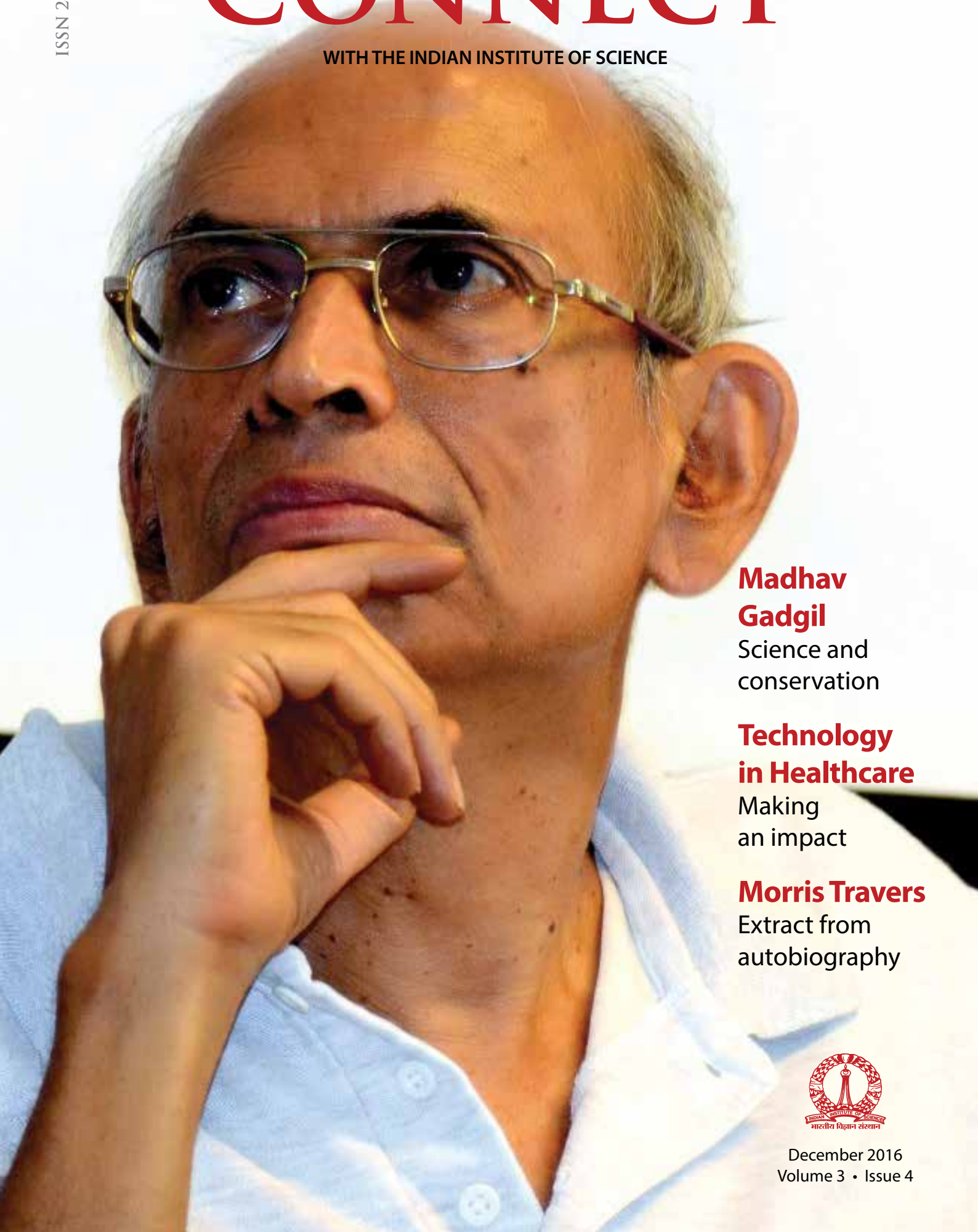


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CONNECT

WITH THE INDIAN INSTITUTE OF SCIENCE



**Madhav
Gadgil**
Science and
conservation

**Technology
in Healthcare**
Making
an impact

Morris Travers
Extract from
autobiography



December 2016
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FROM THE CONNECT TEAM

Greetings!

In this issue, one of the interviews we carry is with Madhav Gadgil, who helped establish the Centre for Ecological Sciences (CES) at IISc in 1983. Very early in life, he realized the uniqueness of ecology as a science and how intricately it is connected to other human endeavours. In fact, his PhD was in mathematical ecology. Based on decades-long experience in both theoretical and field ecology, Gadgil also has a keen understanding of the place of science in society, and of the importance of engaging with non-scientists—not just as a favour or an obligation. Science itself stands to gain from such interactions, as he found out from his early efforts at what we would today call "citizen science". He also understood early that conservation will not be effective if it is based solely on ecological principles and fails to take into account, as he puts it, "a whole lot of other forces which are impinging on conservation efforts."

Harini Nagendra once attended a talk by Gadgil at CES, which inspired her to take up ecology and do her PhD with Gadgil. Today, she is one of the very few urban ecologists in India, and the author of the book *Nature in the City: Bengaluru in the Past, Present, and Future*, published in 2016. She moved to ecology, she says, "to do something that was more meaningful. One of the big attractions for me was working on conservation challenges of direct and immediate relevance." Like Gadgil, she too understood early the fundamentally interdisciplinary nature of her work. Her research shows us how the ecology of a city is intimately tied with its topography, its history, and the social processes that have shaped the city. We talk to her about her work and about Bangalore's ecology—in particular its lakes, whose narrative, she says, has changed in recent years.

One of the other articles we carry in this final issue of 2016 is about researchers at IISc who work to develop inexpensive healthcare devices that are immediately relevant to the country's needs. They too are driven by a strong urge to see their work directly impact society. One of them is Manish Arora, who says that "If we can come down to the level of what the real problems are, then that would be of great benefit. It's something I strongly believe in."

Happy reading!

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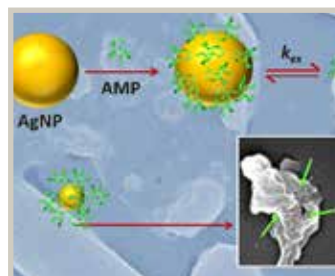
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HEALTHCARE INNOVATIONS: TAKING SCIENCE TO SOCIETY

 NITHYANAND RAO

A closer look at how tech entrepreneurs are attempting to cover new ground in meeting India's medical needs

India is among the worst performers in public health. A recent study ranked India at 143 out of 188 countries in meeting the health-related targets of the United Nations Sustainable Development Goals.¹ One of the reasons for India's poor performance in meeting public health challenges is that it spends only about one percent of its GDP on healthcare.² And a very small fraction of this is spent on basic medical research.

But Subbiah Arunachalam, an information scientist, believes that there is another pressing problem that has led to this dire situation. He argues that medical research in India is not driven by the requirements of public health in the country. And he has good reason to back up his claim. In 1997, Arunachalam did a bibliometric analysis of medical research papers published by scientists in India and compared it to the disease burden in the country.³ The study showed a considerable mismatch between the two. In his study, Arunachalam had considered infectious diseases—such as malaria—and infant mortality as being the major causes of mortality. Today, one could also add to that list lifestyle diseases like diabetes, which affects an estimated 69 million people in India.

Commenting on Arunachalam's paper, the eminent cardiac surgeon MS Valiathan, currently a National Research Professor at Manipal University, wrote in *Current Science* that the reason for mismatch between requirements of public health in the country on the one hand, and medical research carried out in India on the other, is that although

India had absorbed western medicine along with its tools and methods, it had not bothered to learn how to make its own.⁴ "This failure, like a birth defect," he added, "became a handicap and ensured that successive waves of tools and methods from the West, and not societal needs, determined the medical agenda in India."

New Technological Tools

While the mismatch articulated by Arunachalam still remains, a new breed of entrepreneurial researchers is stepping in to bridge the divide by developing inexpensive, modern medical technology relevant to India's needs.

One of them is Satya Tapas. In 2003, his close friend who was unwell, went through the routine blood tests, but they came back negative for malaria. But two days later, Tapas' friend had to be taken to a hospital in Cuttack when his condition worsened. But it was too late—the malaria parasite had invaded the brain.

At the time, in 2003, the rapid diagnostic test for malaria was not available in Dhenkanal, a town in Odisha. If such misdiagnosis can happen in an urban area, wondered Tapas, what must be happening in rural India?

The incident continued to trouble him. Years later, while crystallizing proteins at the Max Planck Institute for Biophysics, it struck him that the automated process used there for photographing and analyzing the photographs could be used elsewhere too, including in the detection of malaria.



Tapas, who did his postdoctoral research at the Molecular Biophysics Unit at IISc, had already developed a portable microscope. He now assembled a team and developed image-processing algorithms, integrating them with the microscope to create a device to automatically detect the malaria parasite in a blood smear mounted on a slide, eliminating human error.



Courtesy: SATYA TAPAS

Satya Tapas (centre), with his SciDogma team



Courtesy: SATYA TAPAS

The portable automated microscope for malaria detection

The device has the potential to make a difference, especially in rural India. For malaria diagnosis, he says, “usually, people from healthcare centres travel to rural areas, collect the blood samples, and send report after one or two days. But here they can carry the device itself. It’s automated, no expertise required.”

Tapas approached the Biotechnology Industry Research Assistance Council of DBT with his idea and was granted Rs. 50 lakhs, for a period of 18 months, to develop a proof-of-concept device. “Now we have done that, and we’re looking for

funding to refine the technology and make it market-ready,” says Tapas, currently at the Centre for Cellular and Molecular Platforms. He feels there is more encouragement now for people with ideas for applying technology to solve medical problems, devices known as “med-tech”. Tapas’ SciDogma was the runner-up in the Stanford Medicine X Challenge in the Medical Product Design Category, and one of the recipients of the DST-Lockheed Martin India Innovation Growth Programme awards.

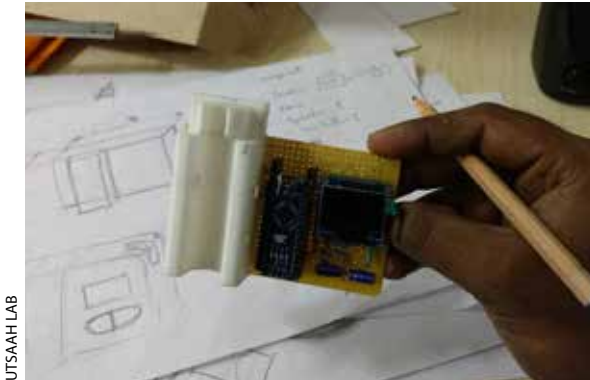
One of the factors holding back healthcare research in India, felt various commentators in the wake of Arunachalam’s paper, was the lack of interaction between clinicians and researchers in other fields. Manish Arora is aware of this drawback, and has been trying to bridge the gap at his lab—Universal Technology Solutions for Accessible & Affordable Healthcare, or UTSAAH—at Centre for Product Design and Manufacturing (CPDM).

Originally a chemical engineer, Arora did his PhD and early research on ultrasound imaging. He later worked at a major technology company’s healthcare division, trying to develop a low-cost portable ultrasound device. That was when he came to understand the industry’s motivations—and their limitations. “Working with big organizations allows you to see the breadth of things you can cover, and also the speed with which you can execute,” he says. “But they have their own limitations to keep the cost down, to connect with the local problems.”



CONNECT

Manish Arora, with the electronic module of the IV drip monitoring device under development in his lab



UTSAAH LAB

The circuit board of the IV drip monitoring device

Like Tapas, Arora too is motivated by making a difference on the ground. Before joining CPDM, he spent a year working for an NGO in healthcare, interacting with clinicians. “The more I went to the clinics, the more I realized that it’s important to connect with the clinic more than the technology itself,” he says.

Such interactions sensitized him to thoughtful design. “You have to look at what the existing solutions are and why they are not accessible and affordable in our country,” he says. If a device is such that it can be handled by a healthcare professional other than a doctor, such as a nurse or a midwife, it can be used more widely. “This is where working with the actual users matters a lot,” says Arora. “We try to engage with them throughout the process of development.” An outgrowth of this philosophy is the Medical Device Hackathon organized at IISc in November 2016 (MeDHa'16”).

One such problem he identified is the complications that can arise when the intravenous (IV) drip delivers fluid into the veins at a rate lower or greater than desired—such as air embolism, blockage of the vein by air bubbles. Arora’s lab is developing an electronic module that uses light to sense the drops falling through the drip chamber, tracking the flow rate. The device can sound an alarm if the flow rate isn’t ideal, or if the drip bottle is running dry. Another project, still in the conceptual stage, is an inexpensive

ultrasound device that could potentially curtail the misuse of this technology in sex selection of an unborn child. This could be accomplished if the device can capture and present the data in a form other than an image.

Open Platform

It is no secret that much of the medical equipment used in Indian hospitals is imported and, therefore, expensive. Part of this cost is down to companies wanting to reap the rewards of their R&D through patent licensing. “There’s nothing wrong with patenting, but it hinders other people from collaborating,” says Arora. Such equipment is made even more expensive, he found, because of the multiple middlemen involved in procuring them. Ultimately, these costs end up being passed on to patients.

Arora envisages an open platform for medical device innovation which, as he puts it, “can be used by clinicians to input their clinical problems, engineers to research potential solutions, designers to come up with a usable prototype and eventually somebody who wants to manufacture.” In fact, he is in discussions with Office of Intellectual Property and Technology Licensing (IPTeL) to create a license for open source hardware, which would enable anyone to commercially market the devices developed in his lab. “That’s a topic of research for one of my PhD students,” he says. “What are the ingredients that need to go in, the tools, for doing this handover more smoothly, from a clinician to engineer to designer to manufacturing.”

Other Challenges

There are other barriers too. “People have this mindset that technology developed in India is not up to the mark,” says Arora. “We would like to address that.” The issue is not regulatory approval, but acceptance by clinicians. Even government hospitals, he says, specify approval by the US Food and Drug Administration or the



European CE as a criterion in their tenders, even though this is not legally required. Approval by FDA or CE, a procedure that can take up to a year, is used as a proxy by clinicians in the absence of an appropriate legal framework in India for regulation of medical devices. Arora sees a positive development in the draft of the Medical Devices Rules notified in October 2016, which specifies the procedure for regulation of medical devices. Although it could take many years for it to be tabled in Parliament, debated and then approved, Arora is hopeful that the eventual bill make the regulatory environment clearer.

While it will be an important first step, Arora is aware there is a long way to go for change to happen on the ground. But he is optimistic. “If we can come down to the level of what the real problems are, then that would be of great benefit. It’s something I strongly believe in.”

Footnotes

1. “On New Health Index, India Ranks 143/188”, *Indian Express*, 22 September 2016; Accessed 28 December 2016, <http://indianexpress.com/article/india/india-news-india/on-new-health-index-india-ranks-143188-unga-sustainable-development-goals-global-analysis-3043225>
2. “Health Budget Figures Tell a Sick Story”, *The Wire*, 16 March 2016; Accessed 28 December 2016, <http://thewire.in/24924/health-budget-figures-tell-a-sick-story>
3. Subbiah Arunachalam, “How Relevant is Medical Research Done in India? -- A Study Based on Medline”, *Current Science*, 1997, 72(12):912-922
4. MS Valiathan, “Medical Research on the Sick List”, *Current Science*, 1997, 72(12):911

MeDHa’16

✍️ **Raghu Menon**

The Medical Device Hackathon, MeDHa, was held at the Centre for Product Design and Manufacturing (CPDM), on 3-6 November 2016, to stimulate innovation in the development of med-tech devices—for diagnostics, monitoring, and rehabilitation—and to address problems faced in elderly care. The event was organized by CPDM jointly with the Biomedical Engineering & Technology incubation Centre (BETiC), IIT Bombay.

MeDHa brought together designers, engineers, doctors, and business professionals to find innovative and sustainable solutions for real-world healthcare problems. The participating students, divided into teams, went through a hands-on training programme that guided them through various stages of the process—identifying a healthcare need, defining the problem, coming up with ideas and developing them, creating prototypes and then developing business models for a healthcare start-up.

“The idea was to see what happens when you bring people from different backgrounds together to work on a problem. The teams came up with novel solutions,” said Manish Arora who leads the UTSAAH lab at CPDM that aims to develop affordable healthcare technologies.



Courtesy: CPDM

Venkatdeep Mohan, an orthopaedic surgeon, and his team at MeDHa, are “hacking” together a prototype of a “smart jig” to be used in knee-replacement surgeries.

The teams worked on developing solutions to real-world problems that were identified by experienced clinicians. Some of the problems that the teams worked on included those faced in mental healthcare, deafness screening for babies, preventing recurrent falls in the elderly, and devices for aiding surgeons and doctors in their practices.

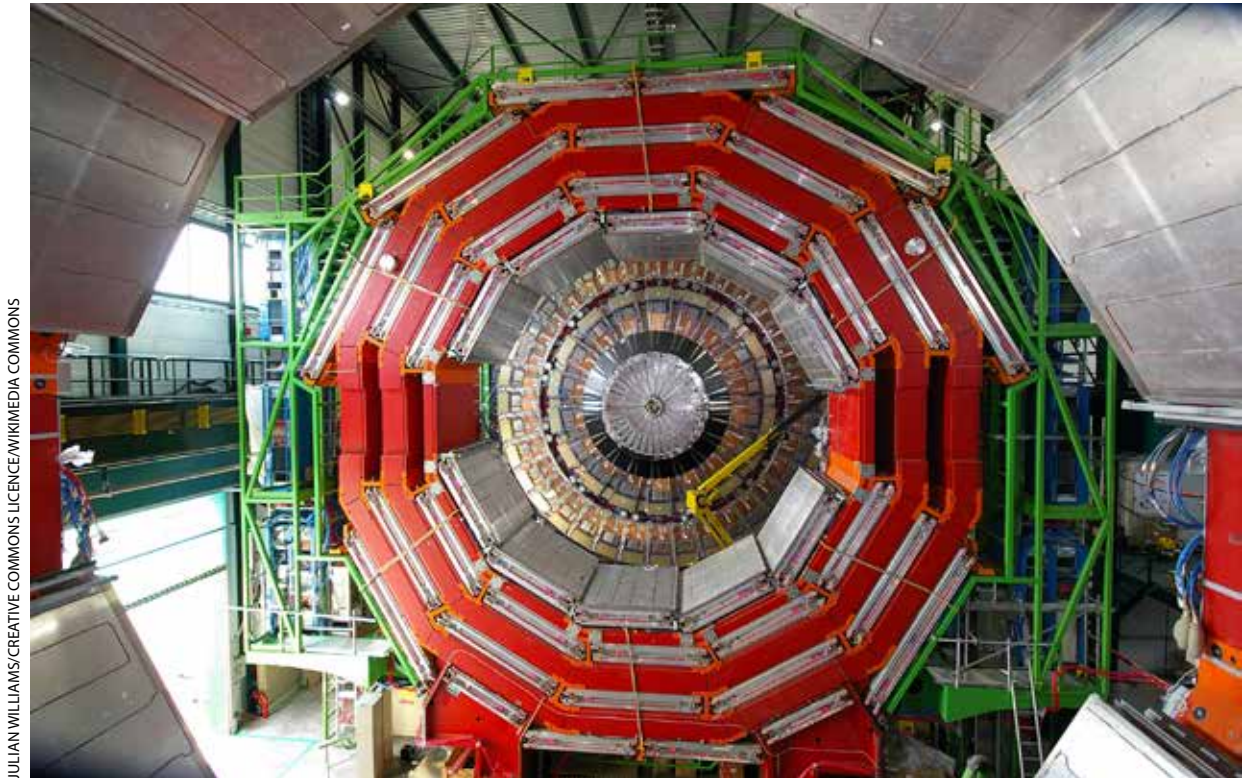
Arora, Amaresh Chakrabarti (Chairperson, CPDM) and B Ravi (Head of BETiC), were the main organizers of the event which was sponsored by ANSYS and Maxim Technologies. The event was mentored by

faculty members from various departments in IISc. Speakers at the event included Rajkumar Deshpande (Fortis Hospital), Vijay Simha (Lemelson Foundation), Ramesh Venkatraman (TÜV), and Anand Kumar Padmanaban (Elado Consulting). The jury of over ten members, impressed with the quality of work on display, found it hard to pick a single winning team. It therefore declared all 11 teams as joint winners. The teams were encouraged to pursue their ideas further and explore possible incubation opportunities at IISc and IIT Bombay.



IISc JOINS CERN EXPERIMENT

✍️ MEGHA PRAKASH



The CMS particle detector at CERN

At the European Organization for Nuclear Research, better known as CERN, located in Switzerland and France, physicists from all over the world have come together to answer some of the most fundamental questions about our universe like the nature of gravity, whether the universe has only three dimensions of space, the origin of mass, etc. They do this by smashing particles at an extremely high speed generated by the Large Hadron Collider (LHC) and record what happens with the help of seven particle detectors. Of these seven, there are two large, general purpose particle detectors, one of which is called the Compact Muon Solenoid (CMS).

On 26 September 2016, physicists working on the CMS experiment at CERN were joined by

On 26 September 2016, physicists working on the CMS experiment at CERN were joined by their counterparts from IISc as well

their counterparts from IISc as well. With this development, IISc will now be part of a 'big science' experiment, said B Ananthanarayan, Professor and Chairperson of Centre for High Energy Physics (CHEP) at IISc. He believes that this development will also give a much-needed impetus to experimental physics at the Centre.

The focus of research at CHEP had been primarily in theoretical physics, but in 2014, under the guidance of Rahul Pandit (Divisional Chair, Physical and Mathematical Sciences), its mandate was broadened



to include experimental physics as well. As part of its expansion, in early 2016, the Centre recruited Jyothsna Komaragiri and Somnath Choudhury as assistant professors. Their recruitment ensured that IISc gained entry into the India-CMS consortium, which then allowed IISc to apply for a direct entry into CMS, Ananthanarayan added.

But even before this partnership was formally announced, senior faculty members from the Institute have long been associated with theoretical research at CERN and have collaborated with CMS/ATLAS members from across the world, says Rohini Godbole (Professor, Centre for High Energy Physics), who is also a member of the DAE-DST committee which oversees the India-CERN collaboration.

The procedure that had to be adhered by IISc was rigorous. Komaragiri, Team Leader of IISc-CMS group, told CONNECT that besides submitting the application, a letter from the Director and proposed contributions from the faculty members were presented at CERN in June 2016. This was followed by a vote to decide whether IISc should

join the consortium. "IISc got 87 out of 90 votes", Komaragiri said about the vote in which all the other collaborating institutes participated.

Under this collaboration, the Centre will participate in data acquisition, design various components of hardware, and train students and postdoctoral fellows to carry out science at the LHC. The Institute also plans to help in the fabrication of new detector technology.

According to Choudhury, besides getting to develop tools and techniques for future experiments, the CMS-IISc partnership will entitle the Institute to share the credit with CMS in all the scientific discoveries. It will also help IISc's researchers, including students, to visit CERN and participate in experiments, and give them access to additional data from CERN's other investigations.

Godbole believes that now that India has become an associate member of CERN, it will boost future collaborations between the various Departments at IISc and those at CERN.

SIR TEJINDER VIRDEE

Sir Tejinder Virdee is one of the 'founding fathers' of the CMS project. For his contributions, he has won several awards, notably the Institute of Physics (IOP) Chadwick Medal and Prize (2009) and the European Physical Society HEPP Prize (2013). He was also named as a recipient of the American Physical Society 2017 WKH Panofsky Prize. Virdee was elected as a Fellow of the Royal Society in 2012 and knighted for services to science in 2014.

Soon after IISc joined the CMS experiment, Virdee visited the Institute and delivered the JN Tata Memorial Lecture on 11 November 2016. During his visit, besides spending time with faculty and students, he also shared his thoughts with CONNECT on how the CMS experiment came about and how IISc can contribute to it.



JAGADEESH



Q The American Physical Society (APS) has just announced that you have won the 2017 WKH Panofsky Prize, which recognizes and encourages outstanding achievements in experimental particle physics. Many congratulations! How does it feel and what do these awards mean to you?

Thank you! I feel honoured, humbled and pleased. I think the pleasure is related to the fact that the enterprise that we work in has succeeded. Though individuals get the awards, we could only have succeeded because of the work of the many thousands of scientists, engineers and technicians. So I think awards, in a sense, validate the work of the many thousands who have been working on these experiments for many years. But what is important is the recognition of good science being done here.

Q IISc has recently joined the CMS Experiment as an independent member institute. What role can it play in the experiment?

We are very happy to have IISc joining CMS because it is known for cutting-edge science and technology; so it is appropriate that IISc has joined us. One possible thing that we can do under this association is to work on the current data that we at CERN are analysing. Besides that, IISc can help in developing new technologies and equipment that would be used when we upgrade our detector, which currently examines a billion proton-proton interactions every second. In the middle of the next decade this will increase by a factor of five. To achieve this, some parts of the detector need to be changed. So we will explore the possibility of designing, manufacturing and testing some of these cutting-edge equipment here at IISc, along with the other institutes in India which are also members of CMS.



We are very happy to have IISc joining because it is known for doing cutting-edge science and technology; so it is appropriate that IISc has joined us



Q You are one of the early designers of the Compact Muon Solenoid (CMS) Experiment. Could you tell us how it happened?

In the early 1990s, a few of us, who were looking for the Higgs Boson and other new physics, had some ideas for building particle detectors for the Large Hadron Collider at CERN. The idea resonated with a lot of people. So we went around to many countries to interest people in the project. I came here to India, and many other countries including China, Taiwan, Iran and Russia, besides America and other European countries. And so, we, in a sense, constructed the collaboration as well as the detectors.



COURTESY: CMS PHOTOBOOK, CERN (HTTP://CDS.CERN.CH/RECORD/1344500)



ALUMNI MEET 2016

✍️ SUDHI OBEROI

IISc hosted its first annual alumni meet from 16-18 December 2016. The event was organized in association with the IISc Alumni Association, IISc Alumni Association of North America and the Office of Development and Alumni Affairs (ODAA).



The event kick-started with a dinner hosted by the Director on 16 December at IISc's Guest House. This informal gathering saw alumni reminiscing over their time together at IISc and also networking. It included a welcome address by the Director of the Institute, Anurag Kumar.

On the morning of 17 December, the Director formally addressed the alumni. He highlighted the progress of the Institute over past few years: improvement in rankings, entrepreneurship initiatives and increased global presence.



The address was followed by two panel discussions which were organized to discuss IISc's future, and entrepreneurship and incubation of new startups at the Institute.



The alumni then proceeded to inaugurate the new building for ODAA, established in 2015, and the main organizer of the event.

After lunch at the Guest House, alumni went to their former departments for further interactions.



The day ended with a cultural programme *Swar Sandhya* at the Satish Dhawan Auditorium.



On Sunday, 18 December, IISc Alumni Association and Students' Council organized a campus run followed by breakfast of *masala dosa* at one of the student messes on campus.

ALL PHOTOGRAPHS BY SWAPNIL NINAWA



RI MAZUMDAR YOUNG INVESTIGATOR



Courtesy: BIOCON

Kiran Mazumdar-Shaw, Chairperson and Managing Director, Biocon Limited, has made a generous contribution to establish the *RI Mazumdar Young Investigator* position. This endowment fund will be used to support

cutting-edge research in Bioengineering. Siddharth Jhunjhunwala, Assistant Professor, Centre for BioSystems Science and Engineering, has been selected as the first *RI Mazumdar Young Investigator*.

HAL-IISc SKILL DEVELOPMENT CENTRE



Courtesy: B N RAGHUNANDAN

HAL and IISc have joined hands to establish a Skill Development Centre at IISc's Extension Projects campus in Challakere. The Centre seeks to offer a wide range of programmes for the benefit of the society at large—unemployed youth and local community members to advanced engineering professionals.



IISCONNECT

IISc PHOTOGRAPHY CLUB



In association with the Office of Career Counselling and Placement at IISc, Qualcomm and Media.net, IISc organized its first research career fair and interaction day on 3 October 2016. Students on campus got an opportunity to present their research to industry stalwarts and learn about career opportunities in industry.

MRS. SUDHA MURTY DISTINGUISHED CHAIR

Courtesy: PRO, IISc



The second of the three Distinguished Chairs established by Kris and Sudha Gopalakrishnan at IISc, in the field of Neurocomputing and Data Science, was named after IISc alumna and Chairperson, Infosys Foundation, Sudha Murty. Vasant Honavar, a professor at Pennsylvania State University, will be the first Mrs. Sudha Murty Distinguished Chair.

FUNDING FOR BIOMEDICAL RESEARCH LABORATORY

RANJINI RAGHUNATH



IISc alumna Desiraju Rajagopal Rao and his wife Vijaya Rao made a generous contribution for setting up of a Biomedical Research Laboratory at the Centre for BioSystems Science and Engineering.





HOT OFF THE PRESS

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

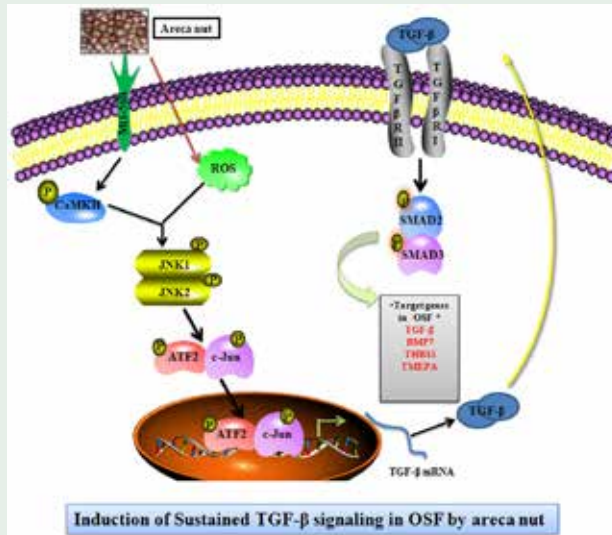
CANCER

How areca nut leads to a precancerous oral disease

Fibrosis is a disease wherein excess depositions of extra-cellular proteins—such as collagens and fibronectins—are observed. Oral Submucous Fibrosis (OSF) is a precancerous inflammatory condition in the oral submucosa tissue caused by prolonged chewing of areca nuts. Previous studies have reported that chewing areca nut causes OSF by activating a signalling pathway called TGF- β in the oral tissues.

A study by researchers from the Department of Molecular Reproduction, Development and Genetics and DA Pandu Memorial - RV Dental College and Hospital, demonstrates how areca nut activates the signalling. They observed the presence of TGF- β 2 protein within two hours of exposing epithelial cells to areca nut. They have also shown, for the first time, the involvement of many molecules responsible for TGF- β pathway activation in OSF.

Nature Scientific Reports, <http://dx.doi.org/10.1038/srep34314>



Courtesy: ILA PANT ET AL AND NATURE PUBLISHING GROUP, CC BY 4.0

CLIMATE CHANGE

Predicting formation of glacial lakes

A glacial lake forms when a glacier erodes the land, then melts, filling the space it has created. In recent years, glaciers in the Himalayas and elsewhere have been retreating faster, forming or expanding glacial lakes which are bound by a natural dam made of loose soil and stones. In 2013, melting of the Chorabari glacier led to a glacier lake outburst flood, devastating Kedarnath.

To better predict the formation and expansion of glacial lakes, researchers from the Divecha Centre for Climate Change propose a new model. The model uses knowledge of the lake bed topography, obtained by subtracting the ice thickness from the surface elevation at different points. This was done by using remote sensing data as well as on-site data. They also validated the model using data from two glaciers.

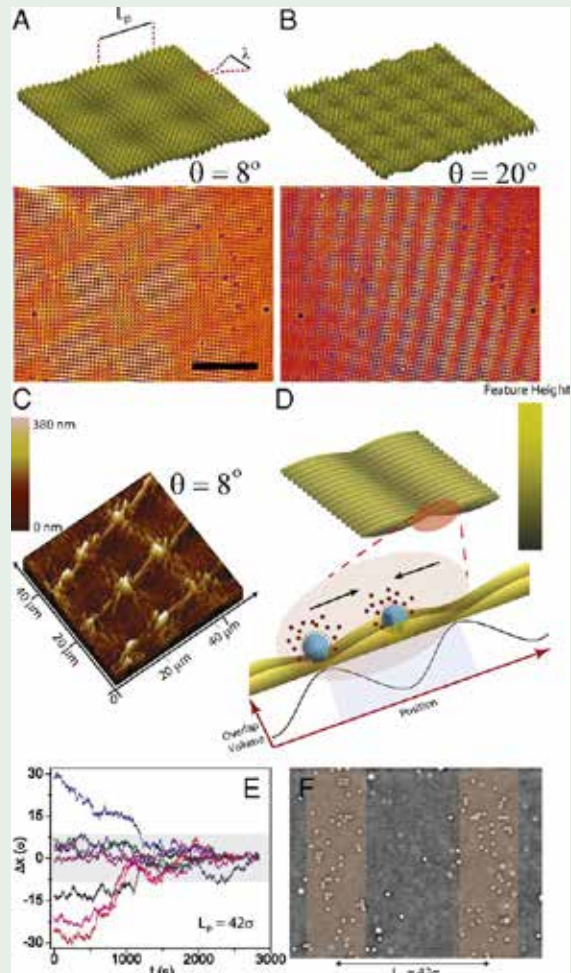
Current Science, <http://www.currentscience.ac.in/Volumes/111/03/0553.pdf>

**COLLOIDS****Growing crystals that imitate the hues of nature**

Colours in nature often result from underlying periodic structures that are self-assembled using nano-sized building blocks. Such structures have so far been difficult to produce artificially because the colloidal particles used are difficult to move around. The conventional techniques—using evaporation or an electric field—do not allow control over the locations at which the particles are deposited or over the structure of the growing crystal.

Researchers from the Department of Physics and JNCASR have now developed a new method using a Moiré pattern, obtained by superimposing two geometrical patterns or lattice at an angle. This creates periodic modulations in channel depths in the template. They then introduced attractive interactions which are sensitive to local channel depths, converting the modulations to energy gradients that guide particles to desired sites.

Proceedings of the National Academy of Sciences, <http://dx.doi.org/10.1073/pnas.1608568113>



Courtesy: CHANDAN K MISHRA ET AL AND PNAS

SOLAR ENERGY**Better inverters for harnessing solar power**

The output from solar panels is direct current, which is typically converted to alternating current using inverters. Since these inverters have low input-voltage, transformers are used to step-up the voltage and provide isolation. For this, high-frequency transformers are preferred over line-frequency transformers because they are cheaper and more compact.

While working with such a setup, researchers from

the Department of Electrical Engineering faced many challenges with the starting up of the inverter. So they designed a new method that sequentially enables the different subsystems in the inverter to avoid issues of over-current or over-voltages that can damage it. The performance of the proposed start-up method was validated and compared with conventional start-up schemes using simulations and experiments. The new method does not require any additional power or control circuitry.

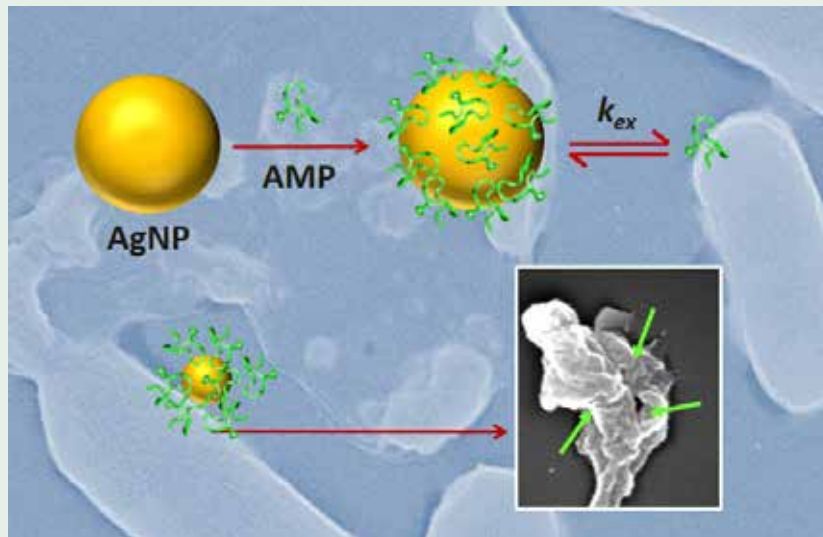
IEEE Transactions on Industry Application, <http://dx.doi.org/10.1109/TIA.2016.2601278>



ANTIBIOTICS

Enhancing antibiotics with nanoparticles

One way to make antibiotic molecules more powerful is to chemically attach silver nanoparticles to them. A team of researchers from the NMR Research Centre, SSCU and MRDG, collaborating with Bose Institute, Kolkata, investigated the nature of interaction between the nanoparticle and an antimicrobial peptide, using Nuclear Magnetic Resonance imaging.



Courtesy: INDRANI PAL

This combination, or conjugation, of the nanoparticles with a peptide drug was found to enhance the stability of the nanoparticle beyond two months. Moreover, it is safe to use and showed enhanced efficacy. One can also pack a large number of antimicrobial drug molecules with one nanoparticle, achieving high density of these molecules that can be delivered at particular location. This has increased potency against bacteria as compared to the free non-conjugated drugs.

Journal of Colloid and Interface Science, <http://dx.doi.org/10.1016/j.jcis.2016.08.043>

SOCIAL NETWORKS

Information diffusion in social networks

How do you spread information as far and as quickly as possible in a social network, given a constraint on the number of nodes one can choose? A study by researchers from the Department of Computer Science and Automation and IBM India Research Labs, looked into the effects of triggering the “seed” nodes in two phases, in contrast to most existing work which triggers diffusion in one go.

They evaluated the model using computer simulations over a standard large network dataset. The results showed that a two-phase process performs better under the standard setting of no time-constraints. Under a strict time constraint, the single-phase process fared better. The set of seed nodes used for the first phase are very influential in directing the diffusion, and a split of 1:2 nodes for the first and the second phases is optimal.

IEEE Transactions on Network Science and Engineering, <http://dx.doi.org/10.1109/TNSE.2016.2610838>



POWER TRANSMISSION

Study of insulators in the presence of fog and mist



Courtesy: B. SUBBA REDDY'S GROUP AT HIGH VOLTAGE LABORATORY

Corona discharge, often manifesting as a purple glow, occurs when the electric field around a conductor, such as an overhead transmission line, is intense enough to cause ionization of the surrounding air. It leads to power loss and also degrades the insulator—often made of polymers—that is meant to protect the conductor. Researchers from the Department of Electrical Engineering studied how corona discharge affects insulators in the presence of mist or fog, including acidic fog conditions.

They found that corona discharge was intensely concentrated in fog conditions, and made worse if the fog is acidic. The surface resistivity of the fog-treated samples was reduced, which could lead to surface conduction and flashover. Formation of nitric acid was also observed on these samples, which may cause fracture and failure of the insulator.

IEEE Transactions on Dielectrics and Electrical Insulation, <http://dx.doi.org/10.1109/TDEI.2016.005541>

CRYSTAL ENGINEERING

A better combination drug to treat infections

Infections are often treated using combinations of medications. These are, however, in the form of physical mixtures whose components have different chemical and physical properties, such as solubility and permeability. This results in the component drugs having different efficacies.

Researchers at the Solid State and Structural Chemistry Unit have designed a new

multicomponent solid, a combination of the antibacterial norfloxacin and the antimicrobial sulfathiazole, in the form of a salt. It has improved physicochemical properties as compared to the individual drugs or their physical mixtures.

The salt form results in the two drugs diffusing better and also ensures they are utilized more fully by the body, enhancing the overall efficacy.

Molecular Pharmaceutics, <http://dx.doi.org/10.1021/acs.molpharmaceut.6b00320>



MADHAV GADGIL ON THE ROLE OF SCIENCE IN CONSERVATION

 HARI SRIDHAR

Madhav Gadgil founded the Centre for Ecological Sciences (CES) at IISc in 1983, where he continued to work till his retirement in 2004. Over this period, he pursued research in a number of topics in fundamental ecology and natural resource management. In addition to over 200 scientific papers, Gadgil has written many influential books, including 'This Fissured Land' and 'Ecology and Equity: The Use and Abuse of Nature in Contemporary India' (with Ramachandra Guha). Currently a visiting professor at Goa University, he came back to IISc to receive the INSA Golden Jubilee Commemoration Medal at an event organized by the Centre for Contemporary Studies in August. During the event, he delivered a lecture titled 'Human Knowledge: An Evolutionary Perspective', after which he spoke to CONNECT about the role of science in conservation.



NISHANTH KS

Q You started out doing theoretical ecology for your PhD. But soon after, you came back

to India and switched almost entirely to doing field ecology, especially in the context of natural resource management work. Was this a conscious decision?

I was interested in nature and nature conservation from my school days. In the 1930s, my father was



an avid birdwatcher who was friends with Salim Ali, and I got to know Ali when I was 12 or 13.

There was another parallel current. JBS Haldane moved to India in 1956, when I was still in school. I came to know him through the many books of his in my father's collection. He has done all sorts of important scientific work—in evolutionary theory, origin of life, enzyme kinetics, etc. But what stood out in all of this was that he was very conscious of communicating science to the public. For example, his important paper on origin of life was not published in any technical journal, but in a publication called *The Rationalist Annual* and written in a way that anybody can understand. It was through Haldane's essays I became very interested in evolutionary theory.

And during this time, I also became convinced that to do good science, one must have a sound background in the relevant mathematics. Today, you have places like the IISERs and IISc, but in those days you could not simultaneously study biology and mathematics in India. I was interested in mathematics, and good at it too—I arranged for a private tutor to teach me BSc level mathematics. So when I got into Harvard, I decided that I must take advantage of the opportunity. They conducted a background evaluation exam for first year graduate students based on which they told you which courses you had to take compulsorily. Fortunately, and surprisingly, they told me I was not weak in anything so I could take whichever courses I wanted to. So I took a good number of courses in mathematics, such as probability and statistics, as well as courses in evolution and ecology. Harvard had very good teachers such as Ernst Mayr and EO Wilson.

Then I worked with one of Wilson's students, Bill Bossert, who was an assistant professor of applied

mathematics and biology, and acquired a good understanding of theoretical biology. But even

“ *Satish Dhawan, who was then the Director of IISc, was a man of very broad interests, including an interest in nature and conservation issues. He encouraged me to develop a full-fledged ecology programme here at IISc and that was how CES was born* ”

then it was clear to me that I will not do only theoretical biology. When I came back to India, I wanted to work in the field along with theoretical work. Of course, doing theoretical work in India was more difficult compared to what it might have been had I taken up one of the positions I was offered in Harvard and Princeton. The academic atmosphere was different in India. On the other hand, India offered rich possibilities for doing field ecology. Therefore, I slowly started doing much more fieldwork. But the interest in fieldwork and nature conservation I had right from my high school days.

Q Can you tell us a little about the formation of CES?

Right from the beginning, CES's mandate included both theoretical work and field ecology. It was a very interesting experiment. We had a very interesting group at CTS: N Mukunda, who was a theoretical physicist; Sharat Chandra, who was a geneticist and Vidyanand Nanjundiah, who did a PhD thesis in physics, but then researched



developmental biology in slime moulds. Satish Dhawan, who was then the Director of IISc, was a man of very broad interests, including an interest in nature and conservation issues. He encouraged me to develop a full-fledged ecology programme here at IISc and that was how CES was born.

Q You have said previously that while science is immensely useful in understanding physical and chemical systems, it has a more limited role in understanding complex systems like in ecology, and in contributing towards conservation. Can you talk a little more about that?

All sciences of complex systems have much greater limitations than sciences of simpler systems, like physics and chemistry. Of course, in physical sciences too you have areas like atmospheric circulation where we have a much less firm understanding of what is going on.

There are a very interesting set of papers by Lawrence Slobodkin, where he talks about the limitations of areas like ecology where we don't have any universal laws or the ability to generalise across the board. In such areas, therefore, case-by-case decisions have to be made, for which detailed understandings of specific systems are needed. For these reasons, he says, ecologists have a limited ability to contribute to applications, compared to a physicist who can help send a satellite up and be sure of what orbit it will take around the Earth and so on. Nothing like that is possible in ecology. It is too complex and too variable.

Q Was this part of the reason you moved away from theory-driven ecology to more case-by-case work?

There were many reasons. I was interested in applying conservation biology understanding to

select conservation areas. So I wrote a report for the Karnataka Government on the important areas

“ Bharatpur was then upgraded from a sanctuary to a National Park, and buffalo grazing was stopped. In the protests that followed, seven villagers were killed in police firing. Did we at least achieve anything in conservation terms? No, because as soon as the buffalo grazing was stopped, Paspalum grass, which was being kept in check by buffalo grazing, choked the wetlands and actually made it a worse bird habitat ”

which should be brought under a conservation regime. One of them was Narasimha Parvatha near Kudremukh. Later I learnt that the consequence of it being added to Kudremukh National Park was actually destructive. When people believed it was under their own control, they were felling trees carefully, but as soon as they learnt they were going to be excluded from the area, they decided to destroy everything in one go. That was when I first experienced the limitations of conservation based solely on ecological principles. But decisions on how to conserve cannot be based only on ecology. One must understand all the social and economic processes operating in addition to conservation biology understanding. So to protect a forest, always putting it in charge of only the forest department is the wrong answer.



A few years later, I went with Salim Ali to Bharatpur for a bird banding camp. In the evenings, we would go on walks and around sundown an enormous number of buffaloes would be going back to their villages through the park. Ali used to say, “Madhav, once these wretched buffaloes are gotten rid of, the sanctuary will be safe.” He had no particular understanding of the role of buffaloes in the ecosystem, and I was unsure about this conclusion. But I also had no particular data so I just listened to him. Ali had a lot of influence with Indira Gandhi, so he wrote to her, along with conservation organisations like International Crane Foundation, and told her she must put a stop to villagers using Bharatpur. Bharatpur was then upgraded from a sanctuary to a National Park, and buffalo grazing was stopped. In the protests that followed, seven villagers were killed in police firing. Did we at least achieve anything in conservation terms? No, because as soon as the buffalo grazing was stopped, *Paspalum* grass, which was being kept in check by buffalo grazing, choked the wetlands and actually made it a worse bird habitat. Around that time, all these notions of adaptive management were coming up. I felt that the park management should have selected parts of the sanctuary, banned buffalo grazing in only those parts and studied its impacts; not just banning buffalo grazing altogether without anticipating what its impacts might be.

So obviously we are not doing things in the right fashion. Also, increasingly, I began to see that the forest department was a very—in simple words—vicious agency. There are some good officers, but they are exceptions. When I started working in Bandipur there was a Project Tiger Deputy Director with whom I trekked from Bandipur to Nagarhole. This was in 1974–75. It was very enjoyable five or six days, trekking and staying in

“*Certainly things have changed, in many cases for the good, but simultaneously the bureaucracy has become more and more dictatorial and vicious. The forest department at that time did not keep researchers out of forests as much as they do today. Some things have actually deteriorated*”

old rest houses which hadn't been used for years. I wrote an article in *Deccan Herald* describing this very interesting trip, and in one place I recorded that good natural forest had been replaced by teak plantations but the teak plantations were a failure because they were infested and stunted by this parasite plant *Loranthus*. Therefore, I said, monocultures should be taken up with considerable caution. That was one of the things the article said among many other things. Then, in 1975, Madam Gandhi declared emergency, and within 10 days I got a letter from the Karnataka Forest Department saying that I shall not publish anything without getting clearance from them.

I showed the letter to Satish Dhawan and asked him what I should do. He said: “Simple; throw it in the waste paper basket. But whatever you write, make sure it is backed up by definite evidence. You come to me if they try to bother you and I will deal with them.” He was a great man. I don't think there are many other scientific administrators with that kind of attitude. So I continued writing and they of course did not have the courage to do anything. This and many other experiences kept showing how vicious an agency the forest



“*So there is an understanding of ecological ideas among local people, even though it maybe not be in Terborgh’s modern scientific terms, but important nevertheless*”

department was, and the traditional prescription that all you need to do to protect nature is hand over large areas to the forest department seemed all wrong.

Q Do you think things are improving? Is the forest department more open to scientific input now?

Certainly things have changed, in many cases for the good, but simultaneously the bureaucracy has become more and more dictatorial and vicious. The forest department at that time did not keep researchers out of forests as much as they do today. Some things have actually deteriorated.

Q Long before it became popular, before it even had a name, you were doing citizen science, involving the people who lived in the areas you worked in. What was your motivation to do this—to get people involved in collecting the data that affects their lives?

First, we simply do not have enough experts to collect the detailed location-specific, time-specific data that is required. Second, I saw that local people do have a lot of understanding of what goes on. One very striking example: While working in Bandipur, I used to spend a lot of time with elephant mahouts. One day they were discussing among themselves—not with me—about how *Ficus* trees were being lopped and why it was not a good idea because the *Ficus* fruit

is one of the few fruits available year-round for birds, squirrels, monkeys and bats. Around the same time, John Terborgh, at the time a professor at Princeton, wrote a paper in which he developed the concept of keystone resources. And he takes *Ficus* as an example and talks about much the same thing the mahouts were saying: that *Ficus* is a genus where many species have fruit available in all seasons of the year. Then I began to look at traditional conservation practices, and *Ficus* is the one genus, which, in many parts of Africa and Asia, is treated as sacred, and the trees are not felled.

So there is an understanding of ecological ideas among local people, even though it maybe not be in Terborgh’s modern scientific terms, but important nevertheless. I felt it was important to take advantage of this understanding and develop a system where a large number of people will be involved in decentralised monitoring, so that good data can be collected at a large-scale.

Q If a student who is about to finish school or undergraduate education comes up to you and says “I’m really passionate about conservation and would like take it up as a career”, what would you say in response?

It’s a very difficult question because a career in conservation for a scientist is very difficult—conservation, officially, is managed by bureaucratic agencies which are allergic to science. Yes, you also have NGOs, but regretfully, even these NGOs, because of their interest in funding and not wanting to get into the bad books of the government, to my mind, are not doing what should be done. They are also colluding with the bureaucracy in dishonesty.

So I do not know really. All I can say is try and be a



good scientist and focus on your scientific career, but then combine it with conservation interest in some way. It is a very difficult proposition.

Q Right now the only formal path in training for a career in conservation seems to be through courses in ecology and wildlife biology. Do you think there needs to be more diversity in the training, i.e. academic disciplines other than ecology, as well as skills outside academia?

I think the training is seriously defective. The ecology stream very often completely ignores a whole lot of other forces which are impinging on conservation efforts and, I'm sorry to say, most people are not willing to engage with that; they are not willing to consider different viewpoints.

Q When the Western Ghats Ecology Expert Panel report was tabled, there was some controversy. The Government then appointed another committee to look at the report, which, to my understanding, diluted the recommendations of your committee. Do you think this was entirely political or was part of it because people didn't understand the science in the report?

It was entirely driven by vested economic interests, especially mining, which controls politics. It is these very powerful economic interests which were driving all the manufactured controversy, which promoted among the people a distorted picture of what was in our report. And it went to such an extent that the Maharashtra Government published a

So it really had nothing to do with not understanding the report or the science behind it. Neither the mine owners nor the bureaucrats or the politicians care about scientific principles

so-called Marathi summary of our report on its website, which was full of distortions. One day I was at a public meeting, where the Minister of Environment and Forests and the Secretary in the Ministry, responsible for the Marathi summary, were both present. I publicly said that there are these distortions in what they were reporting to the public. The Minister replied that he didn't realise that, and that if what I was saying was what was in the report, then he was entirely in favour of our recommendations. I said if that's the case then correct it on your website. Or tell me how many words you want and I will write a summary in Marathi myself. They just laughed and did nothing about this. They kept the distorted summary on the website deliberately.

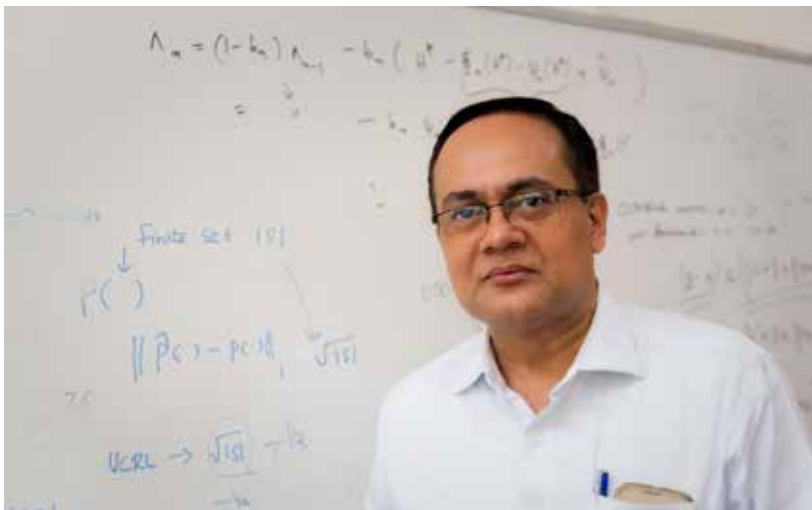
So it really had nothing to do with not understanding the report or the science behind it. Neither the mine owners nor the bureaucrats or the politicians care about scientific principles.





INSTITUTE COLLOQUIUM: OPTIMIZATION VIA SIMULATION

✍️ **SATYANATH BHAT**



Courtesy: PRO, IISc

Shalabh Bhatnagar, Professor, Department of Computer Science and Automation, gave an Institute Colloquium on 21 November 2016 titled *Optimization via Simulation*.

Bhatnagar began his talk by describing how the theory of optimal control, and the underlying optimization techniques, can be applied in everyday situations. An example

is traffic signal control, where the aim is to minimize the average waiting time at the junction, treating all the traffic lanes fairly. This can be done by defining an appropriate “cost” function and minimizing its value.

If the system being analyzed has inherent random noise, one is in the realm of stochastic optimization, where the objective is to minimize the average or expectation of the cost function. In many stochastic optimization problems, the statistical distribution of the noise is unknown—such problems are known as “model-free”. In such cases, simulating samples of the noisy cost function is a useful approach.

Such simulation-based techniques in optimization is Bhatnagar’s area of expertise. During his talk, he gave an overview of research in this area, especially the work done at IISc on stochastic approximation algorithms. Bhatnagar’s research group has made numerous contributions, such as the use of deterministic perturbations, asynchronous update algorithms and application of continuous-time stochastic approximation techniques to discrete optimization etc.

Another research area in his lab is reinforcement learning, which are problems in which the environment evolves with time. Bhatnagar spoke about how a problem in reinforcement learning could be of very high dimensionality, and therefore cannot be tackled directly. This challenge can be addressed by projecting the problem onto a feature space. Bhatnagar’s lab has contributed to research in this area through new algorithms which find the optimal set of features through feature adaptation.

Towards the end of his talk, Bhatnagar returned to his initial example of traffic control and described how the techniques of stochastic approximation can be applied towards minimizing waiting times of road users.



INSTITUTE COLLOQUIUM: EXPLOITING NATURAL PRODUCTS FOR CANCER THERAPY

 AMITASH S



Courtesy: PRO, IISc

In an Institute Colloquium on 24 October 2016, C. Jayabaskaran, Chairperson of the Department of Biochemistry, spoke about his research journey, and the work done by his research group on identifying and producing compounds with medicinal properties from plants.

Biomolecules within living cells are synthesized based on information encoded in the DNA, the

genetic material. Each biomolecule is encoded by a specific part of the DNA called the gene. By modifying the information on these genes, the biomolecules that would be synthesized can be indirectly modified.

Jayabaskaran, originally a plant molecular biologist, works on special RNA molecules inside plant cells called transfer RNA, or tRNA. While studying genes encoding tRNAs, his team stumbled upon some genes that encode compounds known to have anti-cancer properties. These compounds, called secondary metabolites, are produced by plants and fungi that live within plants, called endophytic fungi. "Initially, people believed that secondary metabolites were waste materials released by the plants," said Jayabaskaran. "Later, it was realized that plants [and/or their] endophytic fungi use them as a defence against pathogens and we can use them to cure diseases."

However, because the yield of these molecules is low, their bulk production would require felling of a lot of trees. Jayabaskaran described how his team is using a "metabolic engineering" technique to mass-produce secondary metabolites in lab-grown fungi and plants. In this technique, fungal cells are genetically modified to produce large quantities of secondary metabolites which are then isolated and purified. During this process, they could identify novel anti-cancer, anti-thrombin and other pharmaceutically useful compounds from well-known plants and their endophytic fungi. These compounds are being tested for their therapeutic potential in cultured human cells and model organisms like mice.

Jayabaskaran also described how one of these compounds was successfully patented and the rights to produce it were sold to a Kolkata-based biotech company. He hopes to make available many more such compounds to the clinic. Towards this goal, his team is now planning to use genomics-guided strategies to accelerate various steps of the metabolic engineering process.



S RAMASESHAN MEMORIAL LECTURE: EXPLORING THE WORLD OF SEMICONDUCTOR NANOWIRES

✍️ **SUBHAYAN SAHU**



Courtesy: PRO, IISc

Chennupati Jagadish, a renowned physicist in the field of nanotechnology, delivered the 2016 S Ramaseshan Memorial Lecture at IISc on 27 October 2016. A Distinguished Professor in the Department of Electronic Materials Engineering at the Australian National University (ANU), he spoke about his research on semiconductor nanowires, and their various engineering applications.

Jagadish gave a brief history of the development of the science of semiconductors, a story in which silicon has been the most important player. However, silicon is an indirect bandgap semiconductor. This means that optoelectronic devices made out of silicon are not the most energy efficient. This has motivated researchers to develop composite chemicals, the so-called III-V semiconductors, which have properties that can be tuned for specific applications. But because these materials are expensive when used in bulk, scientists prefer to work in lower dimensions, such as with the zero-dimensional quantum dot, or the one-dimensional nanowire. Moreover, nanowires have novel properties, which led the International Technology Roadmap for Semiconductors to identify them as the building blocks of future devices.

During his talk, Jagadish showed glimpses into the wonderful world of these minuscule wires, hardly a micron in length and more than a hundred times thinner than human hair. His research group has been working to perfect the production of these nanowires. Making radial and axial heterostructures with them, his lab has constructed the smallest lasers and identified materials and configurations ideal for other applications in optoelectronics and photonics. Eschewing traditional materials, they used nanowires for constructing solar cells, which, Jagadish said, allowed them to achieve higher efficiency using less material. He also spoke about an exciting new direction of research in his lab—developing a “brain” on a chip, by constructing a mesh of nanowires and growing and engineering neurons in them.

Towards the end of his talk, Jagadish spoke of his initiative, the Chennupati and Vidya Jagadish Endowment, which supports young researchers from developing countries to visit ANU. Recalling his modest beginnings in a village in Andhra Pradesh, and also the opportunities he had, Jagadish said he hoped to give something back to the country through this initiative. Throughout the talk, he also emphasized the importance of collaborations in science, and expressed his hope of strengthening scientific collaboration between India and Australia.



CENTRE FOR BRAIN RESEARCH LECTURE SERIES: HOW DOES THE BRAIN ENCODE LANGUAGE?

✍️ **KARTHIK RAMASWAMY**



Courtesy: PRO, IISc

Tom Mitchell founded the Machine Learning Department—the first of its kind in the world—at the Carnegie Mellon University (CMU), where he serves as the E Fredkin University Professor. Machine learning is a branch of artificial intelligence (AI) which investigates how computers can learn through data, experience and interaction. In recent years, machine learning has begun to change our world in remarkable ways. A critical reason for

its success has been the willingness of its researchers to borrow from the principles of other sciences—neuroscience in particular—and improve their computer algorithms.

Over the years, Mitchell has himself become interested in understanding the secrets of the human brain. He is attempting to unlock some of these mysteries by reverse engineering—employing machine learning techniques to the field of neuroscience.

This was the subject of Mitchell's lecture, organized by the Centre for Brain Research on 6 December 2016, titled *Using Machine Learning to Study Neural Representation of Language Learning*. In his talk, he focused on how neurons encode meanings of words and also how they combine them into sentence meanings based on work that he has been doing in collaboration with neuroscientists from CMU.

As a first step, Mitchell and his colleagues displayed different words (for example, *bottle* or *hammer*) to dozens of volunteers and obtained images of their brain activity using fMRI. These images were then fed to a statistical classifier to train it to distinguish patterns of neural activities associated with different words. After being trained, the classifier was tested on how well it had learnt. It was given fMRI images of brain activity of new subjects who read one of the two words (*bottle* or *hammer*), and asked to predict which word it corresponded to. Mitchell's classifier turned out to be a proficient learner. While the trained classifier came out with flying colours when it came to decoding concrete nouns like *hammer*, and emotion nouns like *happiness*, it struggled with abstract nouns like *justice*. This experiment, however, provided a crucial insight: words, certainly concrete nouns, are represented in a similar fashion in the brains of different individuals. When the experiment was performed with non-English speaking volunteers, the results were the same, showing that even people who speak different languages encode concrete nouns in their brains in an identical manner.



Mitchell's team then tested if verb associations of a noun are important in how it is encoded in the brain. The classifier was trained with fMRI images of verbs that co-occur with a noun like *celery* (for example, eat, taste, etc.) or with airplane (for example fly, crash etc.), but not those corresponding to the nouns themselves. It was then asked to predict whether a novel image it was shown was the response of a subject who read the words *celery* or airplane. Again, it was successful—with an accuracy of 79%. A more advanced version of the model used by the classifier had an even better prediction accuracy, giving greater credence to Mitchell's hypothesis. fMRI, however, is not an ideal tool to understand the dynamics of what happens in the brain when it processes a word since it only gives us a snapshot in time of brain activity. When we read a word like *hand*, the brain takes about 400 milliseconds (ms) to comprehend it. A more dynamic picture of how a word is processed is revealed by electroencephalography (EEG) outputs, according to Mitchell. So his team trained the classifier on a series of images obtained using EEG for a particular word at different time intervals. The classifier was able to predict accurately, based on these images, attributes of the word at different time periods: Word length and other semantic features (for example, is the object an animal or is it made of wood), before it finally predicts the word at around 400 ms, not unlike the human brain.

Using similar imaging and modelling techniques, Mitchell and his team are now trying to understand how phrases (like *angry man*) and entire sentences (like *The dog ate the bone*) are neurally encoded, which he hopes will give us a richer understanding of how language is represented in the brain.

CENTENARY LECTURE: MARTIN GRUEBELE

 **NITIN SAXENA**



BRYAN STAUFFER/WIKIMEDIA COMMONS

Martin Gruebele is the James R Eiszner Chair in Chemistry at the University of Illinois at Urbana Champaign, USA. On 15 December 2016, he gave Centenary Lecture titled *From Nanostructures, to Proteins, to Fish: The Evolution of Natural Systems*.

In his talk, Gruebele discussed the dynamics of movement—from quantum motion to animal behaviour. Research in Gruebele's lab uses state-of-the-art laser techniques to study and manipulate complex natural systems to understand phenomena ranging from protein folding to coordinated swimming behaviour in zebrafish larvae.





LESZEK BORYSIEWICZ: GLOBAL COLLABORATIONS AND CHALLENGES

✍️ SUDHI OBEROI

Sir Leszek Borysiewicz is the current Vice-Chancellor of the University of Cambridge. Before joining this position in 2010, Borysiewicz served as the Chief Executive of the Medical Research Council where he frequently contributed to public debates pertaining to medical sciences. He has been a proponent of translation of research discoveries in medical sciences into treatments, while urging researchers to never lose sight of the importance of fundamental research. He has been a driving force behind the development of the Francis Crick Institute, formerly known as the UK Centre for Medical Research and Innovation, which is the biggest single biomedical laboratory in Europe. Trained as an immunologist, Borysiewicz was knighted in 2001 for his contribution to medical education and research into developing vaccines, including work towards a vaccine to combat cervical cancer.



Courtesy: PRO, IISc

Sir Borysiewicz was on campus in September 2016 to deliver a special lecture titled 'Global Collaboration in the Face of Global Challenge', in which he addressed the importance of international collaboration in the development of science and research, and role of university partnerships in tackling some of the most pressing global problems. He also had a discussion with the IISc administration on the Bangalore-Cambridge Innovation Network, an initiative to foster links between academics, businesses, researchers and entrepreneurs from the two cities. He spoke with CONNECT about global collaborations and its challenges, particularly in the wake of Brexit.

Q What brought you to Bangalore?

Enhancing engagement with India is a strategic priority for the University of Cambridge. For over 150 years, Cambridge has enjoyed a particularly close relationship with India. But we are visiting India now to build on broad, deep and enduring links of friendship and academic partnership.

Cambridge researchers work with colleagues in India's leading research institutes and universities, corporations, government departments and civil society organisations to solve challenges which face not just India, but the whole world in the 21st century—whether it is improving crop yields, or finding better drugs and improved therapeutic methods to combat cancer.



Q What is your vision for the Bangalore-Cambridge Innovation Network that was launched in April 2016?

The Network was actually launched in 2012, during one of my earlier visits to Bangalore, and I am delighted that its Bangalore secretariat has been established this year, based at IISc. It is obvious that the cities of Cambridge and Bangalore share many characteristics. Both are high-tech hubs: Bangalore is known as India's Silicon Valley, and Cambridge is often called Silicon Fen. Both have a strong focus on knowledge-driven sectors such as biotechnology, information technology, advanced manufacturing and nanotechnology.

There are very clear compatibilities in scientific research, in innovation, and in industrial research and development. The relationship between Cambridge and Bangalore has already been fruitful, and I expect it be even closer in the future. We still have much to learn from each other.

Q In your lecture at IISc *Global Collaboration in Face of Global Challenges* you said that the sort of collaboration we look for is to serve the global society. What do you mean by a global society?

I refer to global society because the challenges we face are no longer the problem of a single country, or even a single continent. Think about climate change. Whether you live in Karnataka or in Cambridgeshire, it is an urgent issue. Think about antimicrobial resistance—the threat it poses does not stop at any international border. The problems that arise from food, energy or water security are not unique to one specific place. So when a university like Cambridge, or an institute like IISc, sets out to tackle some of those global problems, they must be thinking about the potential impact beyond their own communities or countries.

The problems that arise from food, energy or water security are not unique to one specific place. So when a university like Cambridge, or an institute like IISc, sets out to tackle some of those global problems, they must be thinking about the potential impact beyond their own communities or countries

Q What are the challenges you think we face while collaborating across countries or continents?

The challenges in collaborations across countries are similar. One of the main ones is ensuring the compatibility of different regulatory frameworks. In Cambridge's collaboration with India, however, we see more opportunities than challenges.

Q In an interview with *The Guardian*, you mentioned that there is an emerging perception in India that Britain is not welcoming. Why do you think that is?

For many years, the UK government has been uneasy about the number of people migrating to the UK, and has tried to reduce this number. Our friends in India tell us that the political rhetoric has often made the UK appear unwelcoming. I have repeatedly made the case that international students make a very significant contribution to the UK's economy, culture and knowledge base, and should be welcomed. As a globally competitive institution, Cambridge would like to attract the brightest and best academic staff and students, no matter what their background.



Q The number of students opting to go to the UK for further studies has gone down. Is the University of Cambridge or the administration in general addressing this issue?

The number of applications by Indian students wishing to do a postgraduate degree at Cambridge has actually increased over the past few years. We were very pleased to be chosen as one of only four UK institutions allowed to pilot a new visa scheme for Master's students, announced in the summer. It will streamline the visa application process for international students, including Indians, and extend the time students have to find work in the UK after the completion of their studies. We hope this pilot will make Cambridge an even more attractive institution for Indian students.

Q With the Brexit vote, the general perception is that collaborative research with the UK might suffer. Do you agree with this? If not, why?

Brexit, when it happens—and remember that it is not likely to happen formally for at least another two years—will certainly require adjustments to the way in which we currently collaborate with international partners. But I'm confident that, if anything, it will spur us on to engage with our foreign partners more intensely than ever before.

Q What are your thoughts on Indian science, especially science at IISc?

Excellence is the main driver of our partnerships, and India produces science of the highest quality. Indian scientists have a record of world-class research. This is why I'm here, and why my colleagues and I have met with Professor [Anurag] Kumar and other leaders of IISc. Cambridge and IISc are already partners in research on subjects as diverse as infectious disease, open-source drug

discovery, and environmental risk. Cambridge University Press and IIScPress have been jointly

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publishing academic titles since 2013. One of our newly appointed lecturers under the DBT-Cambridge Lectureship scheme launched last year will be spending some of his time over the next few years here at IISc.



Borysiewicz with IISc's Director, Anurag Kumar

Courtesy: PRO, IISc

Q Do you get time for research?

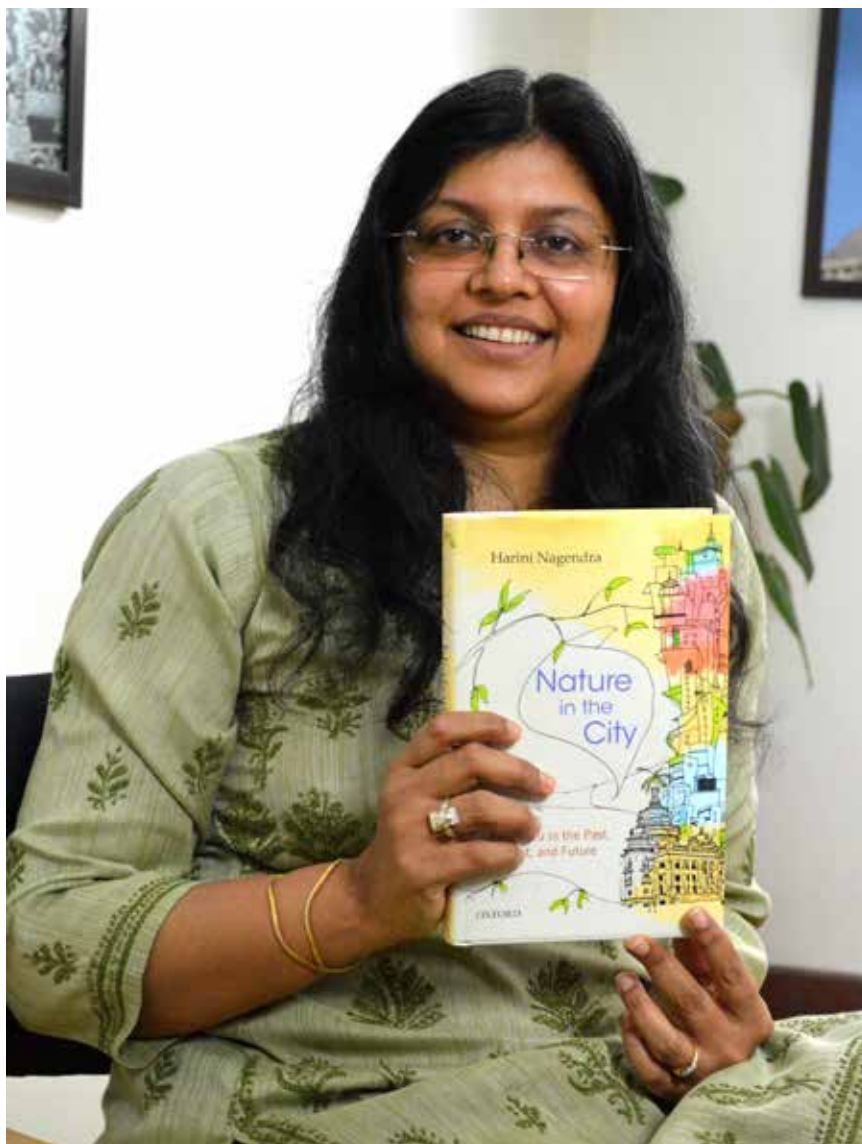
Sadly, it's been many years since I was able to carry out my own research. I miss it tremendously, but I am able to live vicariously by hearing about what so many of our extraordinary scientists are doing. This is certainly one of the perks of heading a research-intensive institution like the University of Cambridge.



HARINI NAGENDRA: NATURE IN THE TIME OF URBANIZATION

✍️ BHARTI DHARAPURAM

Harini Nagendra is Professor of Sustainability at Azim Premji University, Bangalore. She studies the interaction between humans and nature in cities using a mixed bag of research methods drawing from ecology as well as the social sciences. Her book, 'Nature in the City: Bengaluru in the Past, Present, and Future' published by Oxford University Press in 2016, derives from several years of her work on Bangalore. She gave a plenary talk titled 'Urbanization: A New Frontier for Conservation' at the Student Conference in Conservation Science in September 2016, hosted in IISc. Excerpts from a conversation with CONNECT.



Courtesy: HARINI NAGENDRA

Q Tell us a bit about your background and what got you interested in ecology?

I did my BSc in Microbiology and came to IISc in 1992 as part of the first batch of Integrated PhD students in Biology. And I found that I hated being in the lab and spending most of my time

in a closed space. At that time CES [Centre for Ecological Sciences] was celebrating its 10th anniversary with a series of talks, and I landed up there and listened to Madhav's [Madhav Gadgil, then Professor at CES] talk by accident. I really liked what he said, and ended up doing a project with him and staying on for a PhD.



Q What led to the shift of your research focus to urban landscapes, studying the ecology of cities?

I moved to ecology to do something that was more meaningful. One of the big attractions for me was working on conservation challenges of direct and immediate relevance. I worked on forests in the Western Ghats for my PhD, then in Nepal, north Bengal and a number of different places. The main shift was in 2005-06 when I started looking at some of the impacts of our work. To see results getting translated to practice while doing policy relevant work is a frustrating exercise. It has worked for some people but it was really not working for me. I started thinking about being located in a place—my place being Bangalore—and doing something meaningful there.

A couple of other things happened that were more personal. We were building a house in Bangalore and I started thinking about creating a new place in the peri-urban city where, for instance, there are very rapid land-use changes which nobody is paying attention to. When my daughter was born in 2007, I started thinking about what kind of experience she would get growing up in the peri-urban city which is full of pollution and filth. At the same time, I became part of this group of people working with BBMP [Bruhat Bengaluru Mahanagara Palike] on restoring a lake near our house—the Kaikondrahalli lake, which was getting degraded. This work satisfied me much more in terms of policy relevance, at which point I said, “Let’s start looking at this city.”

Q Why are there so few urban ecologists?

They just don’t exist—there are very few in India and also globally. I think it is partly the



I started thinking about being located in a place—my place being Bangalore—and doing something meaningful there



fascination ecologists have for forests; I have that too. [In my forest research] I worked in places where communities manage forests and I heard a lot of comments early on saying, “These are not real forests, so you can’t be answering questions of real ecological importance here.” I hear less and less of that now. I think people are realizing that even in the most pristine of areas, humans are there and are doing positive things.

Ecologists don’t look at cities and people who study cities do not look at ecology. There is a lot of very rich urban work but they think nature in cities doesn’t really exist. Now we have some people working on Bangalore, Delhi, Pune, Bombay, Calcutta—larger cities, but nothing from our small cities. That’s such a huge gap. The ecology of cities has to be a part of their resilience, especially under climate change.

Q What were the challenges you faced while starting out—especially because your work is at an intersection of various disciplines?

When I started looking at urban ecology, I thought it would be a side project, something that would help us quickly assess what the changes are taking place in Bangalore. And then I realized that there is no baseline data, and we spent years getting baselines of various kinds. We realized that baselines in Bangalore are so driven by social context that you need a baseline for home gardens, parks, streets—each is different in nature. Documentation is important. If we need



The interdisciplinarity was woven into the heart of this project because when I started, it was to do something which was a mix of research, outreach and practice. Every new method was prompted by how to engage with people. I found that if you have a little bit of history in the beginning of a story it gets people interested.



to know what is wrong with certain changes and how to fix them, we need to know how they were in the past and why they were that way.

The interdisciplinarity was woven into the heart of this project because when I started, it was to do something which was a mix of research, outreach and practice. Every new method was prompted by how to engage with people. I found that if you have a little bit of history in the beginning of a story it gets people interested. That started us off, but then we found that there is so much in history which explains why we do what we do in the present. So we looked at archival work—we didn't know how to access the archives, didn't know where the archives were or how to read archival material. We had to really train ourselves along the way. There have been a number of studies we have discarded because the methods weren't quite right and we didn't have conclusive answers.

Q How was the history of Bangalore shaped by ecology?

I started looking at the oldest information we

have on the city from inscriptions and started seeing how the city turns out to be two kinds of places. If you are looking at the topography of the city, there is one part to the east which is the *maidan* or the *bayalu*—grassy, rolling plains where the soil is fertile. Early settlements started off here and inscriptions tell you that people were creating tanks and using that for irrigated agriculture here. The area to the west is rocky, undulating and they call this the *malnad* area. It has granite rocks and the soil is very thin, with thorny scrub forest and a lot of wildlife. The inscriptions talk about cattle herding, wildlife attacks and cattle raid fights here.

It is these inscriptions that made me aware of the fact that the city has two ecologies coming together. It has disappeared from our popular imagination. People don't see the topography except that the underlying ecology is still there. All the low-lying areas that get flooded during the monsoons are basically wetlands that were built on, and if you had the drought mapping of the city, I suspect many of these areas are in rocky places in the west.

Q In the same context, what was the importance of lakes in Bangalore's past?

Bangalore is an unusual old city because it is distant from a large water source. We have clear evidence that Bangalore was a settled city and a centre of trade a very long time ago. How did they do that in the absence of water from a large water resource? They built tanks and we have some evidence from inscriptions which talk about clearing the jungle, scooping off the sand in the depression and basically creating a rainwater harvesting reservoir. Around that would be this system—the lake, *kalyanis* [temple tanks], very



tiny pools called *kuntas* and large open wells. They were used for various purposes—irrigation, drinking, washing cattle or clothes. They were spatially and temporally variable. The small ones would dry out in the summer and you would take the silt and use that in the fields. Irrigation was an overflow system—you would open the sluice gate and the entire overflow area became your rice or sugarcane field or whatever else you grew. When the water receded you had these indigenous fish species which would flop around in the mud. When that went away you had these greens—you would harvest and cook them or cows would graze them. This landscape had a continuous system of some kind of ecological use.

Q How has Bangalore's relationship with its lakes changed now?

You have a very different system now—there is a fence and a boundary and everything within that is lake. But the wetlands around it, which used to clean away a lot of the pollutants, are being completely lost. There is sewage coming in, no slow absorption, a lot of soil runoff and the lakes silt up very fast. You have high levels of nitrogen and phosphorous, and eutrophication. All this put together means that there is a complete change in the ecology and social use of lakes over time. You have sewage-filled areas; even when the lakes are clean, eutrophication is a big challenge, and all you can do there is bird-watching, jogging and some fishing contracts go out.

We can really trace when this shift happened. Bangalore faced a drought in 1891-92 when the



If you are looking at the topography of the city, there is one part to the east which is the maidan or the bayalu—grassy, rolling plains where the soil is fertile. Early settlements started off here and inscriptions tell you that people were creating tanks and using that for irrigated agriculture here. The area to the west is rocky, undulating and they call this the malnad area. It has granite rocks and the soil is very thin, with thorny scrub forest and a lot of wildlife



city was running out of water, but couldn't find space to build any more tanks. Following this, the Arkavathy river was dammed and they pumped water into the city. As a result, the entire city began to get piped water, and as soon as that happens, we see a complete decay in the way lakes, wells and *kalyanis* are treated and conserved. They now start talking of them as cesspools of sewage and the cause of malaria, plague and cholera. They drain the water because they say lakes are sources of flooding. They become waste space that gets absorbed by the city. The whole narrative around water changes completely.





LAYING THE FOUNDATIONS OF IISC



IISC ARCHIVES

Morris Travers was the first Director of IISc from 1906 to 1914. Before he died (in 1961), he left behind a typescript of his memoirs, notes and diaries at the archives of University College London. These writings have been meticulously compiled and edited by his grandsons, David MW Travers and John R Ainslie, and will soon be published as his autobiography by

IIScPress. Below is an excerpt from the book.

The main building, to house the library and the administration offices, faced due north onto a 'maidan' or open space. The laboratories first to be built were on the east and west of it, so arranged that wings could be added in the rear to provide increased accommodation as required. Space for other laboratories was reserved to the south of the main building. Bungalows for the Director and staff surrounded the maidan. Blocks of students' quarters were placed to the west. They provided a separate room for each student, and a mess room and kitchen, situated at the ends of the lines of rooms for each group of 12 students. The kitchens and mess rooms were thus as far apart as possible. Lavatories and bath rooms were situated between each pair of lines of rooms. As I should be drawing students from all parts of India I had to consider the prejudices as to

feeding for a variety of races and castes.

The land on a line drawn north and south through the centre of the main building and of the site generally was the crest of a ridge, the ground sloping slightly to the east and to the west. This made it possible, with a small amount of levelling to



provide a maidan as a centre of the layout. Actually on the site of the main building was a 'bund' or bank stretching east and west forming a small 'tank' to catch rainfall from the south. It was old and ruinous. When we removed it to start building, we found in the centre of it the skeleton of a boy, who had clearly been sacrificed when the bund was made.

The subsoil was gneiss, a granite-like material, grey in colour. We proposed to build mainly in coursed rubble masonry using this material. Trial pits sunk about the site showed that immediately below the place where we intended to erect the tower of the main building (the site of the sacrifice just mentioned) was a small pocket of china clay, formed by the action of the water on the gneiss. We built the tower on a platform of light steel beams on concrete.

Before Rudolf had left for England in February he had advertised for a man to act as Engineer in Charge of Building Works. He had many applications, mainly from ex-officials, but he selected W. Miller, a young Englishman, who had been trained in his father's building business and had been for some time in India. He was an excellent draughtsman, and had experience in keeping building accounts and records, but not on the public works system. The Tatas, at Bhabha's suggestion, were anxious that I should engage an ex-Mysore Public Works Officer. The idea was not supported by the Committee.

The work on the foundations, under the contract entered into in April with Mr. T. W. C. Skipp, an Indian-born Englishman, made rapid progress. Now Masson and Clibborn had estimated the initial cost of the buildings at Rs. 7.5 lakhs, the amount of the capital grant of the Government of India and the Mysore Durbar. When in the previous year I had gone into the cost of building with Stevens, it became clear that the estimate, which was for three departments only, was even for an Institute on this scale just a bit of wishful thinking. But I was not worried, as I supposed that the arrears of the income from the Tata endowment, which would amount to

“ *When we removed it to start building, we found in the centre of it the skeleton of a boy, who had clearly been sacrificed when the bund was made* ”

about Rs. 4.5 lakhs, could be used for building and equipment. In August of the previous year Mr. D. J. Tata had told me that we should have this money, but when I returned from England in September he had told me that we should not have it. This was Padshah's doing. My development scheme included only the west wing of the main building and the tower which would serve as a water tower, together with three laboratories, one block of students' quarters and a few bungalows. I set down the capital cost of building and equipment for this at Rs. 13 lakhs. I proposed to make up the deficit of 5½ lakhs from savings on income during the period of development, a procedure which was usual in the case of university institutions in the West. Also I knew already that I should receive financial assistance from the Governments of Bombay and Madras. My proposals as to procedure had not been questioned at the meeting of the Committee on March 23rd. The Tata representatives had neither attended the meeting nor commented on the Report in writing, so I imagined that opposition from that direction had ceased.

At this stage I opened an office in Bangalore. My Chief Clerk was a well-educated young Brahmin, Sundaram Iyer, and soon afterwards I engaged an accountant, Gundu Rao, also a Brahmin, and junior, Bashirodien, a Muslim. These three had no common home tongue, but they all spoke and wrote English as well as I did. I had two orderlies, Ramaswamy and Swilingum, old soldiers from the Madras Pioneers, both wearing many medals, and the usual coolies, and sweepers, etc. At Rudolf's suggestion, all my lower grade workers were paid at a fixed monthly rate, plus a bonus of one anna in the rupee, which



was not a wage but a reward for good service and conduct. On most mornings during my first weeks I had a complaint from the orderly, sweeper, coolie or others, the number of complaints increasing with the number of individuals. I heard the complaints and adjudicated. At last, one morning, when I heard a string of petty complaints involving everybody, I gave judgment: "All bonuses cancelled for the month. Dismiss." "Oh," said my clerk, "but this is most unfair, Sir." I said, "These people have got to learn that while I am ready to listen to serious complaints, it is an offence to waste my time as has been done this morning." The punishment was actually remitted on pay-day, but petty complaints ceased. I held a durbar every pay-day, paying the people myself and hearing complaints. Very rarely did I have trouble. In all my life I have never been better nor more faithfully served than I was by all ranks of my Indian staff, subordinates and servants. I am proud to think that they all became attached to me. A very curious thing happened a few days after I had opened my office. On the morning of March 31st, when I came into the office, my clerk said to me: "Sir, I hear that there is a large sum of money for you in the Resident's Treasury, and that if you don't take it away today you will not have it." I drove to the Treasury where I was told that they had Rs. 87,000 from the Government of India for me. As the afternoon was a holiday, I must clear it before midday or the grant would lapse, as all grants did at the end of the financial year. Also I must take the money in silver rupees. I drove to the bank, obtained the service of a couple of clerks and took away the boxes of rupees in bullock carts.

Now Government had promised to pay the grant of Rs. 87,000 a year from January 1st, so only a quarter of the sum was due. However, I banked the money in a special account, making good the value of five bad rupees myself, and decided to talk to the Finance Department about it when next I visited Simla or Calcutta. Then, when I saw Mr. Baker, he told me that at the end of each financial year there remained certain balances which had to be



In all my life I have never been better nor more faithfully served than I was by all ranks of my Indian staff, subordinates and servants. I am proud to think that they all became attached to me



liquidated. Knowing that the Institute was short of capital funds he had kindly made up our grant to the full annual amount.

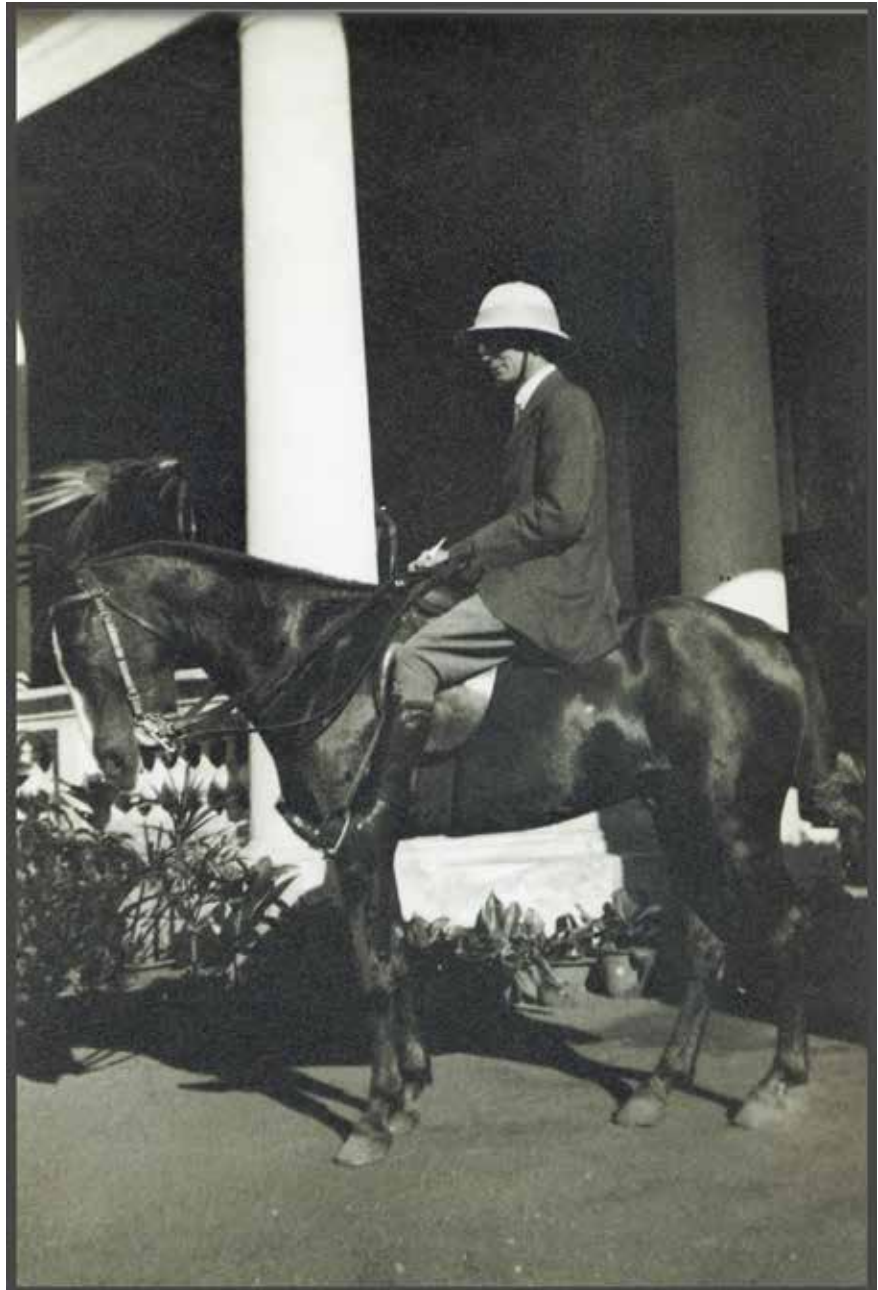
On April 10th I went to Bombay. I lunched at Government House, and had a long talk with the Governor about elementary science education, the first of many such talks.

I saw D. J. Tata but he had no comment to make on my Report. Much of my time was spent with the architects with whom I had to discuss the estimates for the buildings, which I proposed to lay before the Provisional Committee (1908) at their next meeting. I have no further record of my doings during the week I spent in Bombay. On the last night I dined with Burns. He was leaving for home the next day, had wound up his domestic affairs, and had got in temporary staff to cook the dinner. I felt unwell next morning, worse in the mail train to Poonah, and suffered very severely internally during the next thirty-six hours in the train on my way to Bangalore. When I arrived there, I had to be assisted from the railway carriage. Was it food poisoning?

I was still very unwell when I went to Ootacamund for the second meeting of the Provisional Committee (1908) on April 23rd. Again only Fraser, the Dewan, Hay and I were present. The Dewan was anxious that the contract should be given to an Indian contractor, but the tender by Mr. Skipp was the most favourable and was accepted. After the meeting, Hay and I lunched with the Frasers. I

note in my diary: "The more I see of them, the more like them." It was my first visit to Ootacamund. I enjoyed it, but I could only stay there for two nights. Work on the buildings commenced immediately, but I have no exact record of progress. The foundations were to be finished by September. To hasten the work I noted that the Committee agreed to a proposal to purchase an engine and mortar mill, and to rent it to the contractors. The Tata representatives had not appeared at the meetings in March and April, and as we were actually spending money donated by the Government of India and the Mysore Durbar, I thought that I was justified in proceeding in consultation with Fraser and the Dewan.

After the second meeting of the Provisional Committee (1908) I settled down in Bangalore. I rented a bungalow: West Bank, Avenue Road, Bangalore City. It was built of unburned bricks, with burned bricks around door and window openings, and covered with chunam (lime plaster); it was white-washed and flat-topped, with a pillared verandah. It looked palatial when seen from the bottom of the compound (garden), and it certainly was comfortable, but I was kept wondering why the structure didn't collapse. I bought a buggy, holding two with a dicky [a British



IISc ARCHIVES

slang for a male donkey] for the saice [a stable attendant] behind, and a bay waler cob to drive in it.

Marvel was an excellent trapper. I tried to ride him but he was too much for me. I also bought a beautiful little half-Arab, Peter Pan, for a hack, and on him I used to ride out to the building site early every morning.



HELLO!

Meet some of the new researchers to have joined IISc

COMPILED BY **KARTHIK RAMASWAMY**



KAUSHIK BASU

Department of Electrical Engineering



SUBHO DASGUPTA

Department of Materials Engineering



SOMNATH CHOUDHURY

Centre for High Energy Physics



NIRUPAM ROY

Department of Physics



SOMNATH DUTTA

Molecular Biophysics Unit



SRISHA RAO MV

Department of Aerospace Engineering

CONNECT



BHUSHAN J TOLEY

Department of Chemical Engineering



SAIMAA

NAGA PHANI B AETUKURI

Solid State and Structural Chemistry Unit



ANAND LOUIS

Department of Computer Science and Automation



VAMSI PRITHAM PINGALI

Department of Mathematics



CONNECT

SOURABH SUHAS DIWAN

Department of Aerospace Engineering

All photographs were provided by the faculty members unless otherwise mentioned





SUBRA SURESH: SCIENCE POLICY INSIGHTS

✍️ SUDHI OBEROI

Subra Suresh, a celebrated engineer, scientist and administrator, is the President of Carnegie Mellon University (CMU). He has also served as the Director of National Science Foundation (NSF) and as the Dean of the School of Engineering at the Massachusetts Institute of Technology (MIT). For his contributions to science and engineering, he was awarded the Padma Shri in 2011. Suresh, who is no stranger to IISc, was a Brahm Prakash Chair at the Department of Materials Engineering in 2004. He spoke to CONNECT before delivering a lecture organized by the Centre for Brain Research (CBR).

Q How did the CMU-CBR partnership come about? Also tell us about your personal interest in brain research.

I happened to meet Kris Gopalakrishnan [who helped set up CBR], someone I've known for many years, at a reception in Switzerland, in 2014. There he told me about his plans for CBR, and I talked about brain research at CMU, which especially encompasses fields such as artificial intelligence, machine learning, cognitive sciences, psychology and computing. During this conversation, we realized that it would be interesting to connect CMU in some tangible way with CBR. Kris visited CMU and met a number of faculty members, and that led to a formal arrangement with his Trust to support CMU's work and its connections to CBR. Secondly, there



Courtesy: PRO, IISc

was a natural connection between IISc and CMU as there are many faculty members and students of Indian origin at CMU and many CMU alumni on the faculty at IISc, including in neuroscience.

At a personal level, I have an interest in the field and an appreciation for the opportunities in the field through my work linking cell physical properties with human diseases, aspects of which include brain-related diseases.



Q Are there any plans to diversify this partnership to other areas, such as materials engineering, which is also your area of expertise?

We have had many collaborations at the faculty level. One of our professors of machine learning at the Brain Hub [at CMU] will be visiting IISc later this year. Many years before I even joined CMU, I was here as a Brahm Prakash Chair at Materials Engineering, and a number of faculty members in Materials at IISc have worked with professors at CMU. So there are organic interactions, and I think that growing them further at the faculty level will lead to many productive interactions.

Q You served as the Director of NSF. What lessons can India learn from NSF?

When I was at NSF, [Thirumalachari] Ramasami, Secretary of the Department of Science and Technology (DST) was in touch with me to discuss plans for creating a new agency, which came into existence several years ago. It is called SERB (Science and Engineering Research Board).

One of the reasons institutions like the NSF have had a huge impact not just in the US, but around the world is because they have set up certain processes and policies which are powerful, such as the concept of a very rigorous peer review. Adhering to a certain set of practices, irrespective of the political climate and without influence of any individual or political entity, is very healthy for science. It was intentionally set up that way so that the decisions related to science are made based on rigorous evaluation by peers in the scientific community.

NSF is not perfect, but its practices are globally viewed as the “gold standard”. It is the largest basic science funding agency in the world with an annual budget of about \$7.4 billion. It handles roughly 55,000 proposals and funds 200,000 individuals a year. It seeks to fund the best ideas, from large to small projects, and the best people. Many major international awards in science, such as the Turing

“ *NSF is unique, even for an American agency, with a goal to further basic research in science and engineering and in education. Its mission is not to push a particular agenda or perspective or outcome, like other federal agencies, but rather to foster fundamental understanding in sciences and engineering and to enhance human capital development* ”

Prize in computer science, and Nobel Prizes for physical, life and economic sciences have been won by scientists who were funded partially by NSF over a long period of time.

NSF is unique, even for an American agency, with a goal to further basic research in science and engineering and in education. Its mission is not to push a particular agenda or perspective or outcome, like other federal agencies, but rather to foster fundamental understanding in sciences and engineering and to enhance human capital development. For instance, NASA’s mission is air and space, the Department of Energy’s mission is energy, the mission of the National Institute for Standards and Technology is standards.

Q How do you think science will or should be funded in the future as government funds dry up? Do you see universities relying more on industry and philanthropy?

I think we have multiple concerns right now, at least in the US where research funding has been stagnant for the last 10 years. At the same time,



money for basic research from industry—Bell Labs, Ford Motor Company, GM, Rockwell International Science Center, etc.—no longer exists. In the US, historically, industry supported a lot of research. For example, Bell Labs played a crucial role in the development of the transistor. Today, they do more developmental research than basic research, mainly driven by market pressures, short-term focus on earnings, and intense global competition. Cutting-edge companies in the IT space like Apple, Google, Amazon, Facebook etc., do a lot of in-house product development, but they don't do basic research that is accessible to the broader scientific community, and you don't see many of their scientists going to professional meetings to present scientific papers. There are a few exceptions, such as Microsoft, where scientists publish papers, but even there the focus on a Bell-Labs type basic research is limited.

So I think we have an issue, and it is here that organizations like NSF play an important role. If you look at the return on investment, NSF funding alone has played a part in about 230 Nobel Prizes since 1950. There is no other government organization in the world that has had that kind of return on investment in basic science. So we as a society have to decide which model works the best for science to grow.

Q You are an engineer, but your work has combined engineering with basic sciences in other fields, especially life sciences. As the CMU President, have you been pushing engineers and researchers doing fundamental science to work together?

Yes. But I think that this has always been one of the strengths of CMU. Brain research is a very good example of cross-discipline research. It was started about 60 years ago by computer scientists when they wanted to create a computer to mimic human brain. They are as engaged as the neuroscience and psychology departments are in study of the



You can do very good fundamental research which also happens to have a lot of applications.

*A good example is Ramanujan: his mentor [GH] Hardy wrote a book called *A Mathematician's Apology*, apologizing for doing anything to do with applications. But in fact both Ramanujan's and Hardy's work ended up having so many applications in cryptography, number theory, cyber security and much more.*



brain. So it does not have to be mutually exclusive. You can do very good fundamental research which also happens to have a lot of applications. A good example is Ramanujan: his mentor [GH] Hardy wrote a book called *A Mathematician's Apology*, apologizing for doing anything to do with applications. But in fact both Ramanujan's and Hardy's work ended up having so many applications in cryptography, number theory, cyber security and much more. Many Nobel Prizes which are given for very rigorous basic research end up having numerous practical applications. I have seen it in my own career—I used to write single author papers in the early part of my career but in areas like medical research a typical paper that I now write will have six or seven co-authors including medical doctors. Without their collective perspectives, I will not be able to do what I do. It brings different fields together in unique ways, and also increases the impact of the work.





AND THE AWARD GOES TO...

Researchers whose work has received recognition

✍️ COMPILED BY SUDHI OBEROI



K MUNIYAPPA
Professor, Biochemistry
**Karnataka Rajyotsava
Award**



SOMNATH DUTTA
Assistant Professor,
Molecular Biophysics Unit
**DST Early Career Research
Award**



D GANESH
Associate Professor,
Biochemistry
**DBT National Bioscience
Award**



**VIJAYALAKSHMI
RAVINDRANATH**
Professor, Centre for
Neuroscience
**Lifetime Achievement
Award from Scigenome
Research Foundation**



**RISHIKESH
NARAYANAN**
Associate Professor, Molecu-
lar Biophysics Unit
**Shanti Swarup Bhatnagar
Prize**



HS ATREYA
Associate Professor, NMR
Research Centre
**Prof. P K Bose Memorial
Award**



PS MUKHERJEE
Professor, Inorganic and
Physical Chemistry
**Shanti Swarup Bhatnagar
Prize**



ARAVIND PENMATSA
Assistant Professor,
Molecular Biophysics Unit
**DBT Innovative Young
Biotechnologist Award**



**SUDHIR KUMAR
VEMPATI**
Associate Professor, Centre
for High Energy Physics
**Shanti Swarup Bhatnagar
Prize**



**SRIDHARAN
DEVARAJAN**
Assistant Professor, Centre for
Neuroscience
**SERB Early Career Research
Award**



R NARASIMHAN
Professor, Mechanical Engineering
Distinguished Alumnus Award IIT; Madras



SHANKAR KUMAR SELVARAJ
Assistant Professor, Centre for Nano Science and Engineering
DST-SERB Early Career Research Award



UDAY REDDY B
Assistant Professor, Computer Science and Automation
INSA Medal for Young Scientists and INAE Young Engineer Award



ANINDA SINHA
Associate Professor, Centre for High Energy Physics
ICTP Award



ANURAG KUMAR
Professor, Electrical Communication Engineering
Lifetime Achievement Award- Systems Society of India and Distinguished Alumnus Award for Academic Excellence, IIT Kanpur



V KUMARAN
Professor, Chemical Engineering
Infosys Prize

MANOJ SUDHAKARAN

CONNECT



PRADEEP BARPANDA
Assistant Professor, Materials Research Centre
Ross-Coffin Purdy Award



NEELES B MEHTA
Associate Professor, Electrical Communication Engineering
Hari Om Ashram Prerit Vikram Sarabhai Research Award



AMIT SINGH
Assistant Professor, Centre for Infectious Disease Research
NASI-SCOPUS Young Scientist Award



VV SRINIVAS
Professor, Civil Engineering
Distinguished Alumni Professional Achievement Award, NIT-Warangal



N. SURYAPRAKASH
Professor, NMR Research Centre
Prof. G.V. Bakore Memorial Award

All photographs were provided by the faculty members unless otherwise mentioned





CAMPUS CRITTERS
A pair of green bee-eaters



MAIN BUILDING, IISC