great strides in imparting education in aeronautical engineering, it lacked the infrastructure to do high-quality experimental work. To plug this gap, IISc's first wind tunnel was constructed (built by Koenigsberger and designed by Ghatage) in 1943. This elliptical return circuit wind tunnel measuring 7 feet by 5 feet was built with financial assistance from the Governments of India and Mysore[5]. In this wind tunnel, structural tests, photoelastic and

Courtesy: IISc ARCHIVES



Courtesy: IISc ARCHIVES

Top: The second wind tunnel built in 1959; Bottom: Text of the inauguration speech by the Maharaja of Mysore

strain gauge tests on scaled models of aircrafts were done, and it was equipped with a balance built at HAL. It initially ran on a Rolls Royce Kestrel Engine because a dedicated high-power engine could not be procured on account of the war.

A decade later, in 1959, a larger 14 feet by 9 feet open circuit wind tunnel was built. Inaugurating this new facility, the then Maharaja of Mysore, Jayachamarajendra Wadiyar said, "The 20th century has brought us instruments to fly with. The *puspakavimana* of the *rishis* and kings of our legend is now flying at the behest of the common man[6]." This wind tunnel, which continues to be functional to this day, has been used to test industrial models and even some of the satellite launch vehicle models for their structural strength, aerodynamic design and performance.

In the 1950s, the Aeronautical Engineering Department was headed by Satish Dhawan (who eventually went on to become the Director of the Institute). During his time, he revamped the facilities and courses in the Department. He built the country's first supersonic wind tunnel here. An indigenously designed hypersonic wind tunnel was also built. This national facility was used by other

Courtesy: IISc ARCHIVES

organizations like the ISRO and Defence Research and Development Organization (DRDO). At the behest of the Defence Ministry, a course in rockets and missiles was started by the Department in 1968. For many years, Dhawan served both as IISc's Director and the Chairperson of ISRO; this ensured cross-pollination of ideas and technology between the Department and the space organization. An outcome of this was the birth of the Space Technology Cell in 1982. IISc collaborated extensively not just with ISRO, but also with DRDO and Defence Research and Development Laboratory (DRDL). This collaboration led to the establishment of a Joint Advanced Technology Programme (JATP) in 1983[7].

Practical Training

When the Department was born, Walchand's step brother, Lalchand, gifted his personal aircraft to the Department, while HAL presented two aircraft engines to the Department for instructional purposes[4]. A few years later, a Pushpak VT-DWA aircraft was acquired from HAL to impart flying lessons. An airstrip was built in the northern part of the campus; and the Institute also obtained a license to operate the aircraft which was initially flown by trained pilots from HAL. Later the Department appointed a full-time pilot. Though not used anymore, this aircraft, now parked in front

An aircraft parked outside the Department

of the Department, not just attracts the attention of the passers-by, but also inspires a new generation of young men and women to take up aeronautics. One such young man who was inspired by the sight of an aircraft at close quarters was Roddam Narasimha, who went to become one of India's leading aerospace scientists. In a biographical sketch of Narasimha published in *Current Science*, GS Bhat and KR Sreenivasan write about a visit he made to IISc on Open Day: "He saw [a] Spitfire aircraft of World War II vintage (loaned for the occasion by the Indian Air Force), standing in the quadrangle of the Department of Aeronautical Engineering. It was love at first sight; he was so fascinated by the overall design of the aircraft and the complex technology that made it fly that he decided to study aeronautics after his undergraduate degree[9]."

Aeronautics to Aerospace

With rapid growth in aeronautics and with research becoming more interdisciplinary in recent years, the Department has evolved to keep pace with the changing times. It began to offer courses in areas such as rocket propulsion, aeroelasticity, fluid

KG HARIDASAN

The wind tunnel complex

KG HARIDASAN

The new building housing the Department

mechanics, and turbulence. To reflect the increased scope and diversity of courses and research, in 1982 the Department was renamed as the Department of Aerospace Engineering. With new labs being added, the number of faculty and students also grew. To accommodate the additional labs, class rooms and research facilities, the Department has moved into a new building, built in the shape of an aircraft. The new building also comprises a High Speed Wind tunnel complex, which was inaugurated by Narasimha himself.

As it steps into its 75th year of existence, the Department continues to remain at the forefront of aerospace research and education in the country.

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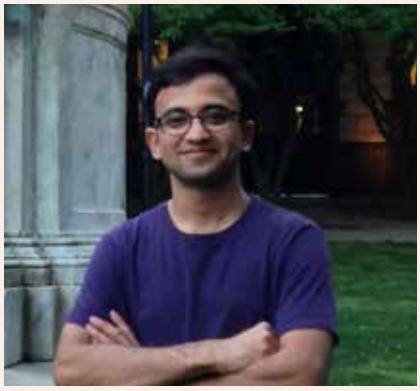
HELLO!

Meet faculty who have joined IISc recently

COMPILED BY **SUDHI OBEROI**



RAMSHARAN RANGARAJAN (Assistant Professor, Department of Mechanical Engineering) hails from Chennai. He got his PhD from Stanford University, USA, where he worked on computational mechanics, and did his postdoctoral research in the same area at Brown University, also in the US. At IISc, he studies numerical algorithms for problems in mechanics.

PRADIPTA BISWAS (Assistant Professor, Centre for Product Design and Manufacturing), a native of Kolkata, received his PhD in computer science at the University of Cambridge, UK, where he studied 'Inclusive User Modelling'. He continued at Cambridge for his postdoctoral studies. He is currently interested in human computer interaction for spastic children and for military aviation environment with special emphasis on multimodal interaction and intelligent user interface.

MANISH ARORA (Assistant Professor, Centre for Product Design and Manufacturing) is from Delhi. He did his PhD on the biomedical applications of cavitation from University of Twente in the Netherlands. His postdoctoral work at the University of Oxford, UK, was on High Intensity Focussed Ultrasound (HIFU) therapy for non-invasive treatment of cancer. He is currently interested in using a design-centric approach for developing affordable medical devices and free hand 3D-ultrasonography.

GEETHARANI K (Assistant Professor, Inorganic and Physical Chemistry) grew up in Madurai. She received her PhD from IIT Madras on the synthesis and applications of metal-borane clusters. She then moved to the University of Wurzburg in Germany for her postdoctoral research where she developed a transition metal-mediated cyclization reaction of iminoboranes. Her research at IISc focuses on developing main group catalysts for organic transformations and efficient synthetic routes for highly functionalized organoborane derivatives.

SIDDHARTH JHUNJHUNWALA (Assistant Professor, Centre for BioSystems Science and Engineering) was born and brought up in Chennai. He received his PhD from the University of Pittsburgh, USA, where he developed controlled release formulations for modulating immune responses. He then did his postdoctoral work at MIT, also in the US, on developing and testing new biomaterials for tissue engineering and medical device. He plans to work towards the development of a drug delivery system for the treatment of diabetic foot ulcers to understand the limits of immune responses.

SIVARAM AMBIKASARAN (Assistant Professor, Department of Computational and Data Sciences), who is from Chennai, obtained his PhD in computational mathematics from Stanford University, USA. Before joining IISc, he was an Assistant Professor at the Courant Institute of Mathematical Sciences, USA, working on developing fast algorithms for electromagnetic scattering and Gaussian process regression. Now at IISc, he is working towards developing novel reduction techniques to obtain reduced order models for detailed chemical mechanisms.

PRASAD S HEGDE (Assistant Professor, Center for High Energy Physics) grew up in Mumbai. He obtained his PhD from Stony Brook University in the US, working in the area of finite-temperature lattice. He went on to do his postdoctoral studies at Brookhaven National Laboratory, USA, and the National Taiwan University in Taipei, Taiwan. His current work allows him to extrapolate thermodynamic quantities from zero to finite density.

LAKSHMINARAYANA RAO (Assistant Professor, Center for Sustainable Technologies) hails from a village called Mydala, 70 km northwest of Bangalore. He obtained his PhD in chemical engineering from McGill University, Canada, which focused on improving the life of a plasma torch. He pursued the same line of research for his postdoctoral studies at PyroGenesis Canada Inc. His research interests lie in the application of plasma technology to a variety of problems such as waste to energy, hazardous waste destruction, resource recovery from waste streams, etc.

PUNIT SINGH (Assistant Professor, Center for Sustainable Technologies) was born in Delhi, but spent his entire childhood in Bangalore. He pursued his PhD from Karlsruhe Institute of Technology (KIT), Germany, on experimental optimization and system design of pumps as turbines for decentralized power generation. He continued at KIT for his postdoctoral work on field implementation of pumps as turbines in remote areas and designing low head hydro turbines associated with water resources management. He is interested in thermal turbomachinery and seeks to bridge the science of non-thermal and thermal turbines for renewable energy application.

HALL OF FAME

A rendezvous with those who have been honoured for their research contributions

SRIRAM RAMASWAMY: ANOTHER FEATHER IN HIS DISTINGUISHED CAP

✍ **MANBEENA CHAWLA**

The Royal Society, founded in 1660 under the patronage of King Charles II, is one of the oldest scientific bodies in the world. The most eminent scientists from the United Kingdom and Commonwealth of Nations are elected each year as its Fellows, and citizens of other countries as Foreign Members. It currently includes about 80 Nobel Laureates and previously had legendary scientists like Isaac Newton, Alexander Fleming and Charles Darwin in its ranks. Among the new Fellows elected to the Society this year is Sriram Ramaswamy, a professor in the Department of Physics. He is currently on leave from IISc to help establish the TIFR Centre for Interdisciplinary Sciences (TCIS) in Hyderabad, which he directs.

The Fellowship is yet another accolade for Ramaswamy who has also won the Shanti Swarup Bhatnagar and Infosys Prizes. "It feels nice because it means people think that what we are doing is worthwhile. The most important thing is that the students feel very good," says Ramaswamy, reacting to the recognition.

"It feels nice because it means people think that what we are doing is worthwhile. The most important thing is that the students feel very good"

Ramaswamy, a theoretical physicist, is particularly interested in using physics to better understand biological phenomena like collective motion in

nature. Explaining why this question fascinates him, he says, "When a physicist sees a group of things moving together, the first question that comes to mind is whether the globally organised movement is taking place due to local interactions or is there something much more trivial where each one of them is following an external cue and then moving."

Ramaswamy, a theoretical physicist, is particularly interested in using physics to better understand biological phenomena like collective motion in nature

Ramaswamy's more recent work involves studying the mechanics of active matter by applying conservation principles and symmetry in order to understand their collective behaviour. These active particles, which move in large, coherent groups called flocks, could be motor proteins—molecular motors that move along filaments in the cytoskeleton the polymer scaffold that gives structure to cells—or a school of swimming fish.

Flocking in a fluid arises as a consequence of many dynamic factors that influence the behaviour of the individual particles. Ramaswamy explains that the dynamics surrounding each active particle sets up flows in the fluid, which in turn orient and set the other particles into a systematic motion. It turns out that, given how ubiquitous this phenomenon is, it finds applications in many different fields. "We started working on this concept by adapting the equations of hydrodynamics for liquid crystals to describe collections of swimming organisms, and later other groups discovered the same equations as descriptions of the cytoskeleton," he says.

Ramaswamy also works on understanding the influence of a chemical gradient on the movement of a group of catalytically propelled active particles. "Our idea is to find design principles for creating particles that re-orient in specific ways in response to gradients, and to study their collective self-propulsion", he points out.

Ramaswamy also works on understanding the influence of a chemical gradient on the movement of a group of catalytically propelled active particles

Given Ramaswamy's research agenda, he is very much at home at TCIS. "Our interdisciplinary centre brings interaction and collaboration to address common problems," he says. Elaborating on the nature of interdisciplinary research, he adds, "Collaboration should come in the form of a common question being posed, not just combining a few techniques from different laboratories or departments."

"Collaboration should come in the form of a common question being posed, not just combining a few techniques from different laboratories or departments"

Ramaswamy, who indulges in "running, trekking, watching movies and reading good novels" when time permits, plans to come back to IISc once his job in Hyderabad is done. But for now he is enjoying his work at TCIS.

S RANGANATHAN: VOYAGES OF A METALLURGIST IN SPACE AND TIME

✍ PUNIT KUMAR AND KARTHIK RAMASWAMY

S Ranganathan ("Rangu" to his friends) is a pre-eminent physical metallurgist who has made seminal contributions to his field. More recently, he has also been studying the history of Indian metallurgy. Besides being an Honorary Professor and a Senior Homi Bhabha Fellow at IISc, Ranganathan is a Visiting Chair Professor at the National Institute of Advanced Studies (NIAS). To celebrate his 75th birthday, an International Conference on Metals and Materials Research was *organized at IISc. He spoke to* CONNECT *after the event.*

Q How did this conference come about? What did it mean to you?

A few of my students came forward to organize this conference. Eventually the Department [of Materials Engineering] and a few [science and engineering] societies also collaborated with them. It was an occasion to reminisce. But more importantly, it was a fine academic meeting. The organizers invited many young researchers—normally the Indian tendency earlier was to invite only very senior people—to ensure that the torch is shining bright and passed on to the next generation.

Q How did you get into science and into metallurgy in particular?

I was born in a family in which education was very important. My father was a lawyer and he wanted my elder brothers and me to also become lawyers. But one of them studied chemistry at the University of Madras where he was a classmate of TR Anantharaman [who went on to become one of India's most eminent metallurgists]. I followed in my brother's footsteps. Like Anantharaman, I too was a BSc Honours student. I then came to IISc to do my engineering in metallurgy. Anantharaman then encouraged me to go to Oxford or Cambridge

Universities for my PhD. I went to Cambridge because I didn't get a Rhodes scholarship which required more than just academic excellence. I could say that my life was transformed because I studied at the University of Madras, IISc and Cambridge.

Q What was life at Cambridge like?

My PhD adviser Sir Alan Cottrell wanted me to finish my PhD early, as he was invited to be the Scientific Adviser to the UK Government. I completed my thesis in less than three years. I wish I had stayed a bit longer. There were a number of postdoctoral fellows from other countries who treated me as an equal even though they were much older. And those friendships have lasted. Besides, Cambridge had great scientists which included many Nobel Laureates.

But I must tell you one other thing. For my passage to Cambridge, I received a Tata Endowment scholarship. In England, the Tatas used to have parties for those who won the scholarships. In one of these parties, I met a wonderful lady, who later became my wife. So I often joke that the Tata Endowment not just gave me the passage to England, but also a partner for life!

"So I often joke that the Tata Endowment not just gave me the passage to England but also a partner for life!"

Q You came to BHU and became a full professor when you were just 31. Why did you move to IISc?

I thought that I would be staying in the same place for too long if I remained there till I retired which is not satisfactory. And second reason was unusual—I could never master Hindi; I am not very good at languages. At that time, S Ramaseshan, who was then the Joint Director of IISc, urged me to come to Bangalore. He brought me here and immediately made me the Chair of the Department of Metallurgy.

Q You are also very interested in mathematics…

I had an early interest in mathematics—I used to read *Scientific American* articles by Martin Gardner

who I am a great fan of. He even wrote about the work of [Roger] Penrose on quasicrystals which had an extraordinary influence on me. And I also read *Introduction to Geometry* by [HSM] Coxeter, responsible for reviving geometry which had been relegated to the background. In 1966, I wrote a single author paper on the geometry of coincidence-site lattices which became highly cited. I became more confident after this and there was no looking back. Years later, I coauthored a book *New Geometries for New Materials* along with one of the finest mathematicians, Eric Lord, and the gifted crystallographer, Alan Mackay.

Q What is your proudest academic achievement?

I would like to say bringing ideas to the table. For example, in 2003, I wrote a paper called *Alloyed Pleasure: Multimetallic Cocktails* in which I discussed the extraordinary possibilities of mixing many metals. I called it cocktail because I loved my drink. This was a path breaking idea and caught the imagination of metallurgists.

"I called it cocktail because I loved my drink. This was a path breaking idea and it caught the imagination of metallurgists"

Q You have more than just a passing interest in history. How did you get into it?

It's one of the most interesting subjects. I grew up under the influence of Kalki's *Ponniyin Selvan* (the story of *Rajaraja Chola I* set in the 10th and 11th centuries), which was published as a serial each week. It made a strong impression on me. Later I started to go to conferences on metals and their role in shaping civilizations and vice versa. A few years ago, I was invited to Tokyo University of the Arts as a Guest Professor. Here I taught conservation science for the first time. And in the process I learnt a lot about their metallurgical heritage.

Q One interesting connection between the metallurgical heritages of India and Japan, which you've written about, is the similarity between the Damascus and Samurai swords.

For a long time it was not known, but we were the first to melt steel. We have a furnace that was used to make wootz steel from 300 BC. The Damascus sword, made from this steel, combined high strength, toughness and ductility. A description of the sword from the Crusades says: One blow of the Damascus sword would cleave the European helmet without turning the edge or cut through a silk handkerchief drawn across it. The Samurai sword, made from *tatara* steel, is a layered nanocomposite. Though the processing of the two swords in different, their properties are the same, which is remarkable. We are working on why this happens.

Q You have argued that the attempt to recreate wootz steel in Europe had an important role to play in the birth of modern metallurgy.

When the British saw ordinary craftsmen in India prepare a steel better than anything they had, they asked their most famous experimental scientist, Michael Faraday, who also happened to be the son of a blacksmith, to recreate it. Though he failed after repeated experiments, Faraday is considered the father of alloy steels because of his experiments. The French and Russians also attempted to recreate it. So in some ways, materials science owes a lot to the investigations in Europe into the properties of wootz steel.

Q Could you shed some light on a project you are involved in about the history of India through 101 objects?

The British Museum brought out a book by Neil MacGregor which attempts to tell the history of the world in 100 objects. It's a fantastic book, but it occurred to me that the British are trying to turn the British Museum into a world museum. Even if these artifacts are not returned, people from around the world should be able to tell their stories. This is going to be online, but I would also like it to be brought out as a book.

AND THE AWARD GOES TO...

Researchers who were honoured with awards recently

✍ COMPILED BY **KARTHIK RAMASWAMY**

VINAYAK N

ANSHU PANDEY

Assistant Professor, Solid State and Structural Chemistry Unit

INSA Medal for Young Scientists

Courtesy: PATRICK D' SILVA

PATRICK D' SILVA

Associate Professor, Biochemistry

CDRI Award for Excellence in Drug Research in Life Science

Courtesy: CHANDAN SAHA

CHANDAN SAHA

Assistant Professor, Computer Science and Automation

INSA Medal for Young Scientists and **INAE Young Engineer Award**

MANOJ SUDHAKARAN

SATHEES RAGHAVAN

Associate Professor, Biochemistry

Kobayashi Foundation Award for Cancer Chemotherapy (Japan)

Courtesy: PRAVEEN KUMAR

PRAVEEN KUMAR

Assistant Professor, Materials Engineering

INSA Medal for Young Scientists

Courtesy: PRABEER BARPANDA

PRABEER BARPANDA

Assistant Professor, Materials Research Centre

INSA Medal for Young Scientists

CONNECT

SAI SIVA GORTHI

Assistant Professor, Instrumentation and Applied Physics

INSA Medal for Young Scientists and **INAE Young Engineer Award**

CONNECT

ROHINI GODBOLE

Professor, Centre for High Energy Physics

Prof. Archana Sharma Memorial Lecture Award (National Academy of Sciences)

Campus Critters

Hawk moth feeding on nectar of *Lantana* flowers

Society for Innovation and Development