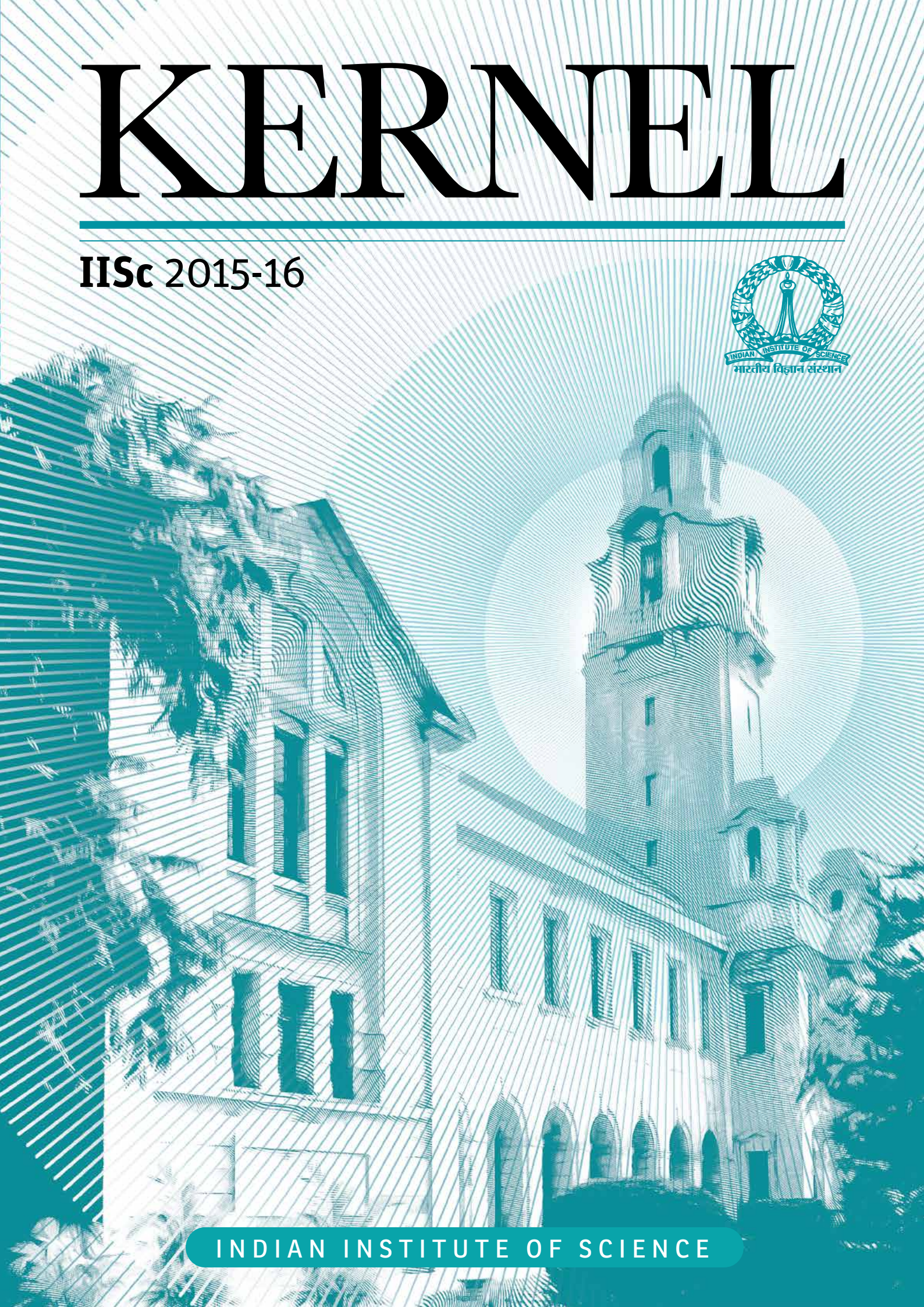
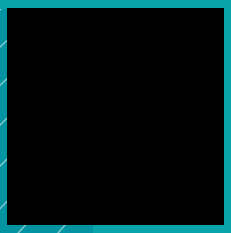
KERNEL

IISc 2015-16



INDIAN INSTITUTE OF SCIENCE



In everyday usage, the word *kernel* refers to the central or the most important part of something. In science and technology, it has several connotations in fields as diverse as biology, computer science and mathematics. For instance, in computer science, the *kernel* is a fundamental, essential part of a computer operating system, providing basic services for all other parts of the operating system. Similarly, in biology, the word is used to denote the softer, usually edible part of a nut, seed, or fruit stone contained within its shell.

KERNEL

IISc 2015-16

INDIAN INSTITUTE OF SCIENCE
भारतीय विज्ञान संस्थान

Contents

From the Director

The Indian Institute of Science (IISc) was established in 1909 by a visionary partnership between the industrialist Jamsetji Nusserwanji Tata, the Maharaja of Mysore and the Government of India. In the words of Tata, its founder, the objectives of the Institute are "to provide for advanced instruction and to conduct original investigations in all branches of knowledge as are likely to promote the material and industrial welfare of India." Since its inception over 107 years ago, IISc has endeavoured to live up to the ideals of its founder by pursuing basic knowledge in science and engineering, as well as on the application of its research findings for societal benefit. This unwavering pursuit has ensured that it has become the premier institute for advanced scientific and technological research and education in India. This was affirmed again when IISc was ranked India's top university in the first ever national rankings (NIRF) brought out by the Ministry of Human Resource Development.

The academic success of the Institute stems in large part from the policy of granting true academic freedom to its high-achieving faculty members, who are active in a broad spectrum of research in science and engineering. The academic excellence of our faculty, numbering over 500, is reflected in the high annual publication output and the accolades they have received. Several of them have won national and international awards and honours in recognition of their contributions to the growth of knowledge in science and engineering. Among the current faculty members, there are 51 Shanti Swarup Bhatnagar Awardees, 79 INSA Fellows, 97 IASc Fellows, 65 NASI Fellows, 54 INAE Fellows, and 56

J.C. Bose National Fellows. The faculty of the Institute also undertake a large number of research projects funded by various agencies, including the Department of Science and Technology (DST), the Department of Biotechnology (DBT), the Council of Scientific and Industrial Research (CSIR), the Defence Research and Development Organization (DRDO), the Ministry of Communications and Information Technology, and many other organizations, in the public and the private sectors.

The Institute places equal emphasis on student research and learning. Out of a student population of over 4000, about 2600 are enrolled in doctoral degree programmes in both science and engineering. The Institute also offers several Masters degree programmes in engineering – MTech, MTech (Research), MDes, and MMgmt – in which about 900 students are enrolled. In 2011, IISc introduced a four-year undergraduate programme, with dedicated classrooms, laboratories, and its own Dean. Apart from their rigorous course and laboratory work, students are exposed to hands-on research in the laboratories of faculty members of the Institute. At the end of four years, successful students receive a Bachelor of Science (Research) degree. They can also choose, in addition, to graduate with a Master of Science (Research) degree by putting in another year of study. There are about 500 students currently enrolled in the undergraduate programme.

2015-16 has been an eventful year for the Institute. Memoranda of understanding were signed with companies such as Tata Consulting Services (TCS), General Electric (GE), and Bosch India to promote interactions between IISc and these leading technology companies. Pratiksha Trust, established by Infosys co-founder Senapathy "Kris" Gopalakrishnan and Sudha Gopalakrishnan, has set up the Sudha Murty Distinguished Chair in Neurocomputing and Data Sciences. The Office of Development and Alumni Affairs (ODAA), established in 2014-15, has already been able to tap various private sources of funds for academic and institutional development initiatives, including for the new HAL-IISc Skill Development Centre in IISc's extension campus at Challakere in Chitradurga District.

In keeping with the founder's vision of improving "the material and industrial welfare of India", the Institute continues to encourage its faculty and students to protect their intellectual property, and to convert the results of some of their scientific investigations into applications via technology licensing or via entrepreneurship. In the recent past, several technologies, such as gas flow sensors, electrical storage devices and related test instrumentation, and fungal pesticides, have been licensed. A few faculty members, as well as students, who have invented new technologies have chosen to take the "startup" route. Some of these technologies include an enhanced electric gradient based water filtration device, a multi-analyte device for diabetes monitoring, a micro-fluidics based cell counter for diagnostics, and optical fibre sensors for structural monitoring.

The developments at IISc in 2015-16 are too numerous to chronicle in detail. I therefore present to you a snapshot of some of the research accomplishments of our faculty and the initiatives we have undertaken during the past year in this, the second issue of KERNEL.

I would also like to use the platform of KERNEL to place on record my personal gratitude to the Chairman and the Members of the Council of the Institute for their valuable support and guidance.

Anurag Kumar
Director, IISc
November 2016

The Institute

The Indian Institute of Science is an institution of higher learning and research established in 1909 under the Charitable Endowments Act 1890. With the establishment of the University Grants Commission in 1956, the Institute came under its purview as a Deemed University.
The principal authority governing the Institute is the Council, which is advised by the Court in the formulation of policies. The Director is the Chief Executive of the Institute and is assisted in its management by the Senate and the Faculties of Science and Engineering.

Visitor: THE PRESIDENT OF INDIA

President of Court: K KASTURIRANGAN

Chair of Governing Council: P RAMA RAO

Director: ANURAG KUMAR

Deans: TN GURU ROW (SCIENCE)
MK SURAPPA (ENGINEERING)
ANJALI KARANDE (UNDERGRADUATE PROGRAMME)

Registrar: V RAJARAJAN


JAMSETJI·NUSSERVANJI·TATA
PARSI·CITIZEN·OF·BOMBAY
BORN·MARCH·3·1839
DIED·MAY·19·1904

The Governing Council

The Council is the principal governing authority of the Institute and its membership includes the Nominees of the Court, Parliament, Government of India, Government of Karnataka, Tata Trusts, Representatives of Indian Universities, University Grants Commission and Scientific bodies. The following are the members of the Council:

P Rama Rao
Chairman of the Council,
Former Vice Chancellor,
University of Hyderabad,
Hyderabad (Nom. GoI)

Praveen Kumar Joint Secretary (Admin), MHRD, Dept. of Higher Education, GoI, New Delhi (Nom.GoI)	S K Joshi Former Director General, CSIR, Gurgaon, (Rep. UGC)	Anil D Sahasrabudhe Chairman, AICTE, New Delhi (Rep. AICTE)
Vinaysheel Oberoi Secretary, MHRD, Dept. of Higher Education, GoI, New Delhi (Nom.GoI)	Suresh C Angadi Member of Parliament (Lok Sabha), New Delhi (Rep. Parliament)	Girish Sahni Director General, CSIR, New Delhi (Rep. CSIR)
Bharat Lal Meena Pr. Secretary to GoK, Higher Edu. Dept., Bangalore (Nom. GoK)	Murli Manohar Joshi Member of Parliament (Lok Sabha), New Delhi (Rep. Parliament)	Anurag Kumar Director (Ex-officio)
ISN Prasad Pr. Secretary to GoK, Dept. of Finance, Bangalore (Nom. GoK)	SN Agarwal Chairman, Bhoruka Power Corporation Ltd., Bangalore (Nom. Court)	T N Guru Row (Ex-officio) Dean, Science Faculty
JJ Irani Director, Tata Sons Limited, Mumbai (Nom. Tata Trusts)	V S Ramamurthy Former Director, National Institute of Advanced Studies, Bangalore (Nom. Court)	M K Surappa (Ex-officio) Dean, Engineering Faculty
R Venkataraman Executive Trustee Sir Dorabji Tata Trust Mumbai (Nom. Tata Trusts)	Harish Padh Vice Chancellor, Sardar Patel University, Vallabh Vidhyanagar (Rep. Indian Universities)	V Rajarajan Registrar (Ex-officio Secretary)

Deans *of Faculties*

TN Guru Row | DEAN, FACULTY OF SCIENCE

TN Guru Row (Professor, Solid State and Structural Chemistry Unit) obtained his PhD from IISc and did his postdoctoral work at SUNY Buffalo and Rosewell Park Memorial Institute, USA. His major area of research is in chemical crystallography and materials design. He has received several prestigious awards and honours for his research, including the JC Bose National Fellowship. Row is a Fellow of the Indian Academy of Sciences and the National Academy of Sciences. Currently, he also serves as Editor of the *Journal of the Indian Institute of Science.*

MK Surappa | DEAN, FACULTY OF ENGINEERING

MK Surappa (Professor, Department of Materials Engineering) obtained his PhD from the IISc. He has made important contributions to the field of Metal Matrix Composites (MMCs). He was the Founding Director of the Indian Institute of Technology, Ropar. Surappa, who has won many accolades for his research, is a Fellow of the Indian National Science Academy and the Indian National Academy of Engineering. He has also received an honourary Doctor of Literature (D.Litt.) degree from the Karnataka State Open University.

Deputy Directors

S Ramakrishnan | DEPUTY DIRECTOR, PLANNING AND INFRASTRUCTURE

S Ramakrishan (Professor, Department of Inorganic and Physical Chemistry) received his PhD from the University of Massachusetts, USA. After a two-year postdoctoral stint at the Corporate Research Laboratory, Exxon Research and Engineering Company, also in the US, he joined IISc in 1990. Ramakrishnan's research interests are in the areas of highly branched polymers, self-assembled polymerizable systems and conformational control in synthetic polymers. His research accomplishments have won him several honours, including the Shanti Swarup Bhatnagar Prize, DAE Outstanding Young Researcher Award, JC Bose Fellowship and Distinguished Alumnus Award from IIT Bombay.

Jayant M Modak | DEPUTY DIRECTOR, ADMINISTRATION AND FINANCE

Jayant M Modak (Professor, Department of Chemical Engineering) obtained his PhD from Purdue University, USA. After a one-year stint at University of California-Irvine, USA, as a postdoctoral fellow, he joined IISc in 1989. Here, he initiated a research programme in the area of bioprocess engineering with an emphasis of modeling, optimization and control of fermentation processes and advanced oxidation technologies for waste-water treatment. Modak is a Fellow of Indian National Academy of Engineering and National Academy of Sciences, and the recipient of several prestigious awards.

Deans, *Undergraduate Programme*

Anjali Karande | DEAN, UNDERGRADUATE PROGRAMME

Anjali Karande (Professor, Department of Biochemistry) received her PhD from the Cancer Research Institute, then affiliated to Bombay University. She pursued her postdoctoral work at Karolinska Institute, Sweden, before joining IISc in 1987. Her research interests are in the field of of immuno-endocrinology. Karande has also had several collaborations with biotech companies.

Balaji Jagirdar

ASSOCIATE DEAN, UNDERGRADUATE PROGRAMME

Balaji Jagirdar (Professor, Department of Inorganic and Physical Chemistry) obtained his PhD from Kansas State University, USA. He was a postdoctoral fellow at the University of Colorado, Boulder, USA, before joining IISc in 1995. His research interests include the activation of small molecules using organometallic compounds, homogeneous and heterogeneous catalysis, and materials for hydrogen storage and generation. He is a Fellow of the Indian Academy of Sciences.

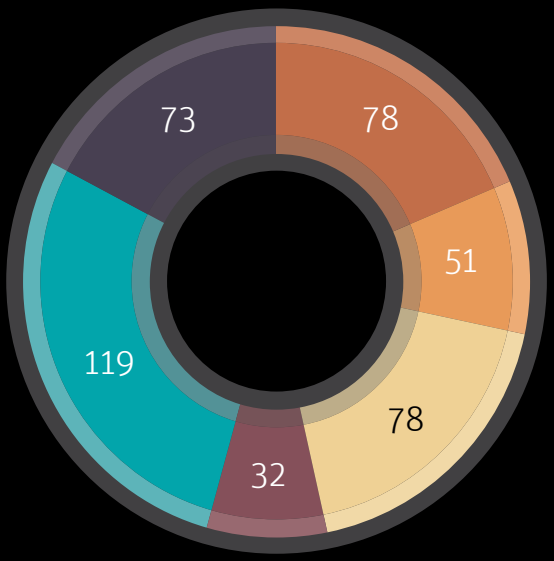
PS Anil Kumar

ASSOCIATE DEAN, UNDERGRADUATE PROGRAMME

PS Anil Kumar (Associate Professor, Department of Physics) obtained his PhD from the University of Pune. He was a postdoctoral fellow at the University of Twente, Netherlands; Max-Planck Institute of Microstructural Physics, Germany and, subsequently, an Alexander von Humboldt Research fellow before joining IISc in 2004. His research interests are in spintronics, magnetic nanostructures, magnetotransport in metallic multilayers and oxides, topological insulators, magnetic properties of ultra-thin ferromagnets, etc.

IISc in *Numbers*

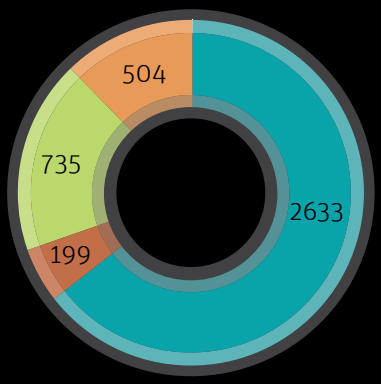
Faculty Members



- Biological Sciences
- Chemical Sciences
- Electrical Sciences
- Mechanical Sciences
- Interdisciplinary Research
- Physical and Mathematical Sciences

Total: 431

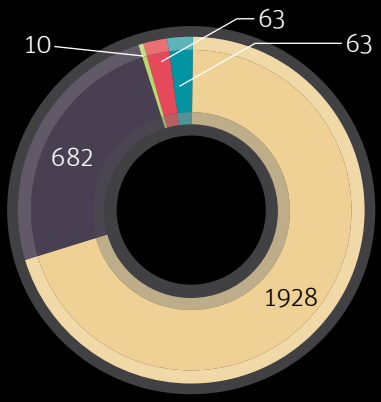
Students on Roll



- PhD/ Int PhD
- MSc (Engg)
- Masters Programme
  (ME / MTech / MDes / MMgt)
- BSc (Research)

Total: 4071

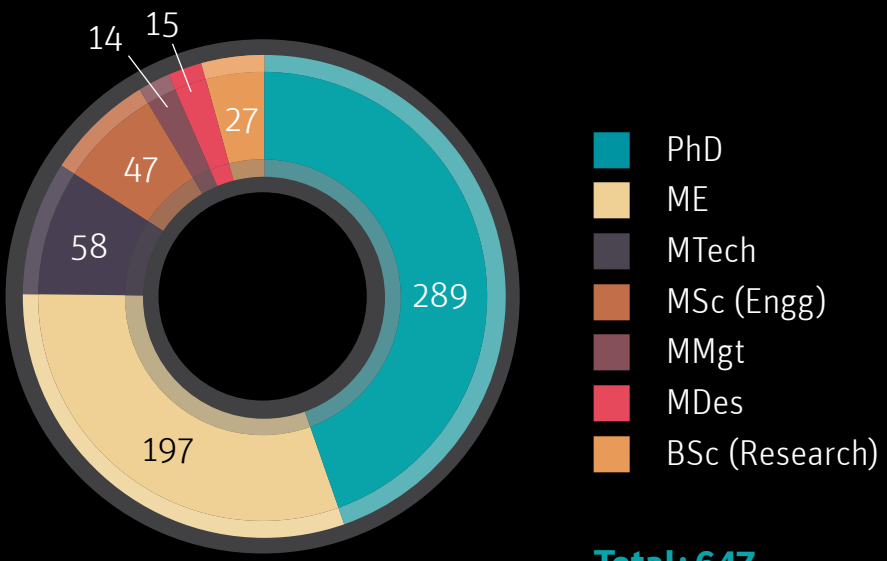
Publications 2015



- Journal Publications
- Conference Publications
- Popular Articles
- Books and Book Chapters
- Reports

Total: 2746

Degrees Awarded 2015-16



Total: 647

FELLOWSHIPS OF SCIENCE AND ENGINEERING ACADEMIES

Indian National Science Academy (INSA)	**79**
Indian Academy of Sciences (IASc)	**97**
National Academy of Sciences, India (NASI)	**65**
Indian National Academy of Engineering (INAE)	**55**
The Royal Society	**3**
National Academy of Sciences (USA)	**1**
The World Academy of Sciences (TWAS)	**27**
Institute of Electrical and Electronics Engineers (IEEE)	**7**

AWARDS

Padma Awards	**6**
Infosys Prize	**3**
Shanti Swarup Bhatnagar Prize	**51**
JC Bose Fellowship Award	**68**
DST – Swarnajayanti Fellowship Award	**29**
Wellcome Trust – DBT Fellowship	**25**

IISc ranked

India's top University

Ministry of Human Resource Development
Government of India

nirf

NATIONAL INSTITUTIONAL RANKING FRAMEWORK

India Rankings 2016

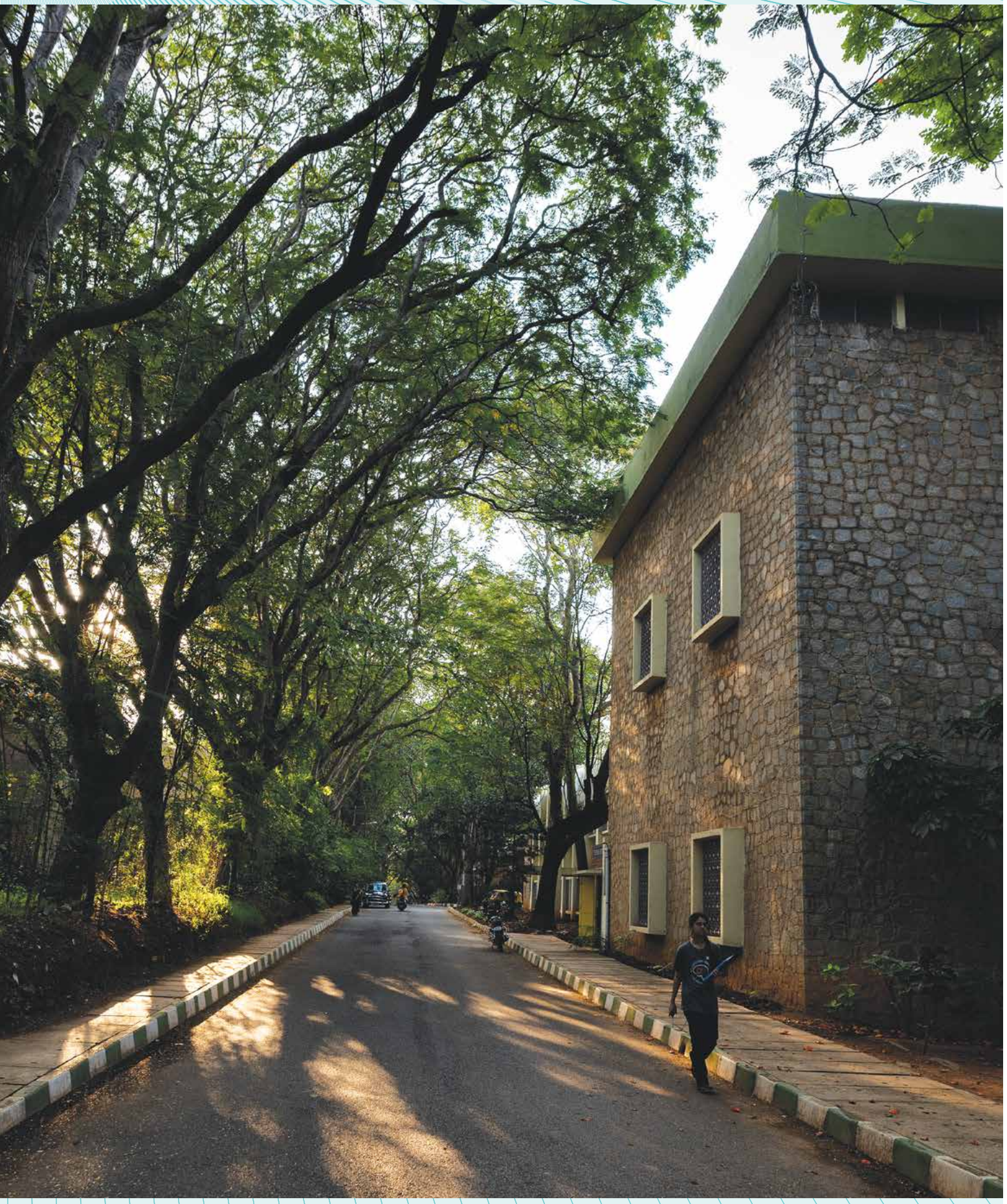
Indian Institute of Science Bangalore

is ranked Number 1 amongst Universities.

Chairman, NBA

Member Secretary, NBA

In 2016, for the first time the NIRF (National Institutional Ranking Framework), under the auspices of the Ministry of Human Resource Development, came out with rankings for Indian Universities and Institutions of Higher Education. Amongst universities, IISc was ranked Number 1.



Divisions

The Institute comprises six Academic Divisions:

Biological Sciences
Chemical Sciences
Electrical Sciences
Interdisciplinary Research
Mechanical Sciences
Physical and Mathematical Sciences

This section offers a glimpse into the composition of and the research carried out in all the six Divisions. It includes the core areas and themes of research pursued by faculty members in each of them as well as snapshots of some of the recent research emerging from these Divisions. It also captures stellar accomplishments of select research groups during 2015-16.


J.R.D. TATA MEMORIAL

Division of Biological Sciences

78
FACULTY MEMBERS

84
FELLOWSHIPS OF SCIENCE AND ENGINEERING ACADEMIES IN INDIA

50
PhD STUDENTS GRADUATED IN 2015-16

340
PhD STUDENTS

65
INTEGRATED PhD STUDENTS

Biochemistry
Estd: 1921 | Chair: Prof. C Jayabaskaran

Centre for Ecological Sciences
Estd: 1983 | Chair: Prof. Rohini Balakrishnan

Microbiology and Cell Biology
Estd: 1941 | Chair: Prof. Usha Vijayraghavan

Centre for Infectious Diseases Research
Estd: 2014 | Convener: Prof. Dipankar Nandi

Centre for Neuroscience
Estd: 2009 | Chair: Prof. Aditya Murthy

Molecular Biophysics Unit
Estd: 1971 | Chair: Prof. Raghavan Varadarajan

Central Animal Facility
Estd: 1971 | Chair: Prof. Kumaravel Somasundaram

Molecular Reproduction, Development and Genetics
Estd: 1989 | Chair: Prof. Sandhya S Visweswariah

Division of Biological Sciences

CHAIRPERSON:
PROF. UMESH VARSHNEY

CORE RESEARCH AREAS

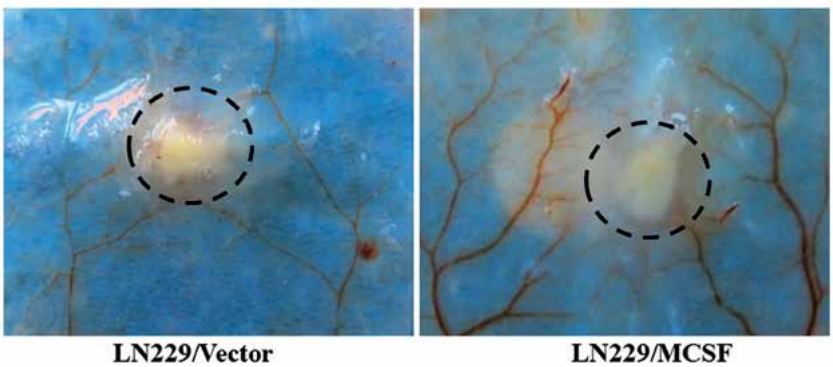
The Division of Biological Sciences forges important links between basic science and innovative research. It is committed to enhancing frontline studies in almost all aspects of modern biology: Neuroscience in health and disease, Infectious Disease, Structural Biology, Oncology, DNA Repair and Genomic Stability, Systems Biology and Bioinformatics, Immunology, Enzymology, Reproductive and Developmental Biology, Ecological Studies, etc.

THEMES

Investigators in the Division focus on numerous processes central to the understanding of life, emphasizing on areas with considerable translational potential, namely, Cognition and Neuronal Reprogramming, Infectious Diseases, Drug and Molecular Design, Diagnostics and Therapeutics in Cancer, Gene Targeting, Genetic Disorders and Genetic Diversity.

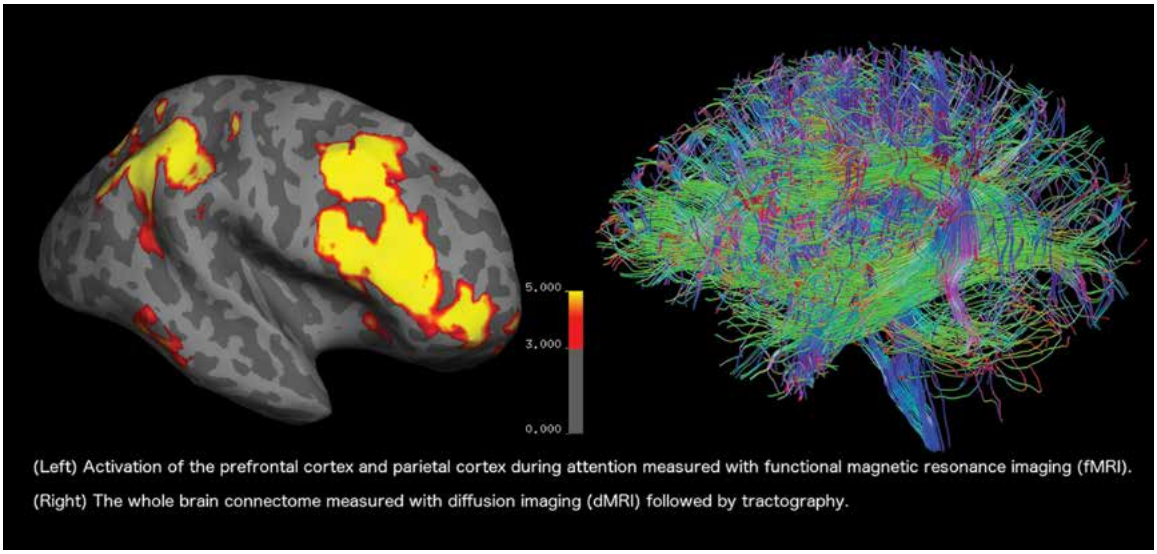
RESEARCH SNAPSHOTS

- Glioblastoma is a deadly form of brain cancer. A protein which causes the tumour to grow faster has been discovered by scientists from the Department of Microbiology and Cell Biology. This protein could therefore serve as a target for new drugs to treat this cancer. [Nijaguna MB, et al., and **Somasundaram K.** Glioblastoma-derived Macrophage Colony-stimulating Factor (MCSF) Induces Microglial Release of Insulin-like Growth Factor-binding Protein 1 (IGFBP1) to Promote Angiogenesis. *J Biol Chem*., 2015, 290(38):23401-15]



LN229/Vector LN229/MCSF

- A pressing question in neuroscience is to understand how the brain pays attention. Using fMRI as well as a novel brain imaging technique called diffusion MRI, researchers from the Centre for Neuroscience have identified the regions of the brain in the prefrontal and parietal cortex which are activated when the brain is being attentive. [Work in progress in **Sridharan Devarajan's** lab]

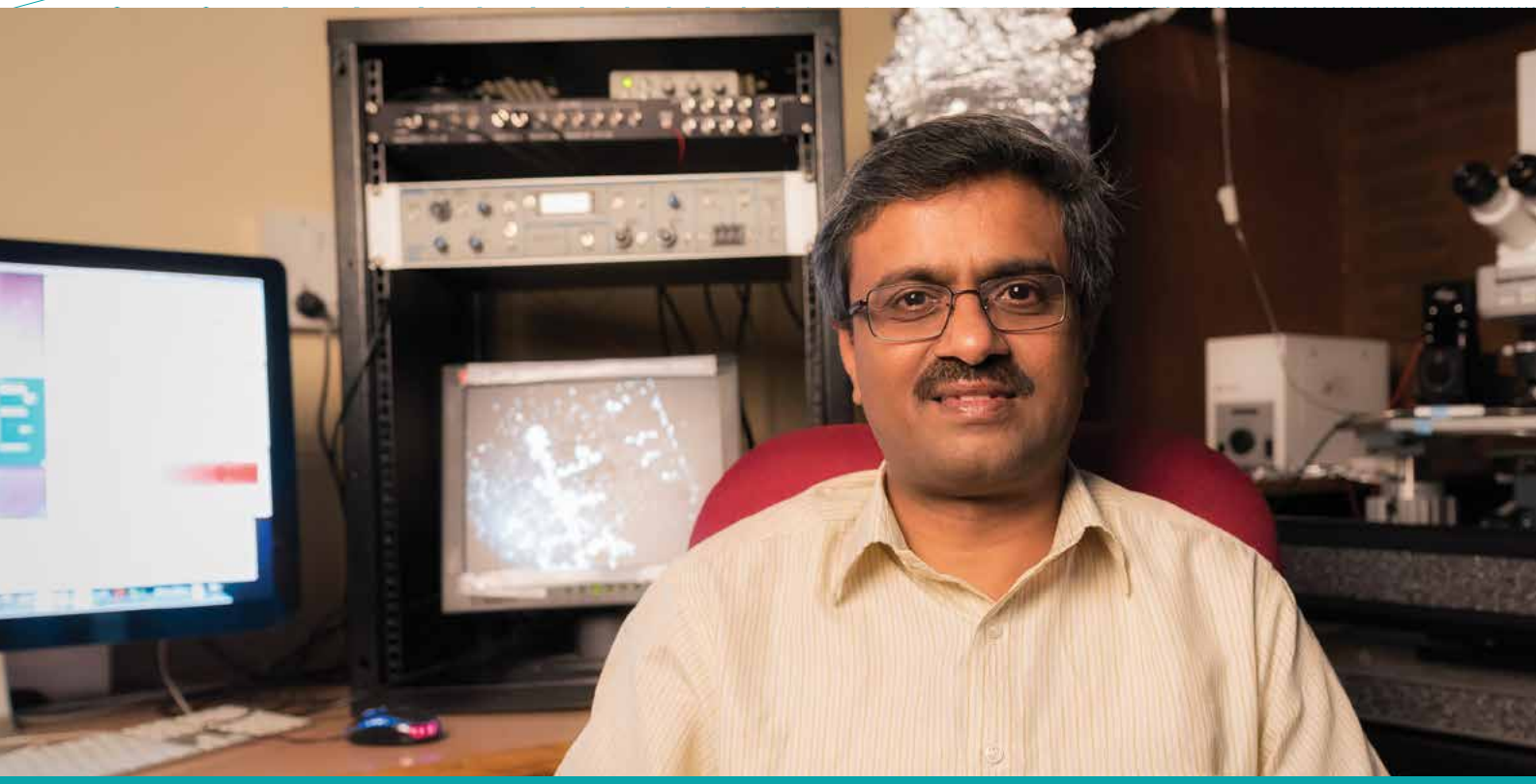


(Left) Activation of the prefrontal cortex and parietal cortex during attention measured with functional magnetic resonance imaging (fMRI). (Right) The whole brain connectome measured with diffusion imaging (dMRI) followed by tractography.

- The Asian and the African elephants may look similar, but they are distinct species which diverged about 7.6 million years ago. To explain the genetic differences between the two species, biologists from the Centre for Ecological Sciences have sequenced the genome and transcriptome of the Asian elephant. Its comparison with that of its African counterpart has revealed many novel transcripts and variants which may help us understand why they differ in many morphological and behavioral traits. [Reddy PC, Sinha I, Kelkar A, Habib F, Pradhan SJ, **Sukumar R** and Galande S. Comparative sequence analyses of genome and transcriptome reveal novel transcripts and variants in the Asian elephant *Elephas maximus. J. Biosci.*, 2015, 40 (5): 891-907]

Action potentials, or spikes, are specific, transient changes in the electrical potential of the membrane of a neuron, and play a crucial role in communication among neurons. However, these are not the only electrical signals generated in the brain. Researchers have long known about another class of electrical signals called the local field potential (LFP), which refers to the slowly-varying component of the extracellular potential in a particular brain region. Although traditional dogma describes LFPs as a composite signal that reflects inputs impinging on neurons in that brain region, the precise origins of LFPs and how they are regulated are yet to be fully understood.

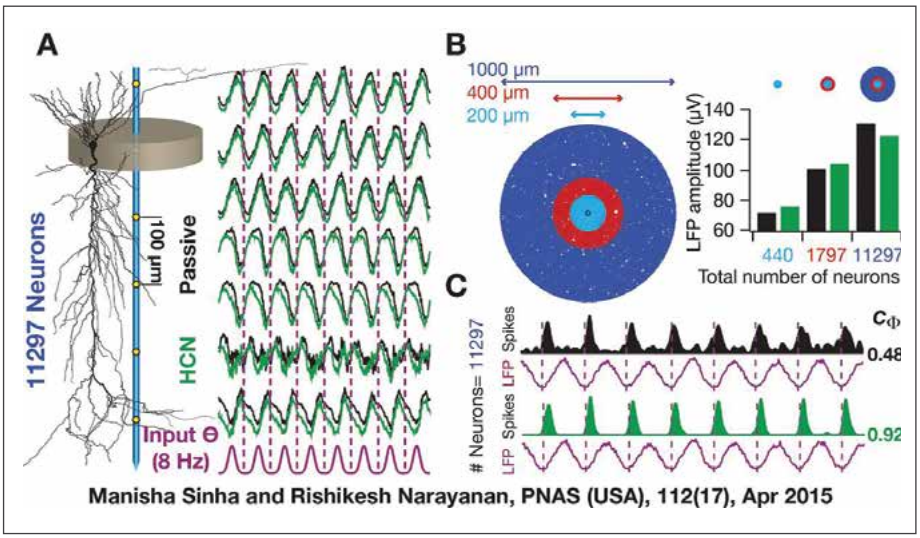
A recent study by Manisha Sinha and Rishikesh Narayanan furthers our understanding of LFPs by showing that these electrical signals are not mere reflections of neuronal inputs, but are critically regulated by "subthreshold ion channels" that are present in neuronal dendrites.* Ion channels are pores in the neuronal membrane that regulate the flow of ions between the exterior and interior of neurons, thus mediating the generation of neuronal spikes. "Our study uncovers a distinct role for neuronal pacemaker channels formally referred to as the hyperpolarization-activated cyclic nucleotide-gated (HCN) channels, in regulating LFPs," says Narayanan. HCN channels allow positively charged ions to enter neurons and, uniquely, are "open" at voltages below the threshold for action potentials.



RISHIKESH NARAYANAN

Associate Professor
Molecular Biophysics Unit

Pacemaker Channels Regulate the Brain's Local Field Potential



The presence of hyperpolarization-activated cyclic-nucleotide-gated nonspecific-cation (HCN) channels in neurons alters the phase (A) of local field potentials (LFP) without significant changes to the amplitude, for computations performed with different numbers of neurons (B). These channels also significantly contribute to enhancement of spike phase coherence (C)

A recent study by Manisha Sinha and Rishikesh Narayanan furthers our understanding of LFPs by showing that these electrical signals are not mere reflections of neuronal inputs, but are critically regulated by "subthreshold ion channels" that are present in neuronal dendrites

"To understand how these subthreshold-activated channels modulate the LFP, we constructed thousands of realistic model neurons, stimulated them with low-frequency inputs and measured the LFP," explains Narayanan. His team found that introducing HCN channels in the model neurons resulted in a phase-lead in the LFP. The phase of the spikes, on the other hand, lagged when HCN channels were present, relative to the spike signal recorded without those channels. Along with alteration of the phase properties of spikes and LFP, the activity of HCN channels also increased the coherence between the phases of the two types of signals.

*Manisha Sinha and **Rishikesh Narayanan.** 2015. HCN channels enhance spike phase coherence and regulate the phase of spikes and lfps in the theta-frequency range. *Proceedings of the National Academy of Sciences (USA)*. 112(17): E2207-E2216.

Prof. Rishikesh Narayanan with his team

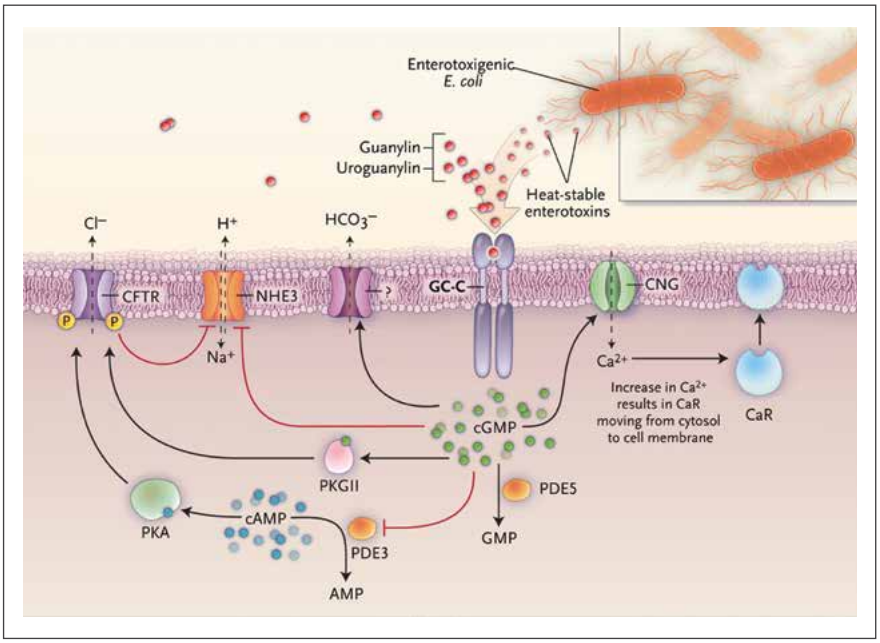
In order to survive, the cells in our body need to track their environment closely and respond quickly to changes. To achieve this, they use signalling pathways which help a cell tune in to the outside world. Understanding the molecular mechanisms underlying cell signalling is the focus of research in Sandhya Visweswariah's lab.

Errors in cell signalling pathways can have serious consequences, including causing diseases. One such disease that has attracted Visweswariah's attention is called congenital secretory diarrhoea (CSD), a form of diarrhoea that manifests soon after birth. Her group, along with Austrian collaborators, has recently discovered that infants with CSD have mutations in a gene called *GUCY2C*.* This gene codes for the receptor guanylate cyclase C (GC-C), an important component of a signalling pathway in gut epithelial cells. Mutations in this gene can disrupt ion and water secretion from cells in the intestine, thus causing diarrhoea. "Many diseases are complex; they usually are the consequence of the interplay between multiple genes," says Visweswariah, whose group has previously characterized a mutation in the same gene in hereditary diarrhoeal disease. "What made this [finding on CSD] a little special was the fact that the disease boiled down to a defect in a single gene."

SANDHYA VISWESWARIAH

Professor
Department of Molecular Reproduction, Development and Genetics

Molecular Mechanisms of Cell Signalling



Guanylate cyclase C (GC-C) present in plasma membrane of gut epithelial cells mediates signalling pathways in response to environmental cues

Sandhya Visweswariah's group, along with Austrian collaborators, has recently discovered that patients with CSD have mutations in a gene called GUCY2C

The current study was carried out in four unrelated children who suffered from CSD, using a combination of genetic and biochemical analyses. The researchers discovered that each of these patients had a different mutation in the *GUCY2C* gene which made the receptor GC-C highly sensitive to binding molecules. A hyperactive GC-C helps synthesize large quantities of cyclic guanosine monophosphate which sends the signalling pathway into overdrive, causing disease symptoms.

The road ahead, says Visweswariah, is to investigate if mutations in *GUCY2C* are also associated with other forms of diarrhoeal diseases, and to use the gene as a target for diagnosis and therapeutic intervention.

* T Müller, I Rasool, P Heinz-Erian, E Mildenberger, C Hülstrunk, A Müller, L Michaud, BG Koot, A Ballauff, J Vodopiutz, S Rosipal, BS Petersen, A Franke, I Fuchs, H Witt, H Zoller, AR Janecke, **SS Visweswariah.** 2016. Congenital secretory diarrhoea caused by activating germline mutations in *GUCY2C*. *Gut*, 65(8):1306-1313

Prof. Sandhya Visweswariah with her team


PHYSICAL CHEMISTRY
STREET RACER

Division of Chemical Sciences

51
FACULTY MEMBERS

77
FELLOWSHIPS OF SCIENCE ACADEMIES IN INDIA

49
PhD STUDENTS GRADUATED IN 2015-16

287
PhD STUDENTS

62
INTEGRATED PhD STUDENTS

Inorganic and Physical Chemistry
Estd: 1909 | Chair: Prof. S Umapathy

Materials Research Centre
Estd: 1978 | Chair: Prof. Arun M Umarji

NMR Research Centre
Estd: 1977 | Chair: Prof. S Vasudevan

Organic Chemistry
Estd: 1911 | Chair: Prof. N Jayaraman

Solid State and Structural Chemistry Unit
Estd: 1976 | Chair: Prof. S Yashonath

Division of Chemical Sciences

CHAIRPERSON:
PROF. PK DAS

CORE RESEARCH AREAS

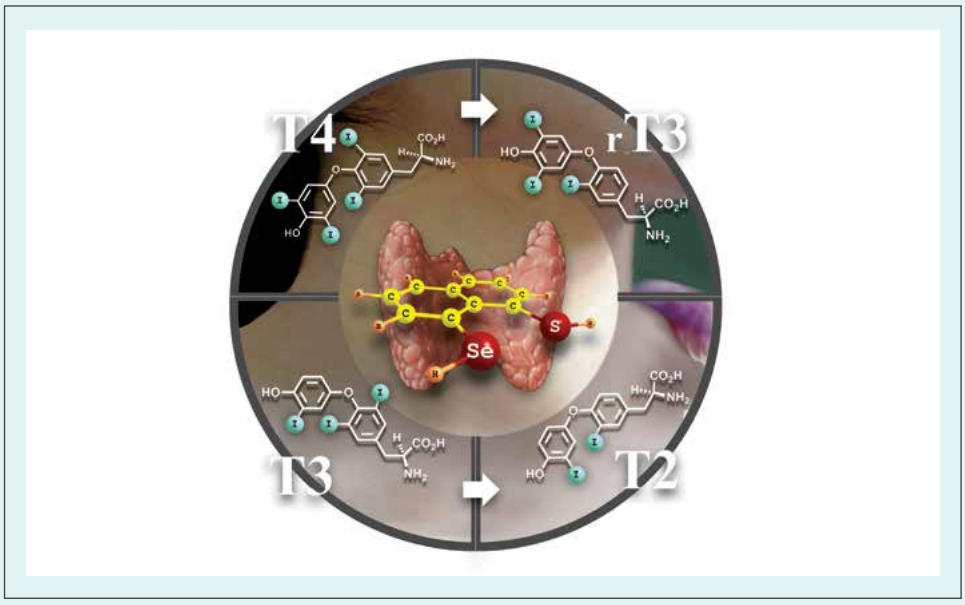
The faculty members of the Division work on all contemporary topics in chemistry, ranging from Chemical Synthesis, Drug Design, Chemical Biology, Materials Chemistry, Surface and Interface Science, Nanochemistry, Molecular Spectroscopy, Ultrafast Chemical Dynamics, Computational and Theoretical Chemistry, Solid State Chemistry and Nuclear Magnetic Resonance Spectroscopy.

THEMES

The Division of Chemical Sciences has consistently maintained its position among the top 50 chemistry departments in world rankings over the past decade. It is a globally competitive Division with clear focus on top quality research in areas such as bio-inorganic chemistry and chemical biology of drugs with a particular aim on disease control and cure, ultrafast spectroscopy and dynamics of molecules towards understanding of structure and reactivity in physical processes related to materials and interfaces, bio-materials for devices to industrial applications, computational materials science, and NMR methods for decoding complex protein structures in solution.

RESEARCH SNAPSHOTS

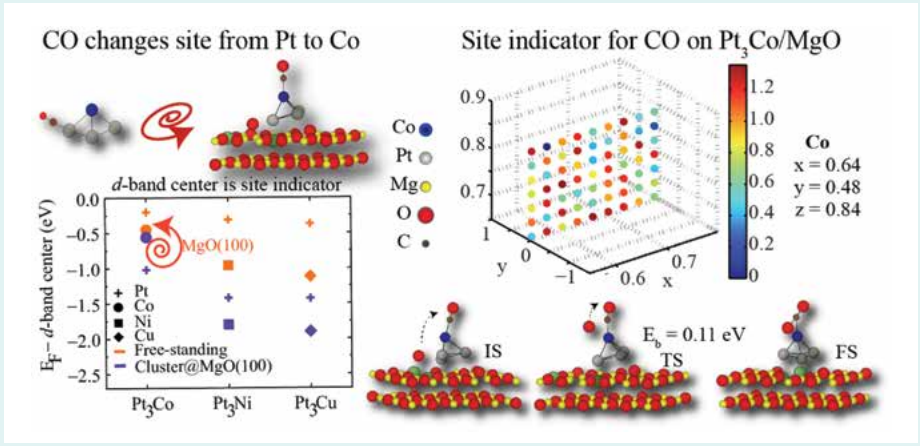
- More than 200 million people worldwide suffer from thyroid-related disorders. A team of scientists from the Department of Inorganic and Physical Chemistry has discovered a compound that can control



thyroxine, the hormone secreted by the thyroid gland. The discovery has potential applications in the treatment of hyperthyroidism. [Raja K and **Mugesh G.** Remarkable Effect of Chalcogen Substitution on an Enzyme Mimetic for Deiodination of Thyroid Hormones. *Angew. Chem. Int. Ed.*, 2015, 54: 7674–7678]

- Semiconductor quantum dots are promising materials for displays and lighting. But they suffer from a serious problem – they reabsorb some of the emitted light. On the other hand, manganese based phosphors have high quantum efficiency and stability, but lack emission tenability. Researchers from Solid State and Structural Chemistry Unit have developed nanocrystals doped with manganese which combine the advantages of quantum dots and conventional doped phosphorus, thus opening possibilities for a wide range of applications. [Abhijit Hazarika, **Anshu Pandey,** and **DD Sarma,** Rainbow Emission from an Atomic Transition in Doped Quantum Dots, *J. Phys. Chem. Lett.*, 2014, 5: 2208]

- Automobiles have catalytic convertors which convert pollutants in the exhaust gas to less toxic substances. Typically palladium and platinum are used to convert CO to CO_2. Now materials scientists from the Materials Research Centre have developed a bimetallic Pt_3Co cluster supported on MgO which oxidizes CO more efficiently to CO_2. This paves the way to develop Pt_3Co/MgO as a next generation catalytic converter in automobiles. [R Ahmad and **AK Singh.** Pt-Poisoning-Free Efficient CO Oxidation on Pt_3Co Supported on MgO(100): An Ab Initio Study, *ACS Catalysis*, 2015, 5:1826]



Biosensors are devices used to detect biological elements like tissues, microorganisms, enzymes, etc., by measuring the interaction of a chemical substance with the biological element. The interaction is quantified by converting it into an electrical or a light signal. They have become important in many fields, including in disease diagnosis, especially in the developing and under-developed parts of the world.

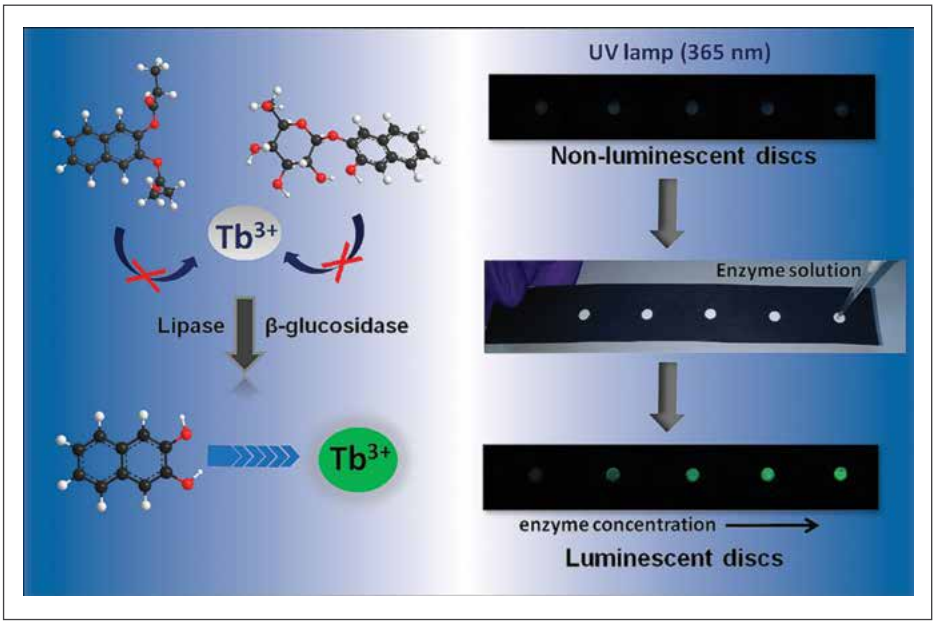
In recent years, biosensors made with paper substrates have generated much interest because they are easily available, are inexpensive and biodegradable. The porous nature of paper also allows the target chemical to diffuse easily.

Uday Maitra's lab specializes in developing such paper biosensors. Recently Maitra and his student, Tumpa Gorai, fabricated a low-cost paper biosensor that rapidly detects the presence of lipase, a pancreatic enzyme that breaks down fats into smaller molecules called fatty acids and glycerol during the process of digestion.* While a certain amount of lipase is important for maintaining normal digestive function, an abnormally high level of lipase indicates damage to the pancreas.

UDAY MAITRA

Professor
Department of Organic Chemistry

Paper Discs for Detecting Enzymes



A schematic representation of how the paper disc detects lipase

Recently Maitra and his student, Tumpa Gorai, fabricated a low-cost paper biosensor that rapidly detects the presence of lipase, a pancreatic enzyme that breaks down fats into smaller molecules called fatty acids and glycerol during the process of digestion

The biosensor comprises a paper disc, embedded within which is a gel, made with terbium – a rare earth metal – and doped with a synthetic enzyme substrate. As the disc comes in contact with lipase, it turns green when illuminated under UV light. The change in intensity of the colour indicates the amount of the enzyme present in the sample. What's more, it costs merely one rupee to make five such paper discs.

Maitra's lab has developed many such gels that make use of rare earth metals which emit light upon photoexcitation. "We have engineered these gels to have tuneable colours. One of them we developed helps in the detection of enzymes," says Maitra.

* Tumpa Gorai and **Uday Maitra.** 2016. Supramolecular approach to enzyme sensing on paper discs using lanthanide photoluminescence. *ACS Sensors.* 1(7):934–940

Prof. Uday Maitra with his team

Using advanced microscopy techniques like transmission electron microscopy, N Ravishankar and his team study nanostructures, especially how they form, grow and attain specific shapes.

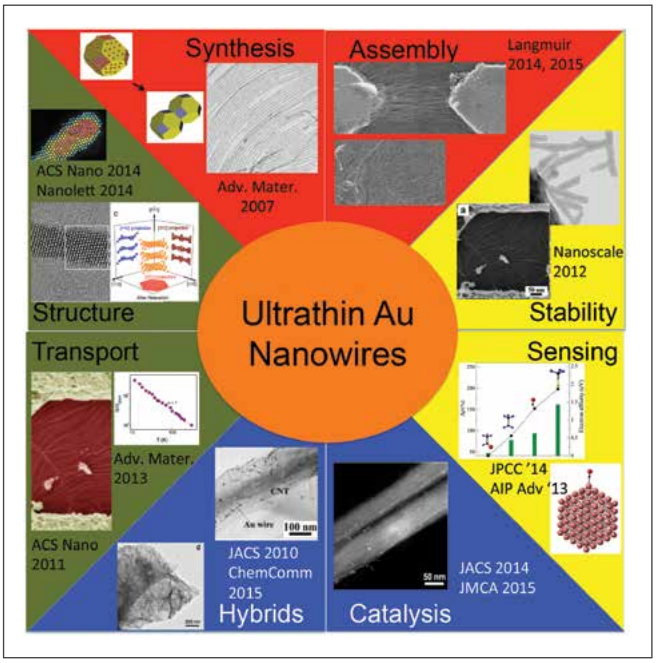
Ravishankar has a special interest in "growing" nanowires, one-dimensional wires which promise to revolutionize many fields. His group was the first in the world to grow ultrathin gold nanowires which are no more than five or six atoms thick – single crystals without high angle boundaries. The wires have a diameter of less than two nanometres (by contrast, a sheet of paper in your notebook is more than 100,000 nm thick). Explaining why growing these ultrathin gold nanowires was exciting, Ravishankar says, "Gold is as simple a system as one can imagine: it has a cubic structure; it is a noble and pure metal with excellent electrical conductivity; and it has high symmetry, with no unique direction to grow along. However in the nanowire form, most of these attributes are changed dramatically."

The process was, however, not easy. Ravishankar says that they had to trick the system into growing along a specific direction. But once he and his team identified a way of achieving this, they discovered several new and unexpected features of these wires, thus contributing towards a new understanding of one-dimensional nanostructures.

N RAVISHANKAR

Professor
Materials Research Centre

Going for Gold



Advances in the development of ultrathin gold nanowires

Ravishankar points out that though his lab's research on these nanowires is primarily fundamental in nature, it is finding many applications. "The results and understanding that we obtain are generic in nature, and can be used for many applications," he adds. One such application, described in a new study, is the use of gold nanowires as reaction catalysts for cells which use non-renewable fuels.*

One such application, described in a new study, is the use of gold nanowires as reaction catalysts for cells which use non-renewable fuels

The study details the performance of these wires and their hybrids using techniques such as cyclic voltammetry and electrochemical impedance spectroscopy. The results reveal that these nanowires outshine bulk gold which suffers from the problem of aggregation and is therefore responsible for low efficiency of fuel cells.

* A Leelavathi, R Ahmad, AK Singh, G Madras and **N Ravishankar.** 2015. Graphene-oxide-supported ultrathin Au nanowires: efficient electrocatalysts for borohydride oxidation. *Chem. Communication.* 51:16856-16859

Prof. N Ravishankar with his team

Division of Electrical Sciences

78
FACULTY MEMBERS

34
FELLOWSHIPS OF SCIENCE AND ENGINEERING ACADEMIES IN INDIA

48 PhD AND 169 MASTERS STUDENTS GRADUATED IN 2015-16

401
PhD STUDENTS

442
MASTERS STUDENTS

7
IEEE FELLOWS

Computer Science and Automation
Estd: 1969 | Chair: Prof. Jayant R Haritsa

Electrical Communication Engineering
Estd: 1946 | Chair: Prof. KVS Hari

Electrical Engineering
Estd: 1911 | Chair: Prof. AG Ramakrishnan

Electronic Systems Engineering
Estd: 1974 | Chair: Prof. Joy Kuri

Division of Electrical Sciences

CHAIRPERSON:
PROF. Y NARAHARI

CORE RESEARCH AREAS

Even while working on high impact artefacts, the Division is assiduously seeking fundamental advances in the following core areas: Signal Processing, Communications, Networks, Microelectronics and Devices, Theoretical Computer Science, Computer Systems and Software, Artificial Intelligence and Machine Learning, Control and Optimization, Power Systems, Power Electronics, High Voltage Engineering, Image Processing, and Computer Vision.

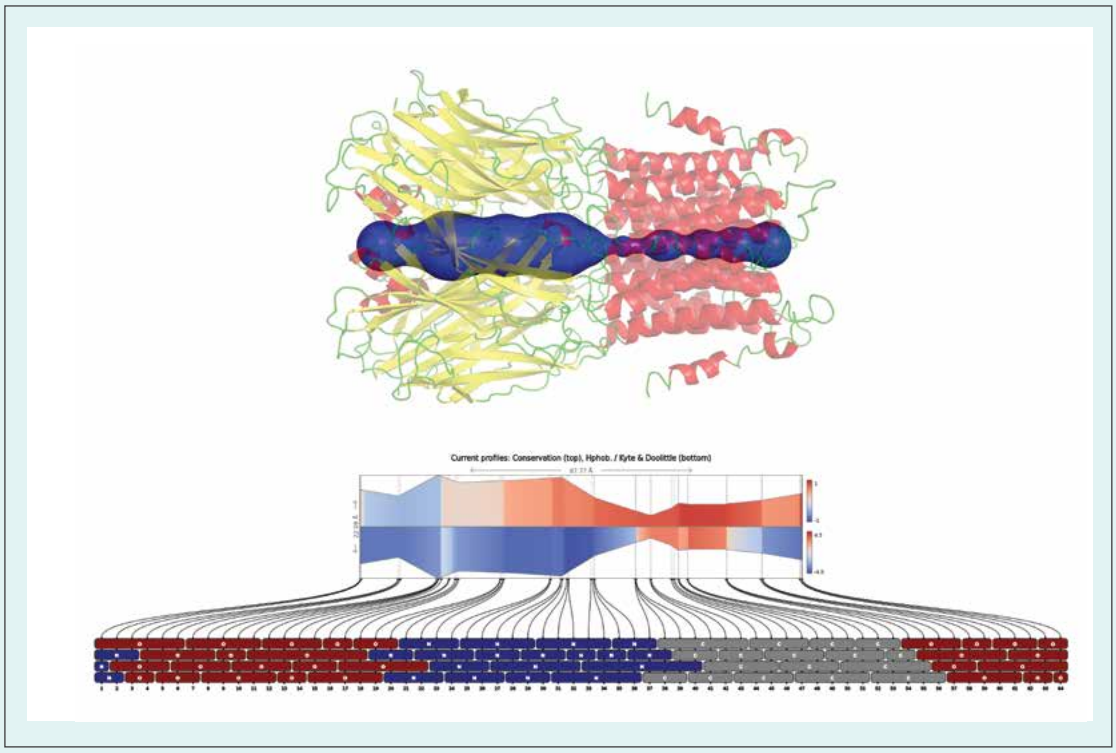
THEMES

A feature of the Division's R&D activities is its focus on rigorous innovation in contemporary, interdisciplinary themes: Big Data Analytics, Internet of Things, 5G Technologies, Devices for Healthcare, Electronics for Strategic Sector, Network Science, Cybersecurity, Multicore Computing, Smart Grids, and Renewable Energy.

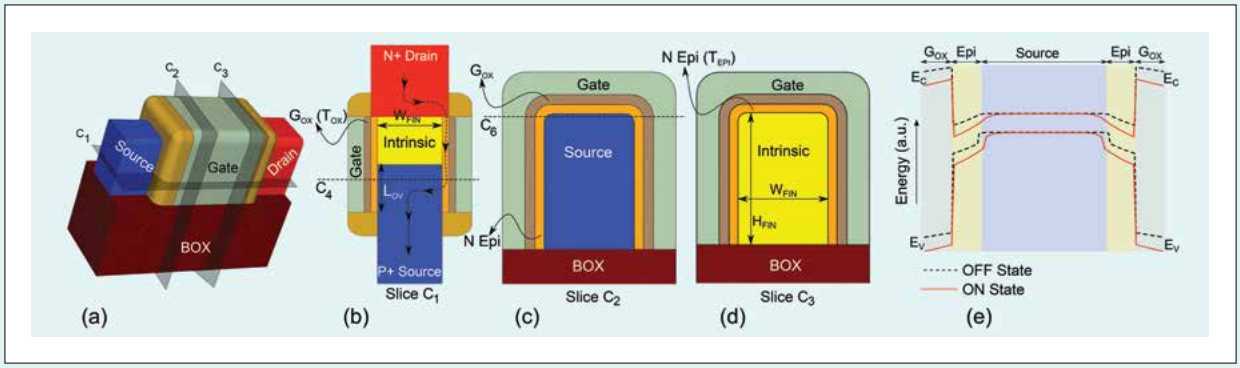
RESEARCH SNAPSHOTS

- A common security problem we face today is how to identify people using the large amounts of information we receive from videos and images. An algorithm to help match photos with images in different poses and illuminations has been developed by researchers from the Department of Electrical Engineering. This algorithm could have several applications in our fast-changing world with increasing security demands. [SP Mudunuri and Soma Biswas. Low Resolution Face Recognition Across Variations in Pose and Illumination. Accepted for publication in *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, 2015]

- Marrying techniques from bioinformatics and computer science, researchers have been able to visualize an ion transport channel in a protein. To help achieve this, they developed ChExVis, a high-end tool for extraction and visualization of bio-molecular channels. [Talha Bin Masood, Sankaran Sandhya, Nagasuma Chandra and Vijay Natarajan. ChExVis: a tool for molecular channel extraction and visualization. *BMC Bioinformatics*, 2015, 16:119.]



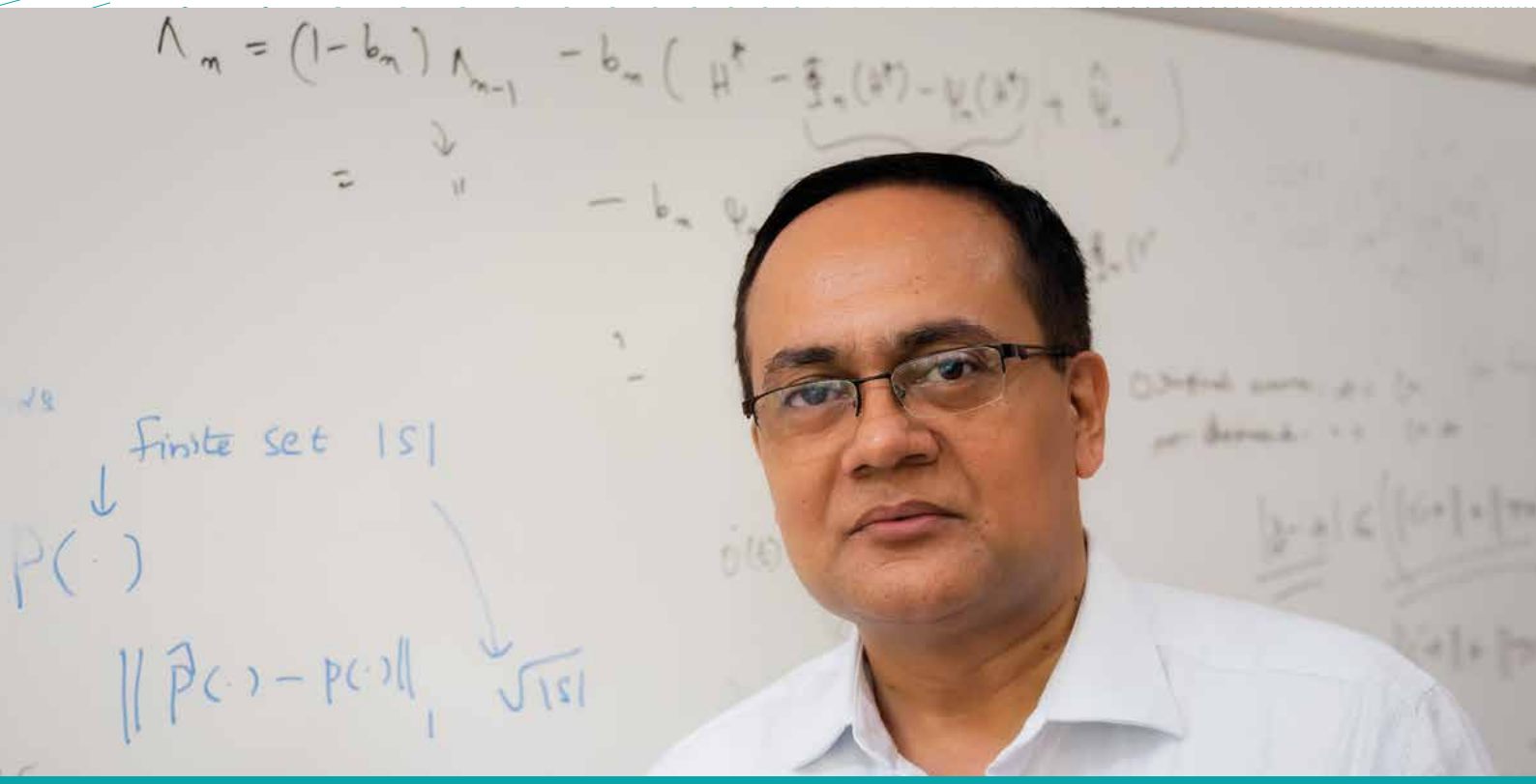
- Engineers from the Department of Electronic Systems Engineering have patented a novel fin tunnel Field-Effect Transistor (FET), demonstrating how today's technology can be used to develop electronic devices for the future. The invention is expected to transform sub-10nm node CMOS technologies. [Kuruva Hemanjaneyulu and Mayank Shrivastava, Fin Enabled Area Scaled Tunnel FET, *IEEE Transactions on Electron Devices*, October 2015, 62:10]



Computer programs that play chess do so not by evaluating every possibility – there are simply far too many – but by looking for indicative "features" in the state of the game (for instance, is the Queen still alive?) This information is then used to assess the "value" of a given state of the system, the objective being to move the system towards a higher value while minimising "cost" (is it worth losing a pawn to protect the King?). Real-life optimization problems are much like a game of chess – complex.

Shalabh Bhatnagar and his group work on the theory and applications of reinforcement learning (RL), an area of machine learning used in optimization problems. They are particularly interested in traffic-handling – the vehicular kind on our roads, and the digital kind in our wireless networks. In RL, the algorithm "learns" with experience by modifying, over time, the features it uses to capture the state of the system. This allows for the optimization even of stochastic systems. These "actor-critic" algorithms can be used to maintain average costs over a given time period, or to minimize long-term costs.

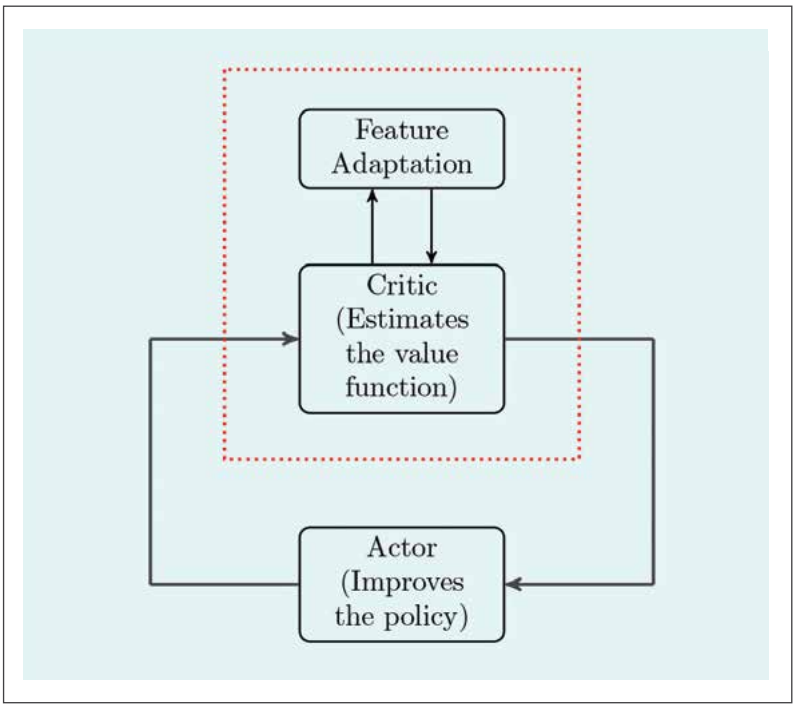
These "actor-critic" algorithms can be used to maintain average costs over a given time period, or to minimize long-term costs



SHALABH BHATNAGAR

Professor
Department of Computer Science and Automation

Making Machines Learn Better



Back in 2013, Bhatnagar and his former student, KJ Prabuchandran, now working for IBM Research, in collaboration with Vivek Borkar, an IIT Bombay professor, devised an algorithm that uses this kind of "feature adaptation" to optimize systems of interest. They showed that the error resulting from the feature adaptation disappears in the limit and one recovers the true value function, i.e., the one obtained from full system knowledge. In a more recent study, they improved their algorithm by allowing it to change the action it would take for a given state of the system.* They parameterize the action that the "actor" part of their algorithm takes; this parameter can then be varied as the algorithm learns from experience. The "critic" part of the algorithm evaluates the action taken using a features-based value estimation as before.

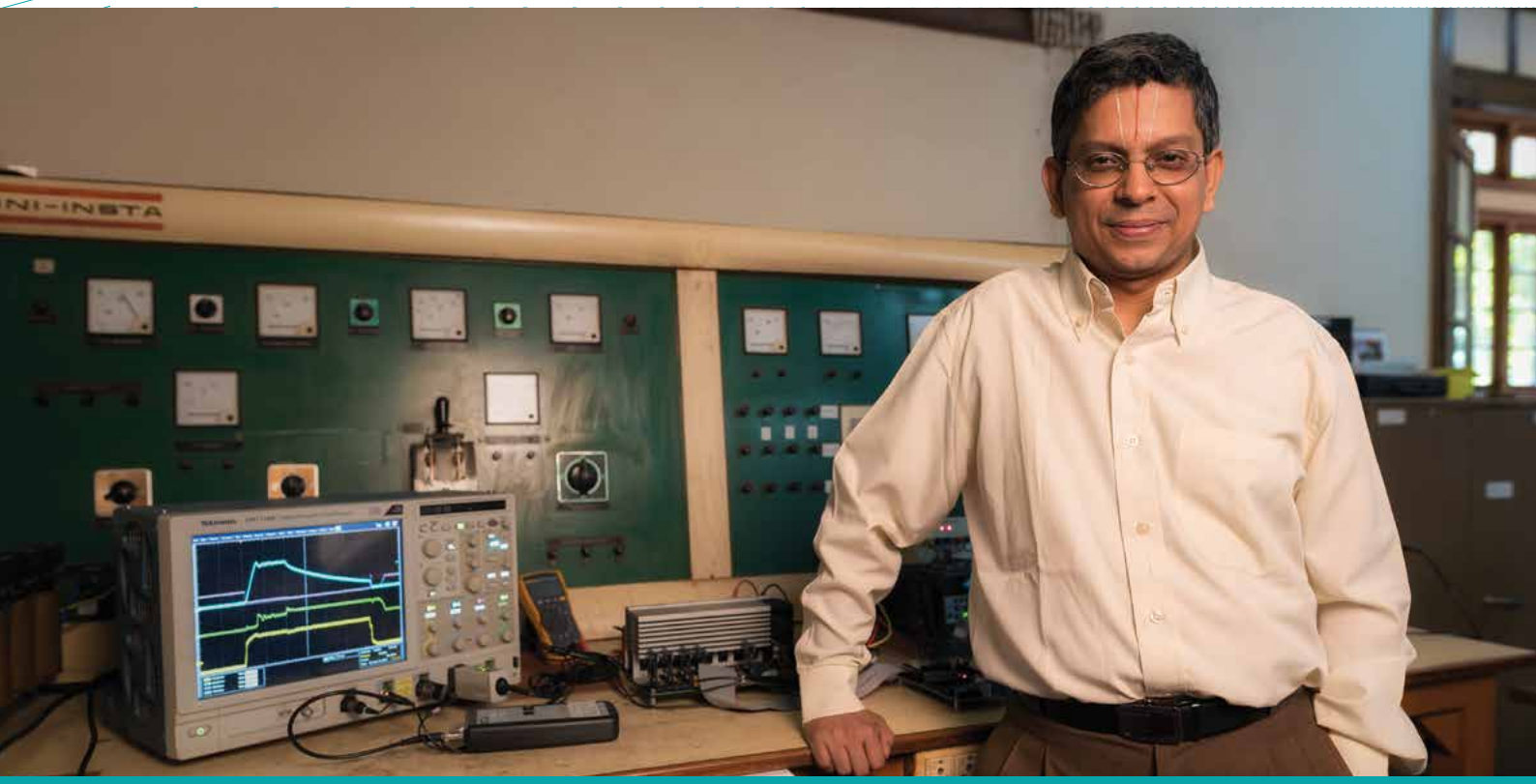
* KJ Prabuchandran, **Shalabh Bhatnagar,** and Vivek S Borkar. 2016. Actor-critic algorithms with online feature adaptation. *ACM Trans. Model. Comput. Simul.* 26 (4): Article 24.

Prof. Shalabh Bhatnagar with his team

"If you use black boxes for your research, you will have power electronics students who cannot handle power electronics devices themselves," says G Narayanan, as we walk around the lab, filled with instruments built by students over the years – including Narayanan himself, who was once a PhD student in the lab.

One such black box, for most people, is the inverter. An inverter supplies alternating current (AC) from its stored power using a technique called pulse-width modulation, or PWM. But the PWM voltage waveforms are never ideal and the process not always efficient. The inverter's output, for example, may not be purely in the form of sine waves. Over the years, Narayanan has built up a body of work, developing various PWM methods to minimize these effects.

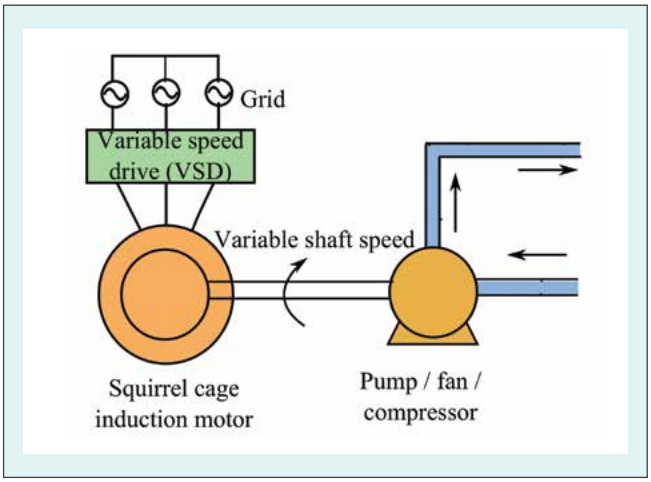
More recently, Narayanan and his student, Anirudh Guha, found something unexpected when, using a standard PWM method, they ran an induction motor powered by AC from an inverter: oscillations of the motor current at certain low and medium speeds, where a steady current was expected.* The inverter has transistors, working in pairs, which alternately turn on and off. But there is a small sliver of "dead time" in the conduction cycle during which, for reasons of safety of the device, both transistors are off. Narayanan



G NARAYANAN

Professor
Department of Electrical Engineering

Modulating Power



A fan/pump load driven by a variable speed induction motor in a typical application

and Guha traced the erratic behaviour of the motor to the inverter dead-time, and developed a model for it that better predicts the region of instability. They also worked with industry to corroborate their findings.

More recently, Narayanan and his student, Anirudh Guha, found something unexpected when, using a standard PWM method, they ran an induction motor powered by AC from an inverter: oscillations of the motor current at certain low and medium speeds, where a steady current was expected

Narayanan's work – which, he scrupulously points out, is not his alone – stems from his long-standing interest in power electronics. And his approach has been deeply influenced by his teachers in the Department – most of all by his PhD advisor, the late VT Ranganathan, who encouraged him to learn how to build an inverter and implement PWM methods from scratch. "While doing that work," Narayanan recalls, "I found that things could be done very differently."

* Anirudh Guha and **G Narayanan.** 2016. Small-signal stability analysis of an open-loop induction motor drive including the effect of inverted deadtime. *IEEE Transactions on Industry Applications.* 52(1):242-253

Prof. G Narayanan with his team


NATIONAL SCIENCE SEMINAR COMPLEX

Division of Interdisciplinary Research

32
FACULTY MEMBERS

12
FELLOWSHIPS OF SCIENCE AND ENGINEERING ACADEMIES IN INDIA

20 PhD AND 49 MASTERS STUDENTS GRADUATED IN 2015-16

141
PhD STUDENTS

95
MASTERS STUDENTS

Centre for BioSystems Science and Engineering
Estd: 2015 | Chair: Prof. GK Ananthasuresh

Centre for Contemporary Studies
Estd: 2004 | Chair: Prof. Raghavendra Gadagkar

Centre for Infrastructure, Sustainable Transportation and Urban Planning
Estd: 2009 | Chair: Prof. JM Chandra Kishen

Centre for Nano Science and Engineering
Estd: 2010 | Chair: Prof. Rudra Pratap

Computational and Data Sciences
Estd: 2015 | Chair: Prof. Phaneendra Yalavarthy

Management Studies
Estd: 1985 | Chair: Prof. MH Bala Subrahmanya

Interdisciplinary Centre for Energy Research
Estd: 2012 | Chair: Prof. Giridhar Madras

Interdisciplinary Centre for Water Research
Estd: 2015 | Chair: Prof. PP Mujumdar

Robert Bosch Centre for Cyber Physical Systems
Estd: 2011 | Chair: Prof. Bharadwaj Amrutur

Supercomputer Education and Research Centre
Estd: 1970 | Chair: Prof. R Govindarajan

Division of Interdisciplinary Research

CHAIRPERSON:
PROF. G RANGARAJAN

CORE RESEARCH AREAS

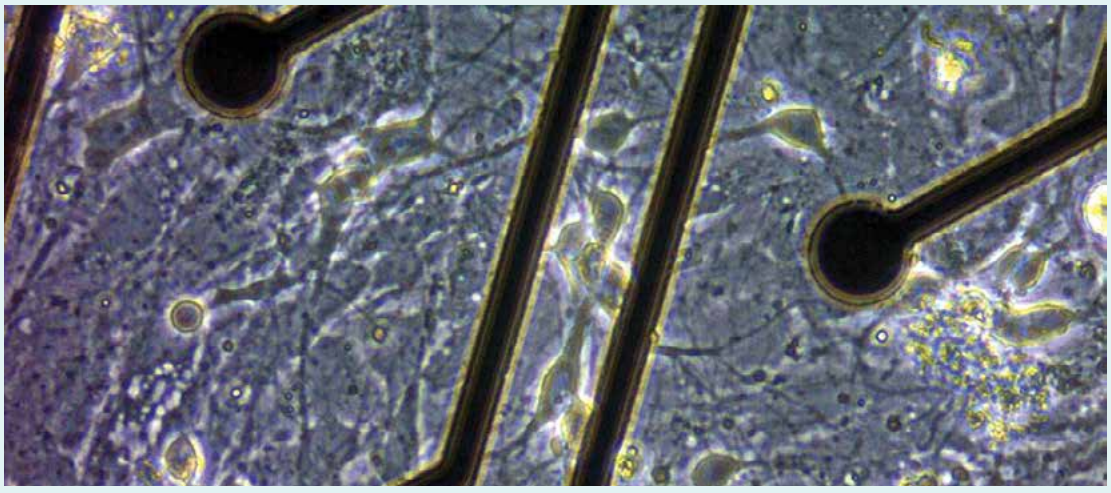
Interdisciplinarity is the characteristic feature of the research carried out in this Division. Specific research areas include Bioengineering, Urban infrastructure and transportation, Nanoscale materials, Nano devices and systems, Economics, Finance, Human resource management, Marketing, Optimization, Public policy, Energy, Water, Internet of things, Distributed sensing, Computer systems, Computational science, Data sciences and bioinformatics.

THEMES

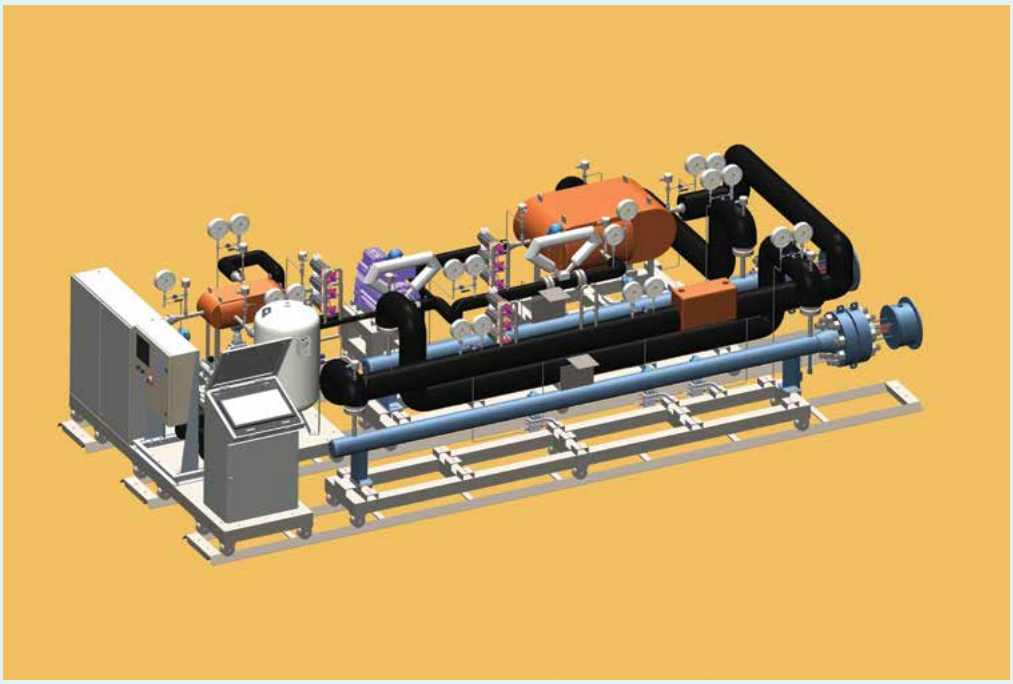
Interdisciplinary research has emerged as a crucial part of the research landscape in recent years. By breaking down departmental barriers, interdisciplinary research facilitates novel breakthroughs that may not be possible within the confines of a particular discipline. The Division of Interdisciplinary Research has a wide range of Departments/Centres with the common theme of a strong interdisciplinary focus.

RESEARCH SNAPSHOTS

- Researchers from the Centre for Nano Science and Engineering have grown a plate of brain cells of a rat on a specialized tiny glass plate covered with multiple electrodes. These electrodes interface with sensors and actuators, making it an artificial brain which can be taught to control a robot. [Jude Baby George et al. and **Bharadwaj Amrutur.** Robot navigation using neuro-electronic hybrid systems. *28th International Conference on VLSI Design* and *14th International Conference on Embedded Systems.* 2015]



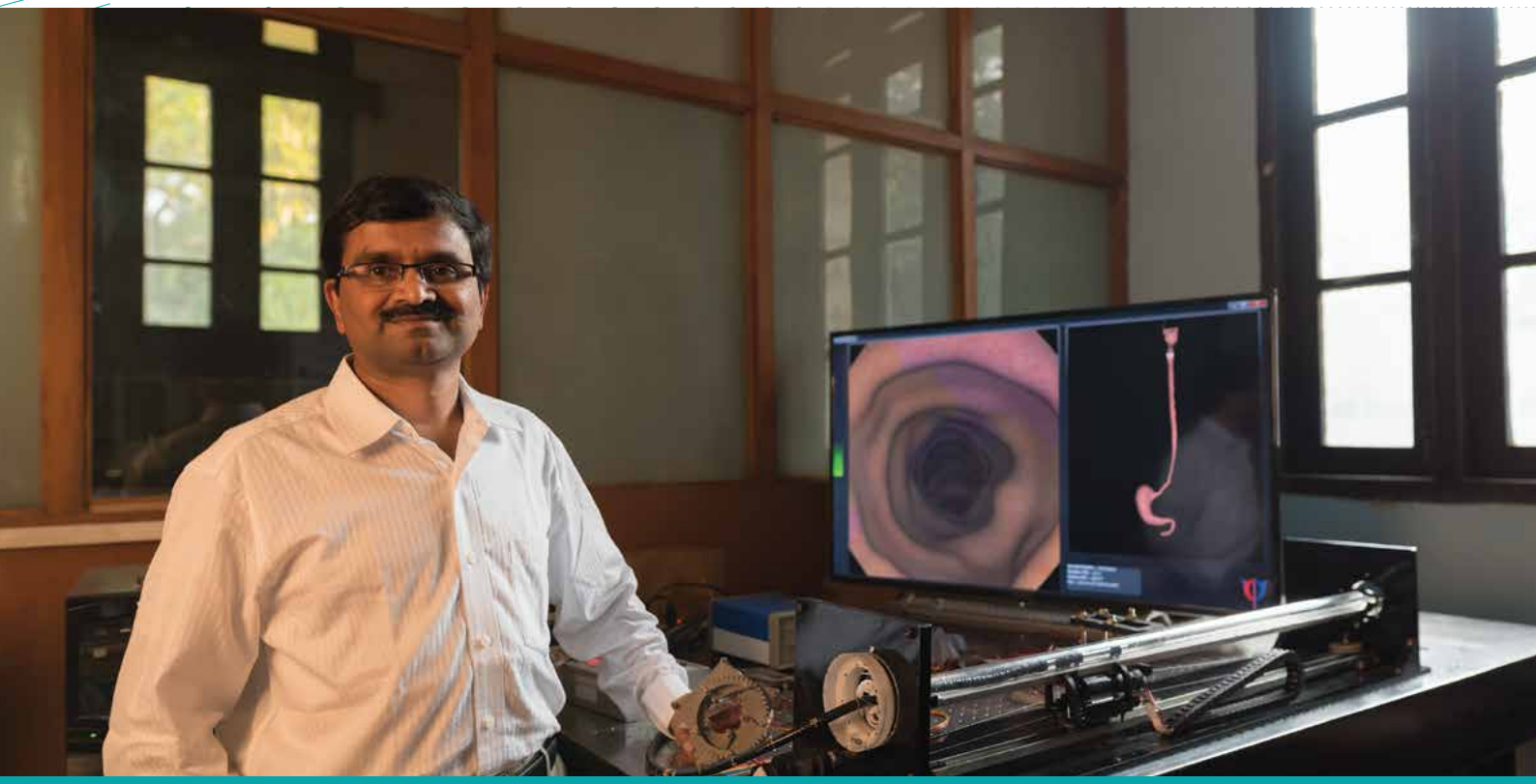
- Today's thermal power plants use steam to carry heat away from the source and turn a turbine to generate power. However, one could generate more power if, instead of steam, supercritical carbon dioxide (S-CO_2) is used. Scientists from the Department of Mechanical Engineering are taking steps towards making this a reality by setting up a solar plant at a laboratory-scale to more efficiently generate power. [Pardeep Garg, **Pramod Kumar, Pradip Dutta,** Thomas Conboy and Clifford Ho. Design of an Experimental Test Facility for Supercritical CO_2 Brayton Cycle. *ASME Proceedings. Geothermal, Ocean, and Emerging Energy Technologies.* doi:10.1115/ES2014-6549]



GK Ananthasuresh and his team investigate the mechanical response of biological cells to biochemical and physical stimuli. As part of their research, they have developed a miniature bioreactor system that mimics in vivo conditions in cell culture.* The custom-designed system, comprising bioreactors and peristaltic pumps, enables high-magnification live microscopy and microbiology experiments.

This bioreactor system has many novel features: It can accommodate scaffolds that alter the microenvironment of cells; its modular construction enables it to be reconfigured for a variety of studies; it is reusable because all its components can be sterilized; and it can be used as a Petri dish in standard incubators.

Ananthasuresh, a mechanical engineer by training, is excited about the potential of their novel device. "It allows for long-term pulsatile flow on cells similar to what they experience in vivo. The constant flow of medium improves nutrient and oxygen delivery and minimizes waste accumulation, enabling extended use," he says.



GK ANANTHASURESH

Chair and Professor
Centre for BioSystems Science and Engineering

A High-Throughput Device for Cell Culture

Perfusion bioreactor that can accommodate scaffolds on cover-slips with provision for high magnification in situ

Using principles of mechanics, Ananthasuresh and his students, in collaboration with biologists and clinicians, are developing scalable miniature tools and computational techniques for quantifying mechanical response of single cells

The bioreactor system is also helping bring researchers from different fields together. For instance, Ananthasuresh's team is collaborating with Saumitra Das (Professor, Department of Microbiology and Cell Biology), to probe the mechanism of Hepatitis C virus infection in liver cells by correlating mechanical and biochemical measurements. "With our technique, results similar to the conventional culture method could be achieved with only a few cells and faster turnaround," Ananthasuresh says, highlighting its potential in biomedical research. What's more, the device can be used to test multiple drugs, reducing reliance on animal models. To reach out to the broader R&D community, two of his former students have started a company – Bendflex – to market the bioreactor system and ultrasensitive force sensors.

The development of the bioreactor will contribute towards establishing mechanical markers of diseases with the larger goal of inventing next-generation medical diagnostics called mechano-diagnostics. This entails understanding the effect of diseases on the mechanical properties of individual cells, development of miniature tools for point-of-care measurement of mechanical responses, and computational techniques for associating diseases to the measured responses with specificity.

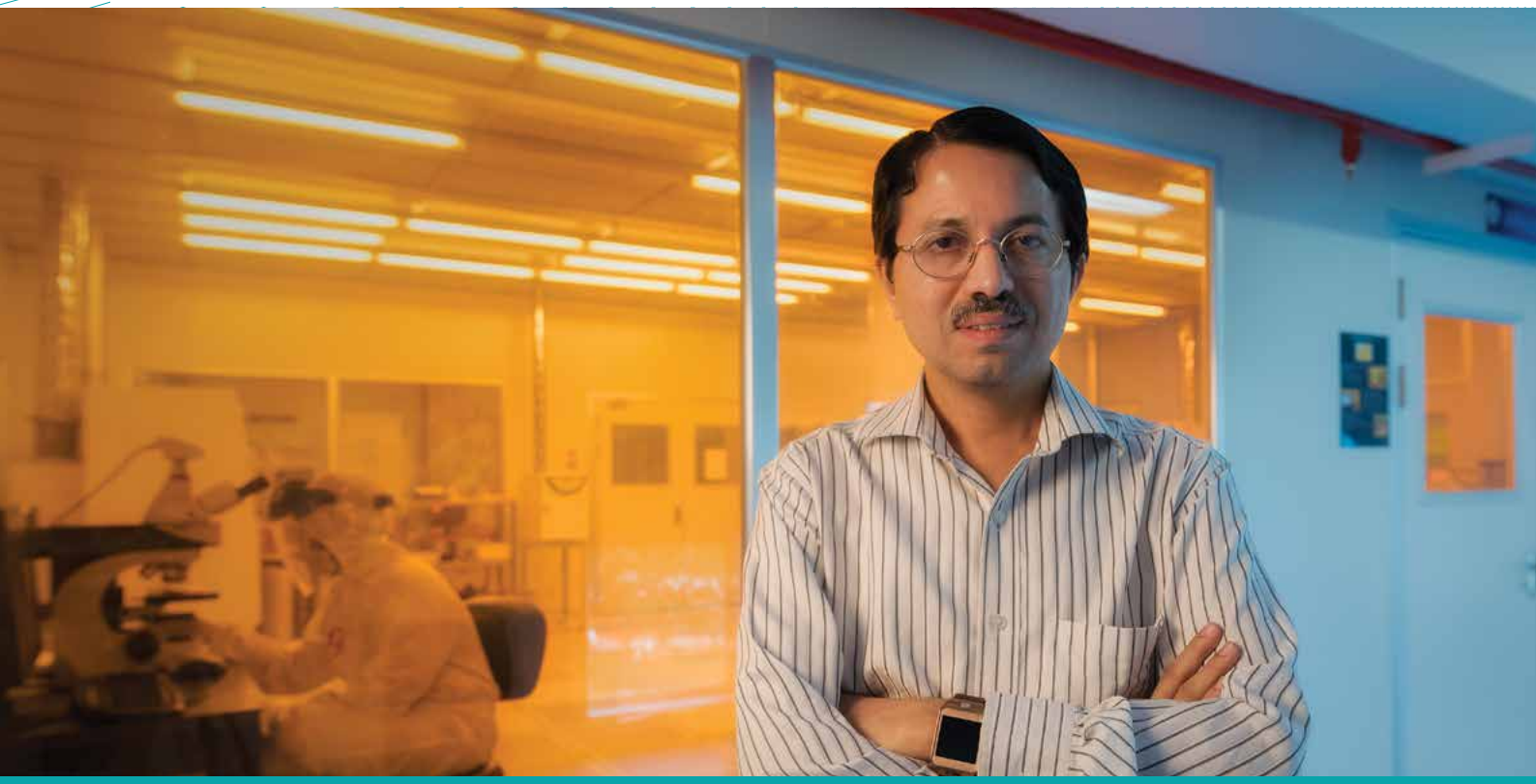
* S Balakrishnan, MS Suma, SR Raju, SDB Bhargav, S Arunima, S Das and **GK Ananthasuresh.** 2015. A scalable perfusion culture system with miniature peristaltic pumps for live-cell imaging assays with provision for microfabricated scaffolds. *BioResearch Open Access*, 4(1):343–357.

Prof. GK Ananthasuresh with his team

For decades, silicon transistors have been shrinking in size. But silicon is no longer a suitable material when transistors become smaller than 10 nanometres.

Navakanta Bhat is interested in semiconductors that could replace silicon, especially 2D materials such as molybdenum disulphide (MoS_2). His research group has developed an ultra-low power switch by integrating an MoS_2 substrate with a gate made of a material with a high dielectric constant, such as hafnium dioxide (HfO_2), using nanotechnology.* "We have been able to demonstrate MoS_2 nanotransistor with record mobility using HfO_2 gate dielectric and sulphur-treated nickel contacts," says Bhat.

Bhat's research group also uses nanoscience to develop gas sensors and biosensors. One of the gas sensors they have fabricated can detect carbon dioxide in the range of 300 to 1000 parts per million.** "This novel low-cost sensor is made by placing a thin layer of mixed metal oxide semiconductor, such as oxides of barium, titanium and copper, doped with silver, on a micromachined suspended hotplate," says Bhat.



NAVAKANTA BHAT

Professor
Centre for Nano Science and Engineering

Making an Impact through Small Devices

The diabetes detection and monitoring device which is to hit the market soon

Navakanta Bhat's group aims to create societal impact through basic research in nanotechnology and its translation to realize novel products

Bhat's work on biosensors has focussed on the management of diabetes and its complications. His group has developed new electrochemical receptors for sensing of HbA1c (glycated haemoglobin), glycated albumin, blood glucose, haemoglobin, serum albumin, micro-albuminuria, urine creatinine and urine ACR. They have also developed a phablet-sized handheld device that can perform these multiple tests in less than a minute, using no more than a drop of blood or urine. The device, which uses special disposable test strips, is now being commercialised under a company *PathShodh Healthcare* that Bhat co-founded with one of his students. The technology is now protected by multiple international patents. It has also been shortlisted by the National Health Systems Resources Centre (NHSRC), a central government agency that works in collaboration with the World Health Organization, as a "priority medical device" because of its potential healthcare benefits.

* KL Ganapathi, S. Bhattacharjee, S Mohan, and **N Bhat.** 2016. High-performance HfO_2 back gated multilayer MoS_2 transistors. *IEEE Electron Device Letters.* 37(6):797-800

** SB Rudraswamy, **N Bhat.** 2016. Optimization of RF sputtered Ag-doped $BaTiO_3$-CuO mixed oxide thin film as carbon dioxide sensor for environmental pollution monitoring application. *IEEE Sensors Journal.* 16(13):5145-5151

Prof. Navakanta Bhat with his team

Division of Mechanical Sciences

119
FACULTY MEMBERS

84
FELLOWSHIPS OF SCIENCE AND ENGINEERING ACADEMIES IN INDIA

88 PhD AND 107 MASTERS STUDENTS GRADUATED IN 2015-16

602
PhD STUDENTS

295
MASTERS STUDENTS

Aerospace Engineering
Estd: 1942 | Chair: Prof. S Gopalakrishnan

Centre for Product Design and Manufacturing
Estd: 1998 | Chair: Prof. Amaresh Chakrabarti

Chemical Engineering
Estd: 1943 | Chair: Prof. Ganapathy K Ayappa

Materials Engineering
Estd: 1945 | Chair: Prof. TA Abinandanan

Mechanical Engineering
Estd: 1945 | Chair: Prof. Pradip Dutta

Civil Engineering
Estd: 1950 | Chair: Prof. Sudhakar M Rao

Centre for Earth Sciences
Estd: 2007 | Chair: Prof. D Nagesh Kumar

Centre for Atmospheric and Oceanic Sciences
Estd: 1982 | Chair: Prof. Ravi S Nanjundiah

Centre for Sustainable Technologies
Estd: 1974 | Chair: Prof. HN Chanakya

Divecha Centre for Climate Change
Estd: 2009 | Chair: Prof. SK Satheesh

Division of Mechanical Sciences

CHAIRPERSON:
PROF. VIKRAM JAYARAM

CORE RESEARCH AREAS

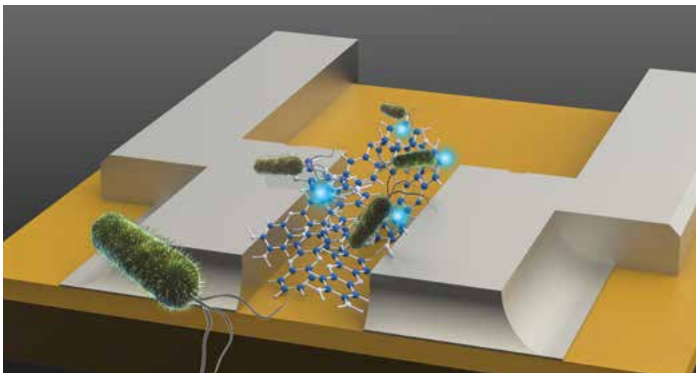
Geotechnical Engineering, Civil and Aerospace Structures, Transportation, Water Resources, Environmental Engineering and Sustainable Habitat, Climate, Structural and Functional Materials, Manufacturing, Design Theory and Methodology, Geochemistry, Tectonics, Planetary Evolution, Remote Sensing and GIS Applications, Aerodynamics, Combustion, Navigation and Guidance, Solid Mechanics, Fluid Mechanics, Thermal Sciences, Acoustics, Robotics, Dynamics, Biomolecular Engineering, Catalysis, Colloids and Interfacial Science, Nanotechnology, Thermodynamics and Simulations across length scales.

THEMES

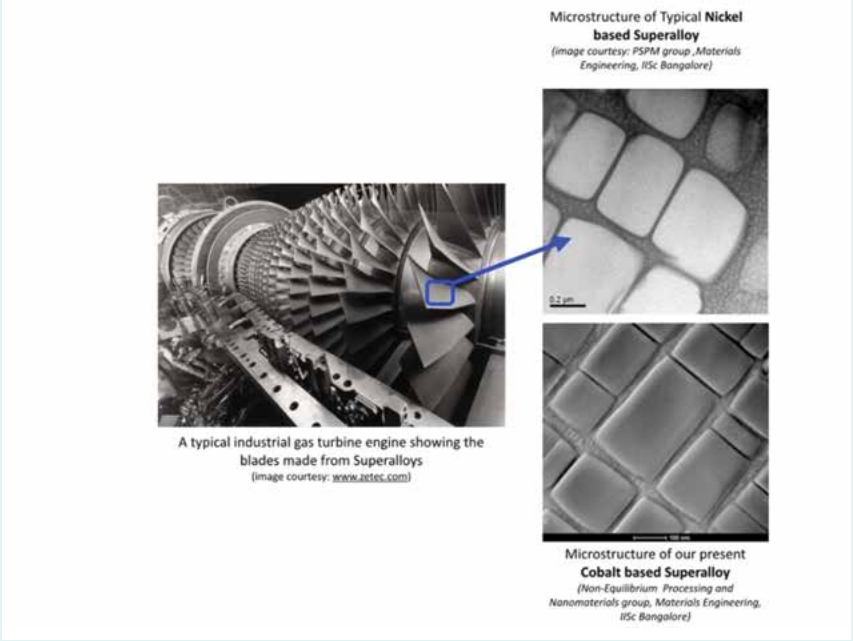
Research work in the Division encompasses diverse areas. Seismology and climate change – modelling as well as paleo studies – are focus areas, which lead naturally to work on environmentally sustainable materials and design and on waste management. The work on materials includes study and modelling of biomaterials, polymers and photovoltaics. Fluid dynamics, including shock waves and other phenomena at hypersonic speeds, is another key area of study that cuts across the various departments in this Division. Researchers in this Division also work on identifying novel drug and vaccine targets for viral infections such as HIV, hepatitis C and dengue.

RESEARCH SNAPSHOTS

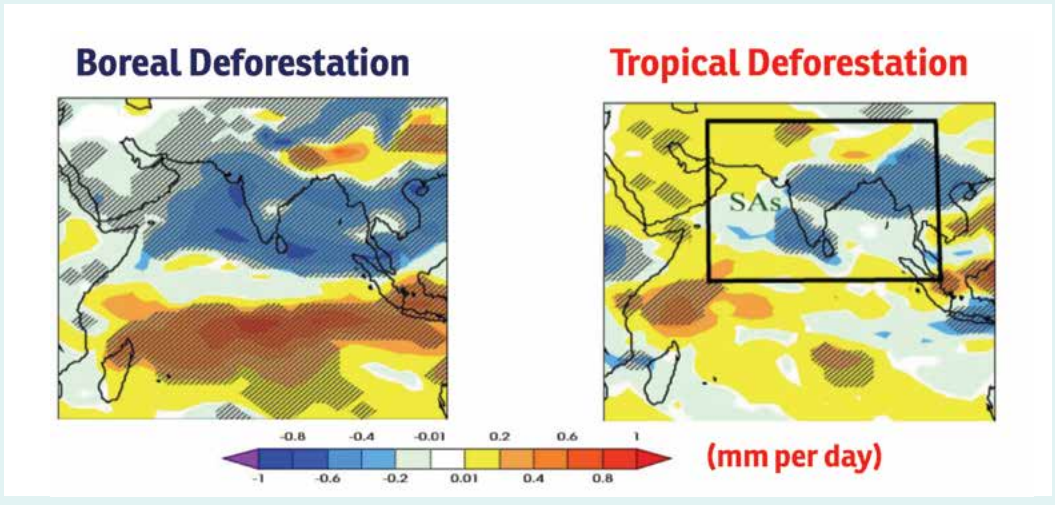
- *E. coli* is a common bacterium found in our environment which can cause serious infections in humans. Researchers from the Department of Materials Engineering have developed an *E. coli* sensor, made of a polymer whose resistance changes with minute changes in the number of *E. coli.* [Ashwini N Mallya and **Praveen C Ramamurthy.** Conjugated molecule based resistive sensor for microbial detection in water with *E. coli* as a case study. *ACS Sensors* (Communicated)]



- Turbines in jet engines have superalloys usually made from nickel to withstand very high temperatures. "Green" fuels will be the norm in the future, but these are more corrosive. Engineers from the Department of Mechanical Engineering have synthesized corrosion resistant cobalt-based superalloys for use in jet engines. [SK Makineni, B Nithin and **K Chattopadhyay.** Synthesis of a new tungsten-free γ-γ′ Cobalt-based superalloy by tuning alloying additions. *Acta Materialia*, 2015, 85:85–94]



- Deforestation is among the biggest threats to our ecology as well as our long term well-being. But we are still studying the many different ways in which they could affect our ecosystems. Scientists from the Divecha Centre for Climate Change have developed a computer simulation which has demonstrated that rainfall in India is affected more by deforestation in higher latitudes than local deforestation. [N Devaraju, **Govindasamy Bala,** and Angshuman Modak. Effects of large-scale deforestation on precipitation in the monsoon regions: Remote versus local effects. *PNAS*, 2015, 112(11): 3257–3262.]

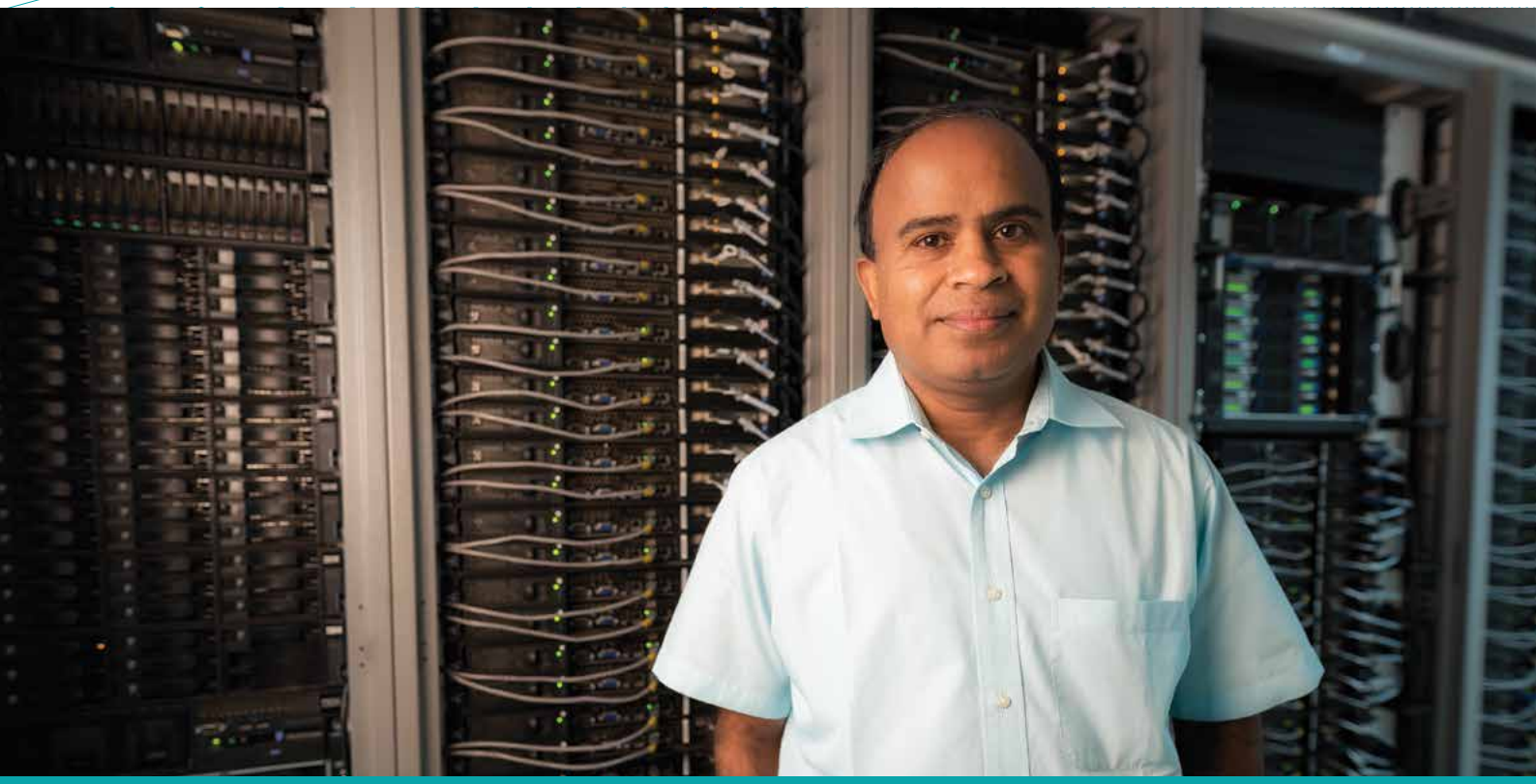


We are currently living in what is considered as the Anthropocene, an age in which human activities have a significant impact on the planet. Perhaps the most serious damage inflicted by humans has been on its climate.

Climate change, driven by an increase in the average surface temperature of Earth, results from a surge in radiative forcing – the difference between the energy received by Earth and the energy radiated back to space. The radiative forcing agents of the industrial era include greenhouse gases such as carbon dioxide (CO_2) and methane, which trap the longwave radiation emitted by our planet.

To measure how effective a forcing agent is in causing Earth's climate to change, researchers use the concept of efficacy, defined as the ratio of global temperature change due to that particular forcing agent to the temperature change caused by CO_2 for the same radiative forcing value.

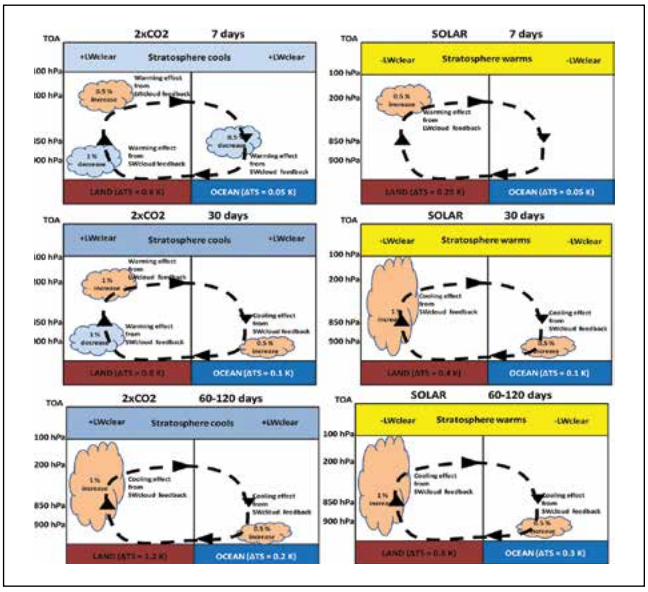
In a new study, Govindasamy Bala – one of India's most well-known climate scientists – and his student, Angshuman Modak, addressed the issue of the efficacy of the incident solar radiation



GOVINDASAMY BALA

Professor
Centre for Atmospheric and Oceanic Sciences

A Significant Step in Understanding Climate Change



This schematic diagram illustrates the differences in climate system response for solar and CO_2 forcing on 7, 30 and 60–120 day timescales. The closed circulation indicates a global monsoonal circulation initiated during climate change. The cloud and stratospheric temperature responses are very different in the two cases

relative to CO_2.* Using a modelling approach, they considered climate system responses during three different time periods: a week, four months and a century.

In a new study, Govindasamy Bala – one of India's most well-known climate scientists – and his student, Angshuman Modak, addressed the issue of the efficacy of the incident solar radiation relative to CO_2

"What we found was that the Sun is less effective than CO_2 in causing climate change," says Bala. In fact, the study shows that solar forcing is only 80% as effective as CO_2 forcing. "This means that for the same radiative forcing, if CO_2 causes 1 °C warming, the Sun causes only 0.8 °C warming," he continues. This finding, Bala argues, is crucial not just for our understanding of the mechanisms of climate change but also for the formulation of more effective climate change policies.

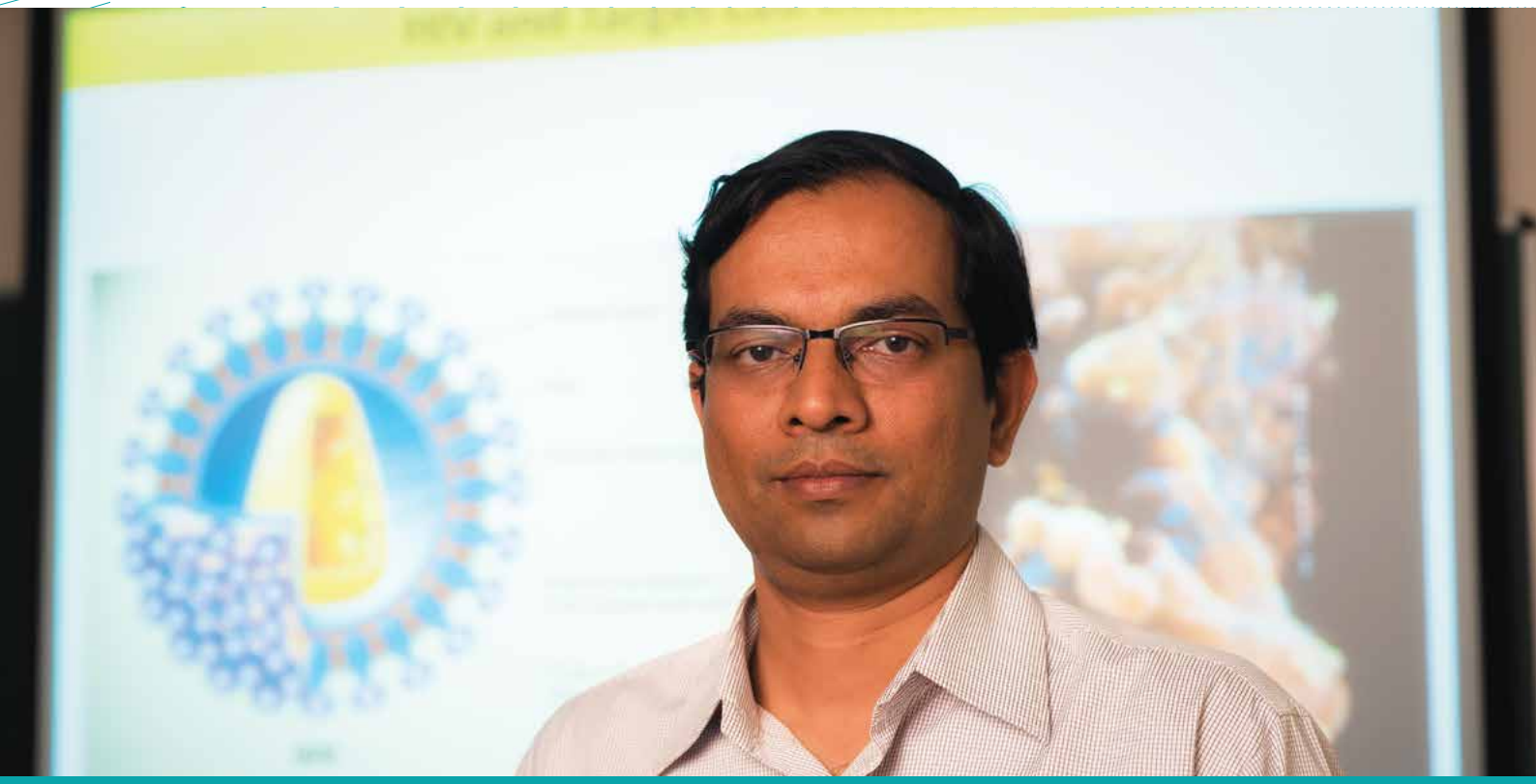
* Angshuman Modak, **Govindasamy Bala,** Long Cao and Ken Caldeira. 2016. Why must a solar forcing be larger than a CO_2 forcing to cause the same global mean surface temperature change? *Environ. Res. Lett.* 11(4):1-12

Prof. Govindasamy Bala with his team

Though the symptoms of Acquired Immuno Deficiency Syndrome (AIDS) can be controlled with a cocktail of anti-retroviral drugs, the disease, caused by the Human Immunodeficiency Virus, or HIV, does not have a permanent cure as yet. The reason researchers have not been successful in this endeavour is because of the high rate at which the virus mutates, causing it to overcome the selection pressures imposed by drugs and potential vaccines.

From the virus's point of view, however, there is a flipside to having very high mutation rates. If it increases beyond a tipping point, called error threshold, then it leads to low fitness in the virus, making it an ineffective pathogen.

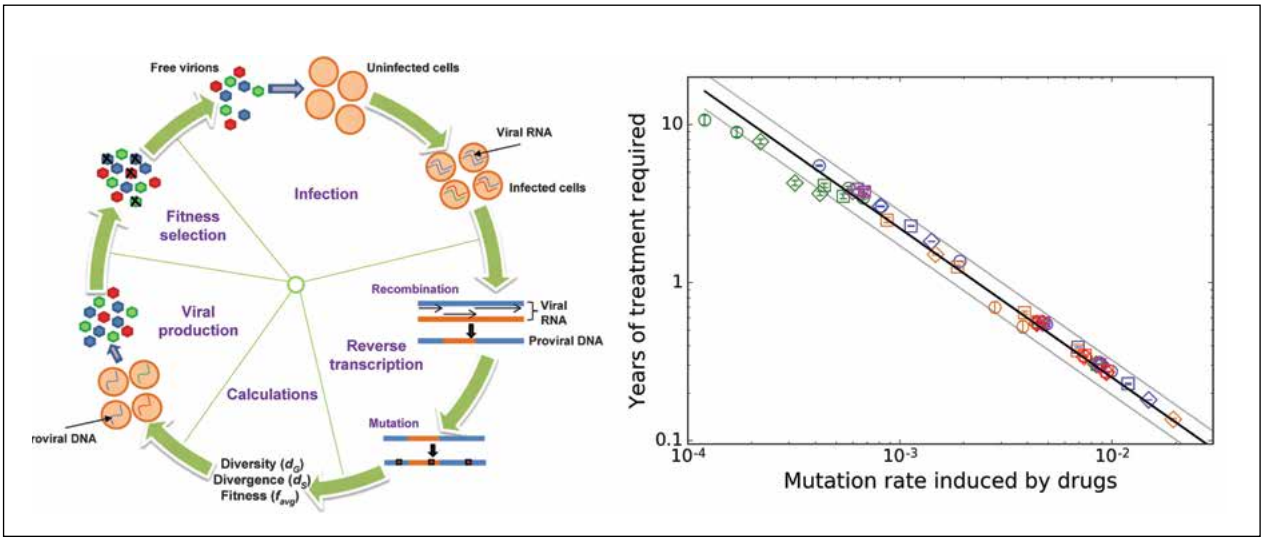
Narendra Dixit and his team have been studying the process of infection caused by HIV and its evolution using stochastic simulation models. These models allow them to closely track the fitness levels of the genetically diverse populations within a host and the factors that contribute to it. A recent study by Dixit and his student, Vipul Gupta, has demonstrated that if the mutation rate of HIV



NARENDRA DIXIT

Associate Professor
Department of Chemical Engineering

Beating HIV at its Own Game



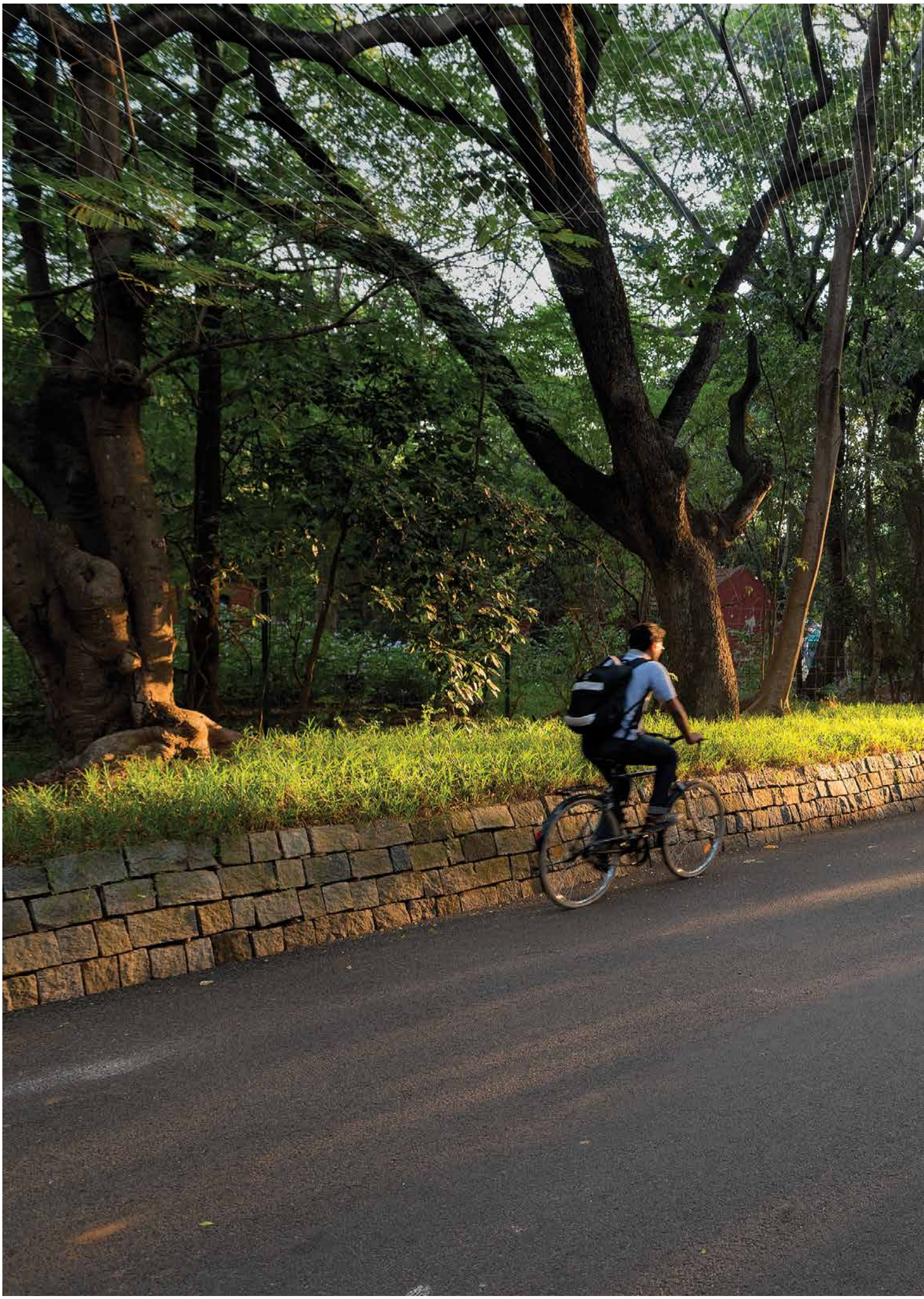
is increased over six times its natural mutation rate then the virus can be rendered inactive against its host.*

A recent study by Dixit and his student, Vipul Gupta, has demonstrated that if the mutation rate of HIV is increased over six times its natural mutation rate then the virus can be rendered inactive against its host

The finding also has implications for how we treat AIDS. High mutation rates can be induced in HIV using a special class of anti-retroviral drugs. If the mutation rate can be raised to the error threshold, then, in principle, the virus can be prevented from causing infection. The research by Dixit's team shows that, in fact, such a benign state can be achieved by using mutation-inducing drugs for a period of about 10 years. Some of these drugs are already undergoing clinical trials. Dixit believes that in the coming years, with better drug combinations, the treatment window could be reduced further.

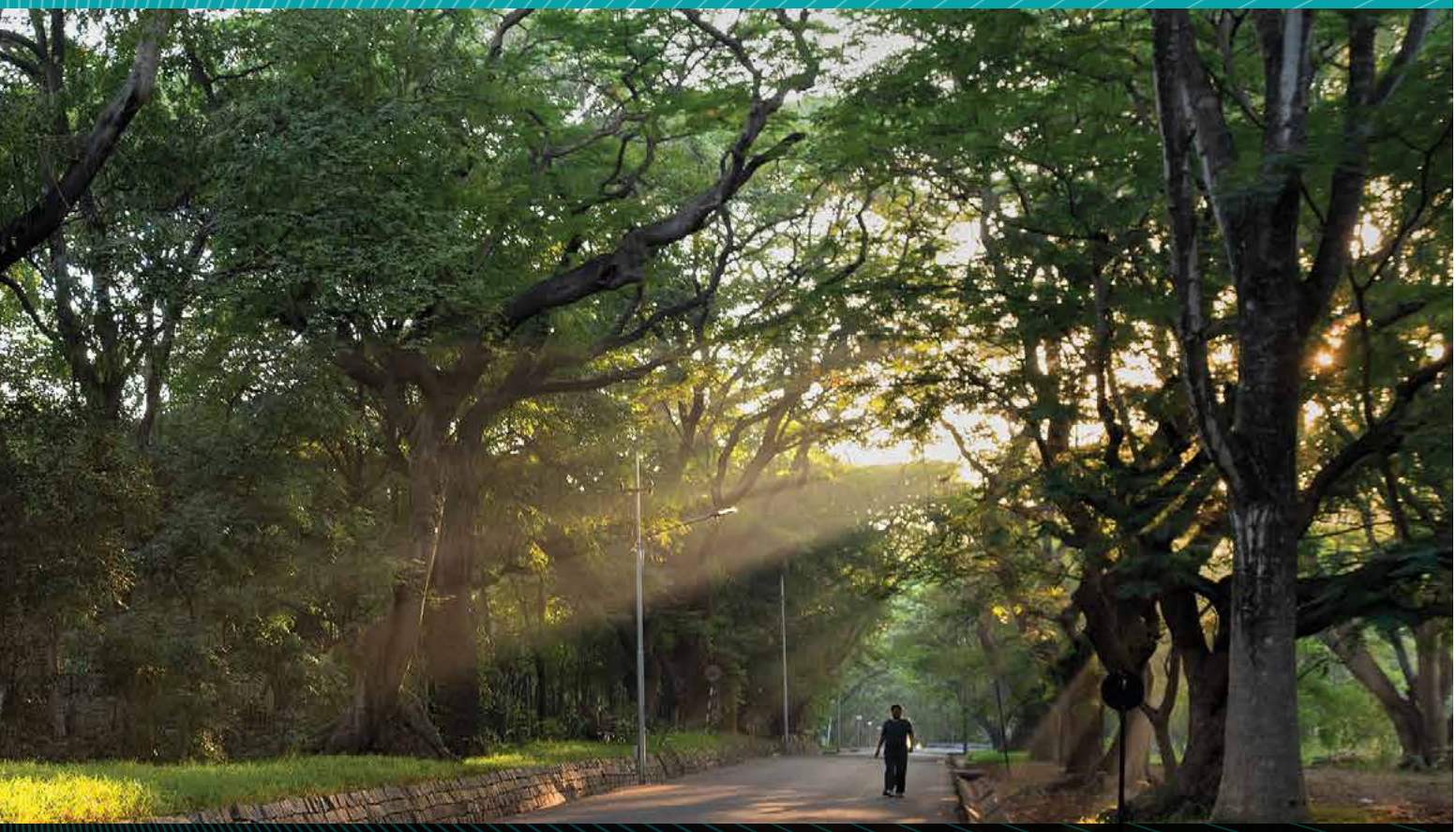
* V, Gupta, **N, Dixit.** 2015. Scaling law characterizing the dynamics of the transition of HIV-1 to error catastrophe. *Phys. Biol.* 12(5): 054001

Prof. Narendra Dixit with his team



Division of

Physical and Mathematical Sciences



73
FACULTY MEMBERS

58
FELLOWSHIPS OF SCIENCE ACADEMIES IN INDIA

39 PhD AND 2 MASTERS STUDENTS GRADUATED IN 2015-16

262
PhD STUDENTS

16 MASTERS STUDENTS

94
INTEGRATED PhD STUDENTS

Centre for Cryogenic Technology
Estd: 1971 | Chair: Prof. V Venkataraman

Centre for High Energy Physics
Estd: 2004 | Chair: Prof. B Ananthanarayan

Instrumentation and Applied Physics
Estd: 1996 | Chair: Prof. S Asokan

Mathematics
Estd: 1956 | Chair: Prof. Gadadhar Misra

Physics
Estd: 1933 | Chair: Prof. V Venkataraman

Division of Physical and Mathematical Sciences

CHAIRPERSON:
PROF. RAHUL PANDIT

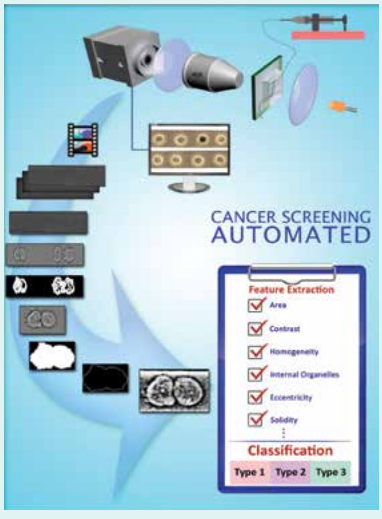
CORE RESEARCH AREAS

Research in the Division covers a wide variety of areas in the Physical Sciences, including fundamental investigations in String Theory, Particle Phenomenology, Field Theory, Condensed Matter Physics, both theoretical and experimental, Soft-Matter and Complex Systems, Biology-Inspired Physics, Biomolecular Structure and Biophysics, Atomic and Optical Physics, Astronomy and Astrophysics, and cutting-edge Applied Physics research including MEMS-based and Fibre-Optic Sensors, Multifunctional Materials, such as graphene and carbon nanotubes, Super-Resolution Fluorescence Microscopy, Nano-Scale Imaging, Optics and Microfluidics, Energy and Health Monitoring Instrumentation, and Cryogenic Technologies, including Cryocoolers, Cryogenic Instrumentation, and Cryogenic treatment on materials. Research in Mathematics covers major areas, both pure and applied, including Probability, Partial Differential Equations, Analysis, Geometry, Topology, Algebra, Algebraic Geometry, and Analytic Number Theory.

THEMES

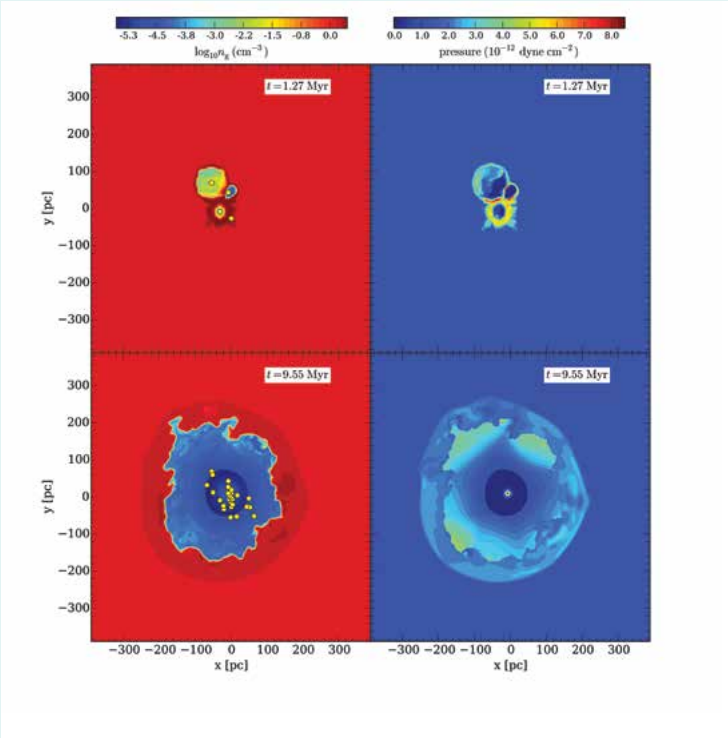
Given the diversity of this Division, there is a diversity of themes in research. These can be gleaned from the core research areas mentioned above. Many of these areas lie in the exact sciences, both theoretical and experimental. Along with these, there are growing interdisciplinary programmes, such as in Mathematical Biology and Nanoscience. Translational research is also being carried out and products, based on innovative and cutting-edge technologies, are being brought into the market by faculty entrepreneurs in the division.

RESEARCH SNAPSHOTS



• Researchers from the Department of Instrumentation and Applied Physics have combined microfluidic microscopy and digital cytology to create a malignant cell surveillance system which can be used for cancer screening. [G Gopakumar, VK Jagannadh, **SS Gorthi,** & GRKS Subrahmanyam, Framework for Morphometric Classification of Cells in Imaging Flow Cytometry, *Journal of Microscopy*, 2016, 261(3): 307-319.]

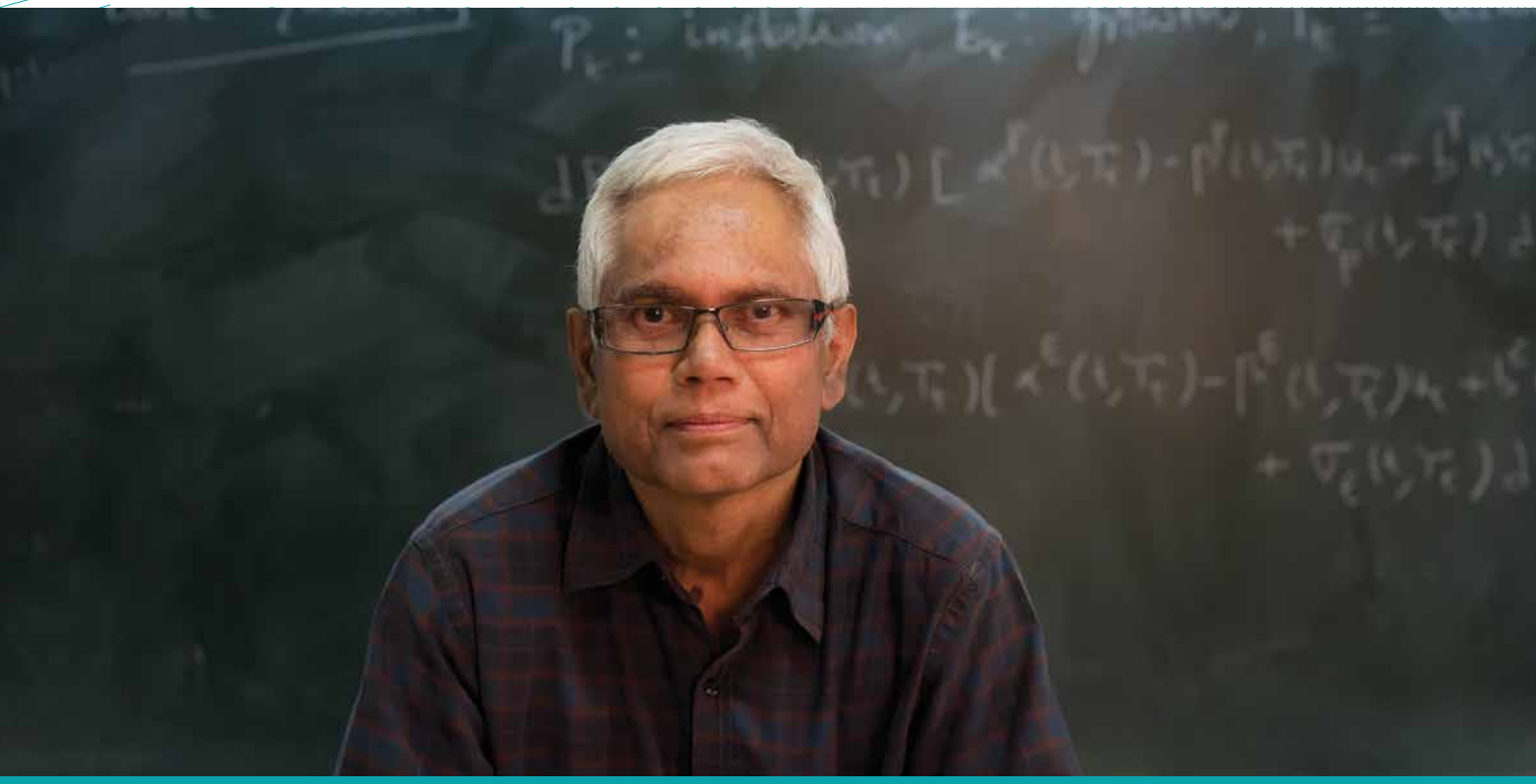
• IISc's new petaflop computer SahasraT is being used by researchers from several disciplines. For instance, astrophysicists from the Department of Physics, using SahastraT, have developed a hydrodynamic 3D model which shows how supernovae coalesce into superbubbles. [N Yadav, D Mukherjee, **P Sharma,** and BB Nath, Supernovae under microscope: how supernovae overlap to form superbubbles, arXiv:1603.00815, 2016]



As an election approaches, most ruling political parties, unsurprisingly, try to stimulate the economy for short-term gains. Elections, therefore, cause an economic pattern known as the political business cycle. This phenomenon is described by models which are typically deterministic – they consider the average value of the inflation in their equations. A more realistic mathematical model has been developed by Mrinal Ghosh and his collaborators, one which considers inflation as having a fluctuating value, given by a stochastic differential equation.*

A more realistic mathematical model of the political business cycle has been developed by Mrinal Ghosh and his collaborators

In this model, besides inflation, the other macroeconomic variable of importance is the unemployment rate. But these two variables are not independent. "Suppose you curb unemployment too much, inflation will go up – because people will have more money. And then the government pays a price for that," says Ghosh. In their model, this is encoded using a "cost" function; and minimizing the cost is the objective.



MRINAL GHOSH

Professor
Department of Mathematics

How to Beat Anti-Incumbency

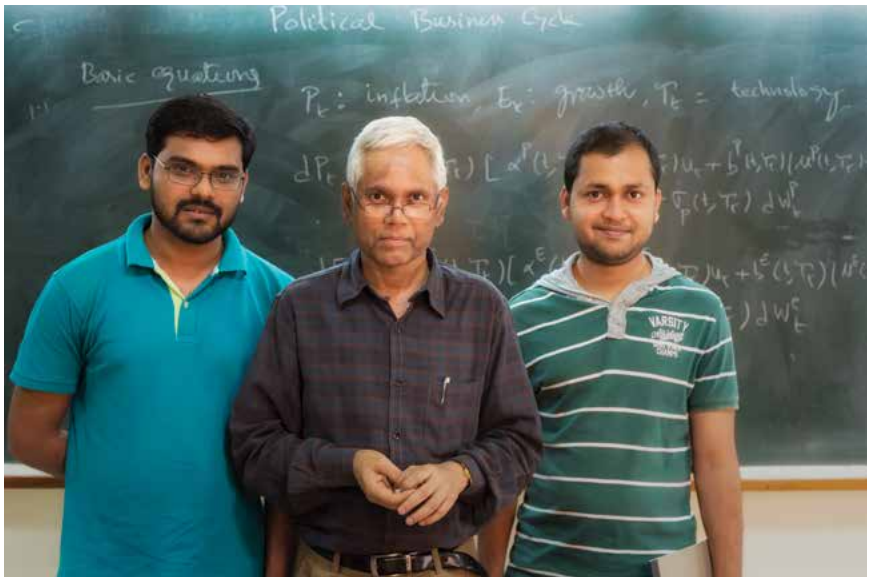
The model can then be analyzed using the techniques of stochastic control theory, which is Ghosh's area of expertise. In the broader field of optimal control theory, the idea is to control a system using feedback in order to optimize its output. In the above model, the unemployment rate is the feedback in the control process.

Working out the implications, Ghosh and collaborators found that controlling the unemployment rate is most crucial if a party is to remain in power. Their model also allows for a special case – dubbed "perfect myopia" – which, as is sometimes the case in the real world, implies that only those policy decisions announced just before elections have any impact in shoring up voter support.

Ghosh has been applying stochastic methods to mathematical finance for about a decade now. But at college, he was more interested in chemistry than mathematics. Until, that is, he started his PhD, in 1984, at the TIFR Bangalore Centre. "I certainly don't regret leaving chemistry to take up mathematics," he says.

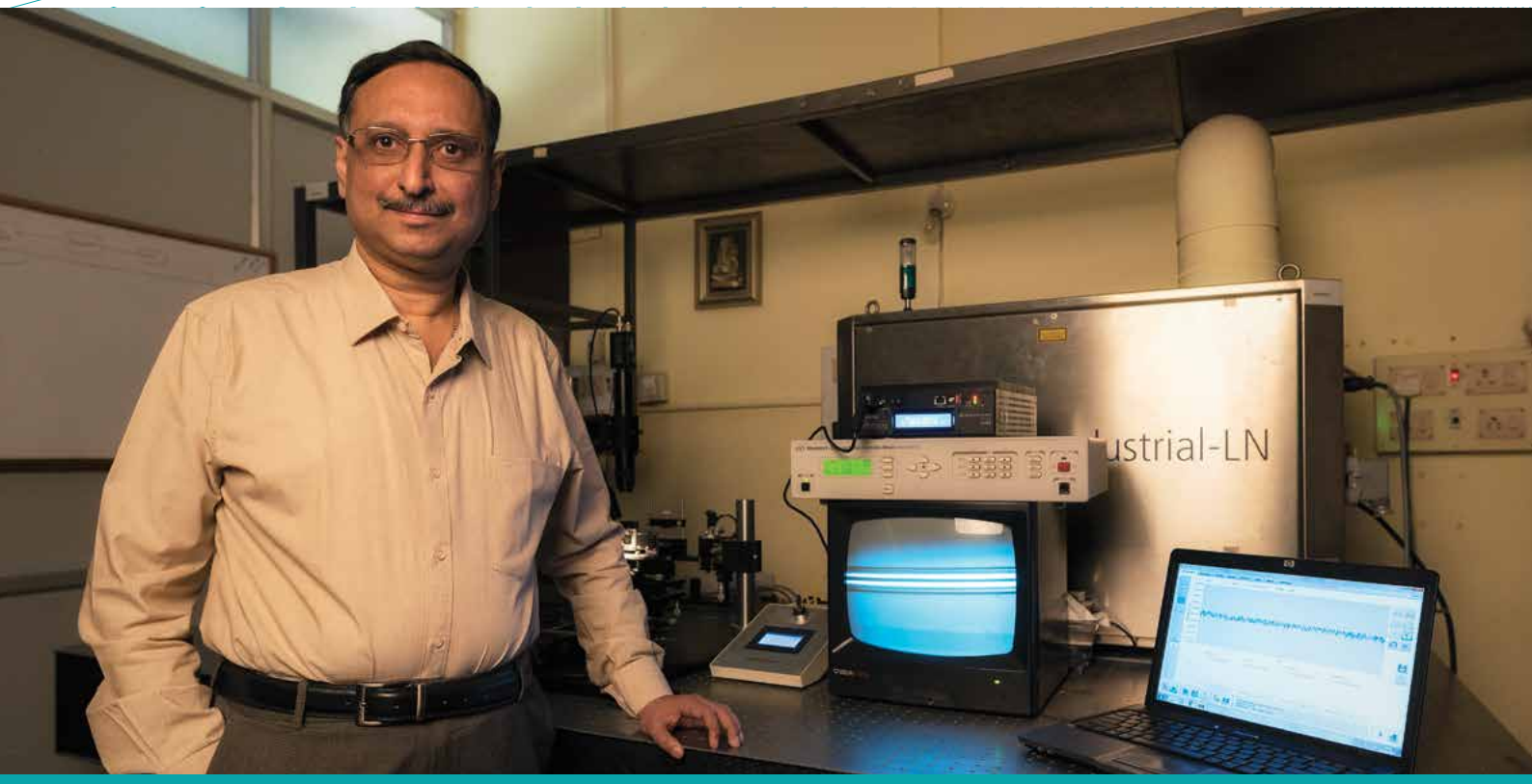
* Gopal K Basak, **Mrinal K Ghosh,** and Diganta Mukherjee. 2016. A mean-reverting stochastic model for the political business cycle, *Stochastic Analysis and Applications*. 34(1):96-116.

Prof. Mrinal Ghosh with his team



Sundarrajan Asokan's team works on a sensor technology known as Fiber Bragg Grating (FBG) which has found a wide range of applications in optical sensing. An FBG consists of an optical fibre core surrounded by a glass cladding. This core is fabricated such that its refractive index varies in a sinusoidal pattern across its length, with a periodicity called the pitch. For a particular pitch, the FBG reflects a specific wavelength of light, while transmitting all the other wavelengths. When the pitch changes – say, in response to an external stimulus like a physical strain or when there is a change in the environment due to a biological or chemical reaction – light of a different wavelength is reflected, which in turn can be accurately measured and calibrated to detect and quantify the external stimulus. This property of the FBG is exploited to make optical sensors which are finding applications in many different fields.

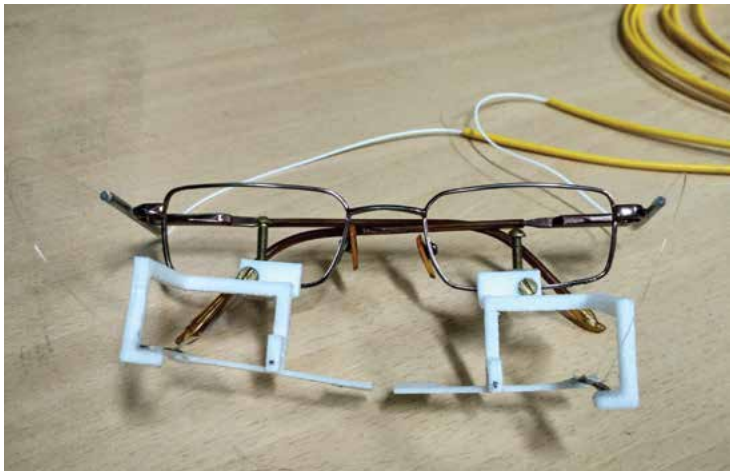
Asokan and his collaborators have developed several innovations based on FBG, aimed at providing solutions to real-world problems such as structural health monitoring of aircrafts, measuring blood pressure and heart rate variability, detecting important bio-markers etc. Recently, in collaboration



SUNDARRAJAN ASOKAN

Professor
Department of Instrumentation and Applied Physics

FBG Devices: Solving Real-World Problems



This wearable device (in white) senses air pressure from patients' exhalation and instantaneously converts it into an audible signal to aid paramedics

with the Department of Electrical Communication Engineering, they have developed an FBG-based device that can help paralyzed patients communicate even if they are unable to speak.* This wearable device senses air pressure from patients' exhalation and instantaneously converts it into an audible signal.

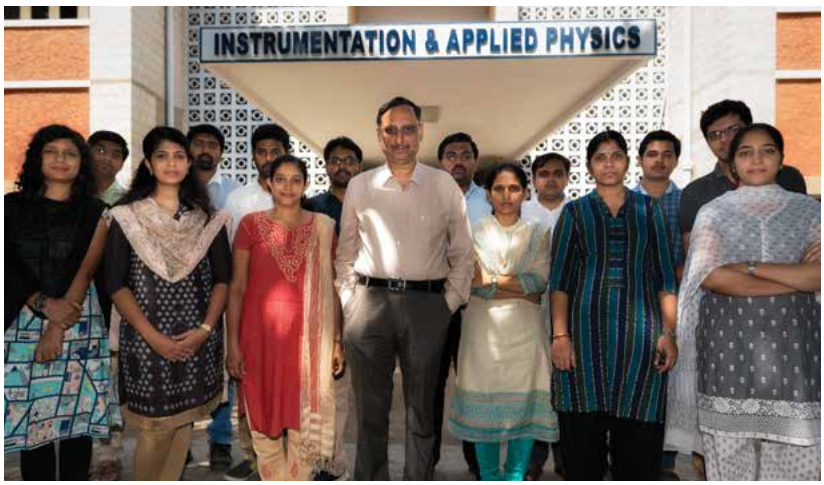
Asokan and his collaborators have developed several innovations based on FBG, aimed at providing solutions to real-world problems

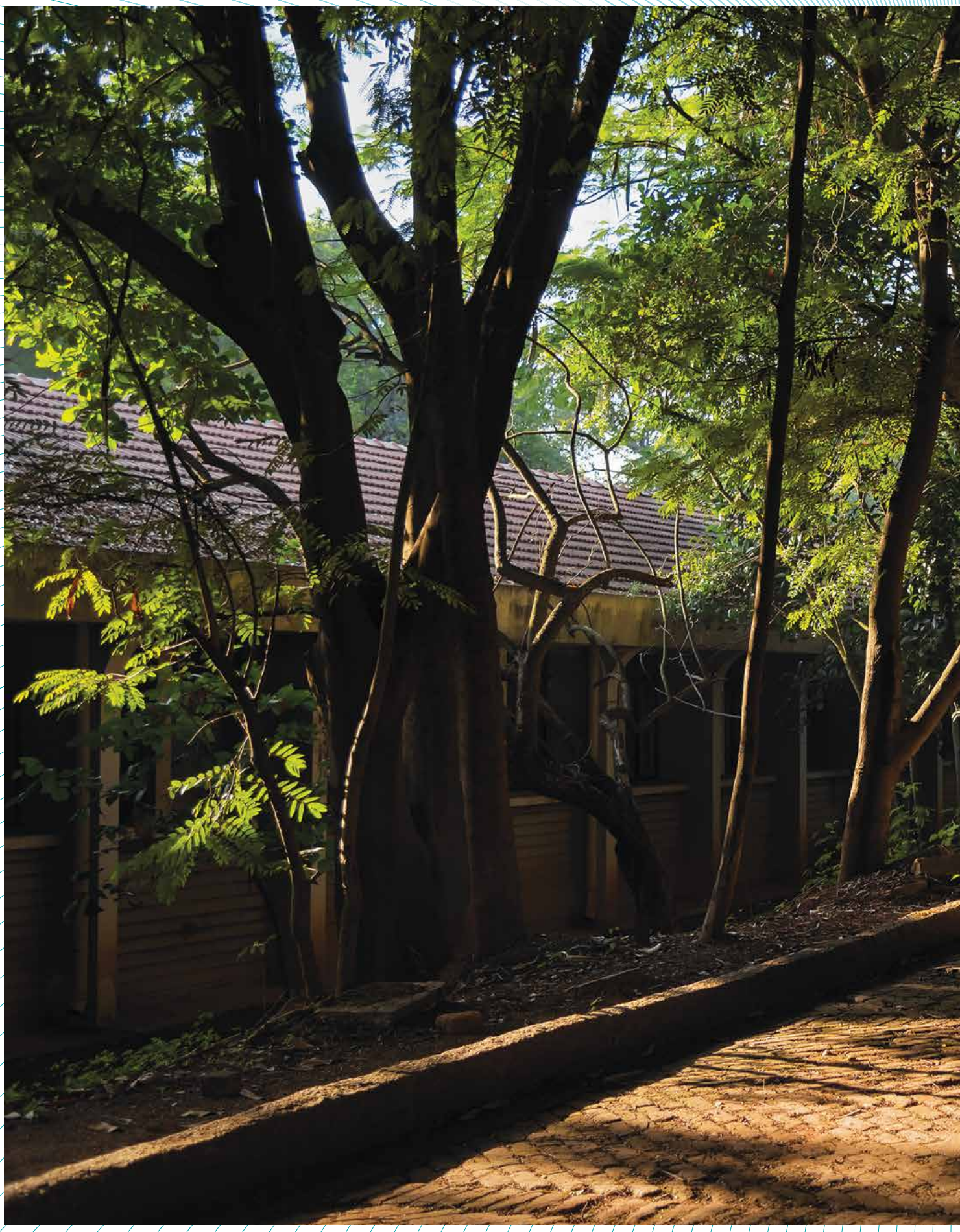
Another focus of Asokan's research is in the area of chalcogenide glasses, primarily made up sulphides, tellurides and selenides. These glasses are transparent to infrared radiation and are used in memory devices and optical amplification applications.

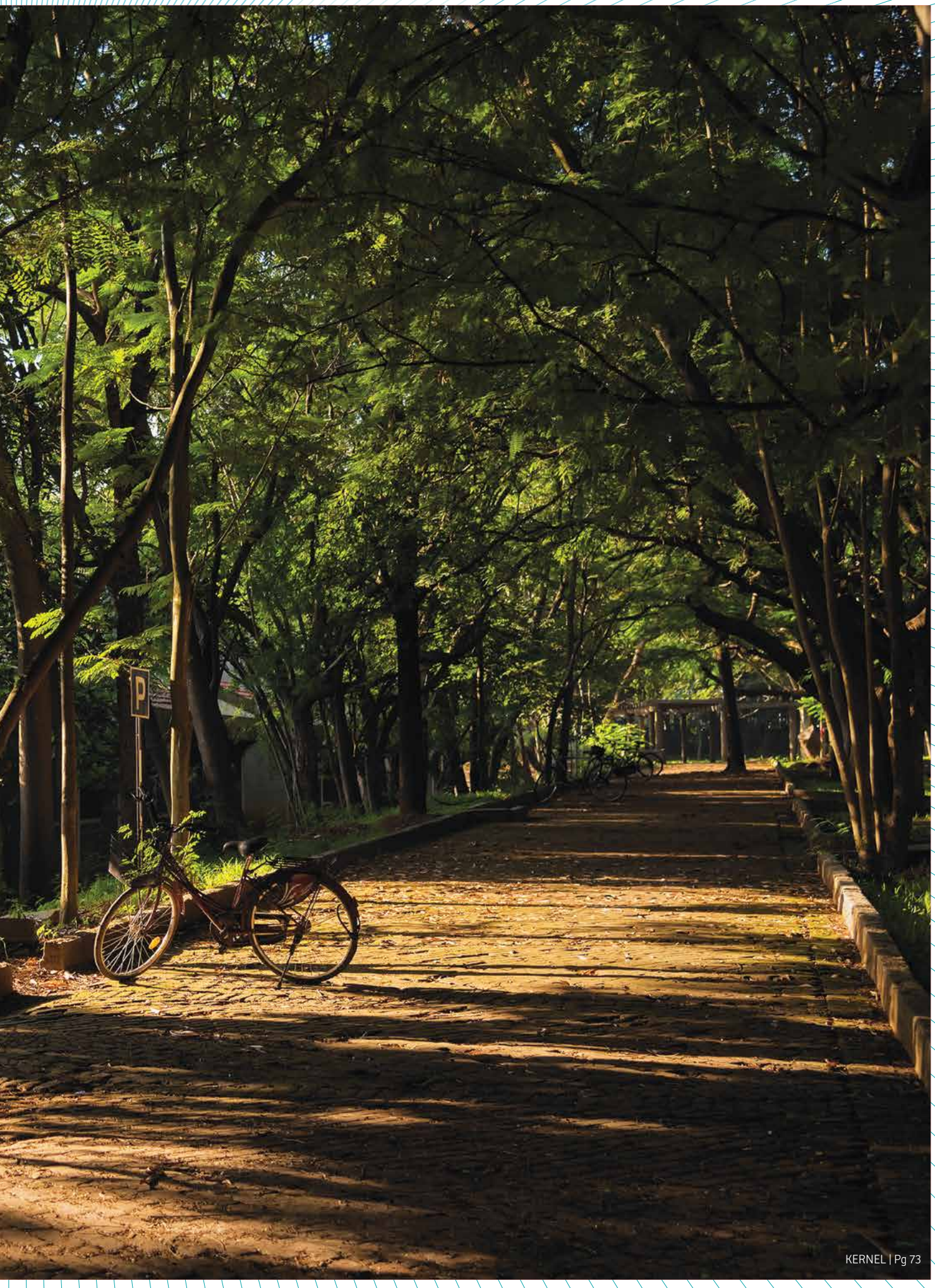
Though Asokan works on areas of physics that have direct applications, he believes in combining applied and basic research. "In fact, while solving a specific problem, a lot of theoretical challenges need to be addressed as well," he explains.

* Srivani Padma, Sharath Umesh, Shweta Pant, Talabattula Srinivas and **Sundarrajan Asokan.** 2016. Fiber Bragg grating sensor-based communication assistance device. *J. Biomed. Opt.* 21(8): 086012

Prof. Sundarrajan Asokan with his team






P

Our Future

Meet the new faculty members who joined IISc in 2015-16 as Assistant Professors

Aravind Penmatsa | **MOLECULAR BIOPHYSICS UNIT**

Sachin Kotak | **DEPARTMENT OF MICROBIOLOGY AND CELL BIOLOGY**

Ramray Bhat | **DEPARTMENT OF MOLECULAR REPRODUCTION, DEVELOPMENT AND GENETICS**

Siddharth Barman | **DEPARTMENT OF COMPUTER SCIENCE AND AUTOMATION**

Sandeepa M Eswarappa | **DEPARTMENT OF BIOCHEMISTRY**

Subhojoy Gupta | **DEPARTMENT OF MATHEMATICS**

Sriram Ganapathy | **DEPARTMENT OF ELECTRICAL ENGINEERING**

Sarasij Das | **DEPARTMENT OF ELECTRICAL ENGINEERING**

Jyothsna Rani Komaragiri | **CENTRE FOR HIGH ENERGY PHYSICS**

Anand Srivastava | **MOLECULAR BIOPHYSICS UNIT**

Rajiv Soundararajan | **DEPARTMENT OF ELECTRICAL COMMUNICATION ENGINEERING**

Vibhor Singh | **DEPARTMENT OF PHYSICS**

Our Future

Ramsharan Rangarajan | DEPARTMENT OF MECHANICAL ENGINEERING

Pradipta Biswas | CENTRE FOR PRODUCT DESIGN AND MANUFACTURING

Manish Arora | CENTRE FOR PRODUCT DESIGN AND MANUFACTURING

Geetharani K | DEPARTMENT OF INORGANIC AND PHYSICAL CHEMISTRY

Siddharth Jhunjhunwala | CENTRE FOR BIOSYSTEMS SCIENCE AND ENGINEERING

Sivaram Ambikasaran | DEPARTMENT OF COMPUTATIONAL AND DATA SCIENCES

Somnath Choudhury | **CENTRE FOR HIGH ENERGY PHYSICS**

Prasad S Hegde | **CENTRE FOR HIGH ENERGY PHYSICS**

Lakshminarayana Rao | **CENTRE FOR SUSTAINABLE TECHNOLOGIES**

Punit Singh | **CENTRE FOR SUSTAINABLE TECHNOLOGIES**

Kaushik Basu | **DEPARTMENT OF ELECTRICAL ENGINEERING**

Subho Dasgupta | **DEPARTMENT OF MATERIALS ENGINEERING**

SID: *Translating Research into Products*

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

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

SID, established in 1991, was the first ever research park in the country. A decade later though, faculty trying to commercialize their research projects hit a roadblock – they had to relinquish their position at IISc before they could be involved in a startup. In response, SID pioneered a faculty entrepreneurship framework. "This model was later replicated in other government-funded institutions," says Swami Manohar. This initiative, believes Manohar, who went on to co-found Strand Life Sciences and PicoPeta Simputers, is SID's unique and foremost contribution.

Aspiring entrepreneurs, from IISc or elsewhere, can approach the Entrepreneurship Cell (E-Cell), founded under the auspices of SID, which can help them analyze if an idea can be taken to the market

through a startup. Once a proposal gets accepted, SID offers entrepreneurs the space to operate for two years, assistance with intellectual properties, seed funding, and access to advice and mentoring from alumni and domain experts with experience in running S&T companies. SID also helps faculty partner with industry and monetise the Institute's intellectual properties through the Office of Intellectual Property & Technology Licensing (IPTeL).

Once a proposal gets accepted, SID offers entrepreneurs the space to operate for two years, assistance with intellectual properties, seed funding, and access to advice and mentoring from alumni and domain experts with experience in running S&T companies

These proactive measures have led to a flurry of companies, rooted in cutting-edge research, being incubated at SID in recent years. The strict criteria for evaluation—"deep science and technology (S&T)" based offerings and the potential for strong societal impact—ensure that companies offering mundane products are kept out of SID's ambit.

Looking ahead, B Gurumoorthy, Chief Executive of SID (who is also a professor at the Department of Mechanical Engineering and the Centre for Product Design & Manufacturing), says that getting faculty to engage more with industry and improving IISc's record of translating ideas into products are a priority. "We want companies to engage more with our students through internships and projects in a structured manner," he says. SID is also bidding for several avenues of funding support, including government grants and corporate funds, to create a chest that can help deserving companies requiring a longer incubation time succeed.

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


NO PARKING

The Rise of Startups

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

The history of IISc alumni founding successful companies stretches back at least 50 years. In particular, graduates from IISc's B.E. programme in 1970s were prolific, many of them even becoming serial entrepreneurs. However, these companies received no direct support from the Institute. Neither were they startups, in the sense that the word is used today. The startup scene in IISc really took off only at the turn of the millennium, owing to the efforts of the Society for Innovation and Development (SID), established in 1991. Since 2000, SID has incubated around 18 startups. The startups that have emerged independently of SID are much larger in number. Here is a closer look at some of the startups established this past year.

***Azooka Life Sciences** (Incubated by SID)*

Azooka aims to market safe RNA/DNA stains for application in genomics. It recently developed a food grade nucleic acid gel stain called tintorang. The stains currently available in the market are carcinogenic. Azooka was founded by Fathima Benazir who pursued her idea as a postdoctoral fellow in the lab of MRN Murthy (Professor, Department of Molecular Biophysics).

***PathShodh** (Incubated by SID)*

PathShodh, a company started by Navakanta Bhat (Professor, Centre for Nano Science and Engineering) and his student Vinay Kumar, has developed a handheld diagnostic device for diabetics. The device is capable of performing eight tests using just a drop of blood or urine. The results of the tests flash on a digital monitor in less than two minutes.

***Astrome Technologies** (Incubated by SID)*

Astrome is a startup which will provide high speed internet streamed directly from space through satellites. It seeks to develop an ecosystem that can make quality education, healthcare and government services more accessible over internet. Astrome was established by Neha Satak and Prasad HL Bhat, an alumnus of the Department of Computer Science and Automation.

BendFlex

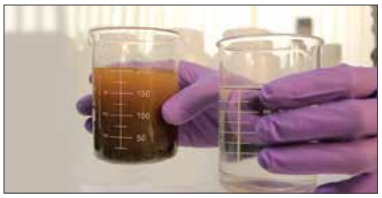
The startup specialises in developing biomedical devices using compliant mechanisms. BendFlex, whose current products include a bioreactor and a compliant mechanism kit, was founded by Ramnath Babu and Santosh Bhargav, former students of GK Ananthasuresh, the Chair of the Centre for BioSystems Science and Engineering.

SciDogma Research

The company is developing a portable, automated microscope for malaria detection. The idea was conceived by Satya Tapas, while he was a postdoctoral researcher in MRN Murthy's lab. The company has won several prestigious awards including the DST-Lockheed Martin Innovation Award.

Openwater.in

Openwater.in's offering is a new water purifying system, which can effectively convert sewage into potable water. Created by Sanjiv Sambandan (Assistant Professor, Department of Instrumentation and Applied Physics), Karthik Raghunandan and his team, the device uses field effect technology, thus removing the necessity for any chemicals or membranes.



IPTeL: *Protecting Ideas and Innovations*

In recent years, IISc has been motivating its researchers to safeguard ideas and innovations conceived in their laboratories

Intellectual property (IP) – fruits of the human creativity, including inventions, works of art and literature, logos and labels used in commerce – are protected either as patents, trademarks, industrial designs, or copyrights. In recent years, IISc, India's premier science and technology institute, too has recognized the need to safeguard the ideas and innovations conceived in its research laboratories. It was this recognition that motivated the Institute to set up the IP Cell in 2004. The Cell was recently rechristened as the Office of Intellectual Property & Technology Licensing (IPTeL). "IPTeL's mandate is to identify innovation and facilitate IP protection, as well as the management, prosecution and commercial utilization of IP through technology transfer", says its Chairperson, Parameshwar Iyer.

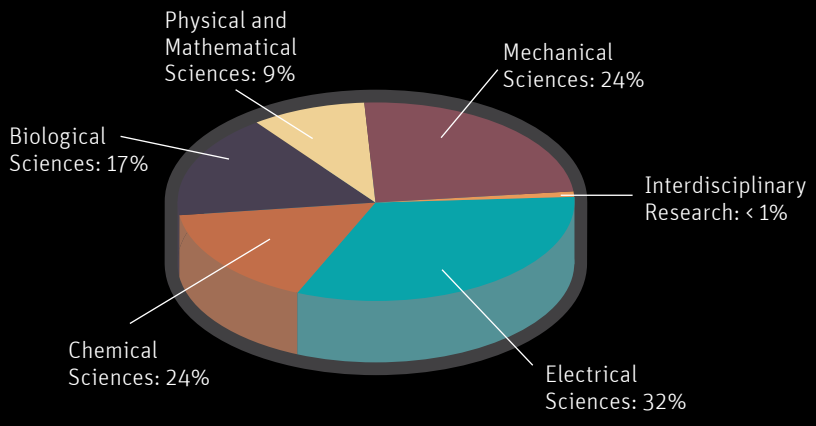
Since the establishment of this office, IISc has seen a steady rise in the number of patents filed each year. So far, 604 patents have been filed, out of which 137 patents have been granted and are in force, 416 are under prosecution, while 51 have lapsed. Not surprisingly, the engineering departments on campus lead the race when it comes to filing patents.

Since the establishment of this office, IISc has seen a steady rise in the number of patents filed each year

Researchers at IISc can choose to file their patents in India or abroad. Of the 604 patents filed, 370 have been filed in India, as compared to 234 in foreign countries. In recent years, the proportion of Indian patents has increased. This is partly because of limited availability of resources. Equally importantly, researchers are realizing that it makes sense to file a patent in the country where it is most likely to be useful. "A patent must be filed in that country where its application is most relevant and where there is more market value", explains Sanjiv Sambandan (Assistant Professor, Department of Instrumentation and Applied Physics), who co-invented a water purification technique capable of converting sewage to drinking water.

In addition to facilitating patenting activities, IPTeL also works towards enhancing industry-IISc collaboration for improved technology transfer via licencing. Licensing patents can pave the way for additional revenue to flow into IISc. The nascent IPTeL generated a revenue of Rs. 70 lakhs in 2015. "IPR can help the research-oriented institutions to generate appropriate revenue for doing further research," adds Santanu Bhattacharya, a professor at the Department of Organic Chemistry, and the co-inventor of an optical nanosensor capable of detecting the infestation of a fruit pest.

A Division-wise breakup of IISc patents



CSSP: *Facilitating Research*

The smooth conduct of research at IISc requires efficient management of research funds and effective coordination with the external agencies that provide them

The Centre for Sponsored Schemes and Projects (CSSP) performs an important task for the Institute – providing administrative support to its faculty in executing research projects. Activities at CSSP cover managing finance, accounts, purchase, and coordinating with faculty and external sponsoring agencies. Most of the research contributions from the Institute come from research and development sponsored by over a hundred external agencies. The primary sponsors on the national front include organizations that come under the Government of India, such as the Department of Science and Technology, Department of Biotechnology, Indian Space Research Organization, Council of Scientific and Industrial Research, Department of Atomic Energy, Ministry of Information Technology, Office of the Principal Scientific Advisor and Ministry of New and Renewable Energy. Research is also funded by international sponsors like Wellcome Trust, IBM, Asian Office of Aerospace Research and Development, Indo-French Centre for the Promotion of Advanced Research, Korea Institute of Science and Technology, the European Union, The Swiss Agency for Development and Cooperation and UK-India Education and Research Initiative.

In 2015-16, of the total of 877 projects with an outlay of Rs. 1087.48 crores and an annual cash flow of Rs. 245 crores, the science departments received 449 projects with a total outlay of Rs. 420.65 crores, while the engineering departments received 428 projects with a total outlay of Rs. 666.83 crores.

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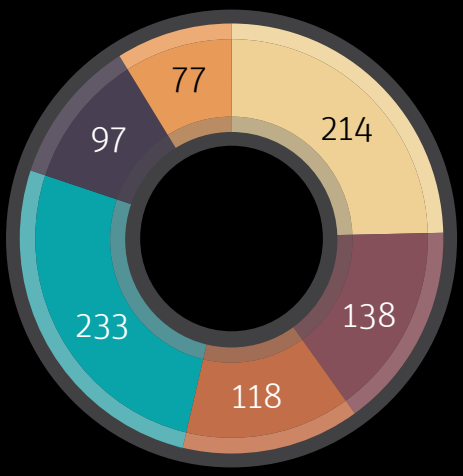
The industrial relevance of projects, and participation of industries in research and its funding, have become more prominent in recent years. Some of these projects have industry involvement right from the beginning whereas others are partially funded with an agreement on transfer of technology when the research matures. Examples of industry grants for research projects are: a grant of Rs. 86.73 lakhs to HS Jamadagni of the Department of Electronic Systems Engineering for his project *RFID-*

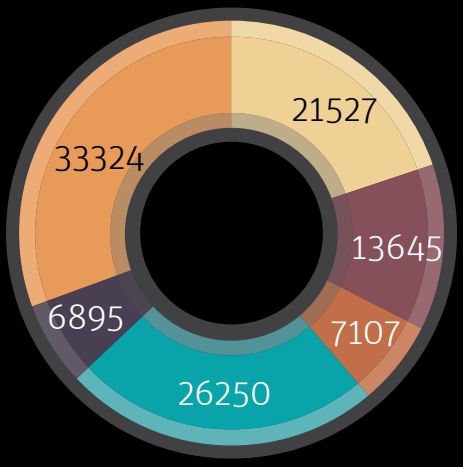
based Aircraft Inventory System (RAIS) provided by the Boeing Company; a grant of Rs. 17 lakhs to PP Talukdar of the Department of Computational and Data Sciences for his project *Predicate Discovery from Instructional Documents* provided by Robert Bosch India; grant of Rs 40.91 lakhs to U Ramamurthy of the Department of Materials Engineering for his project *Smart Materials: Development of High-Temperature Shape Memory Alloys for Environmentally Friendly Aero Engines* provided by Rolls Royce.

Number of Funded Research Projects in 2015-16



- Biological Sciences
- Chemical Sciences
- Electrical Sciences
- Mechanical Sciences
- Interdisciplinary Research
- Physical and Mathematical Sciences

Outlay (Rs. in Lakhs) for 2015-16



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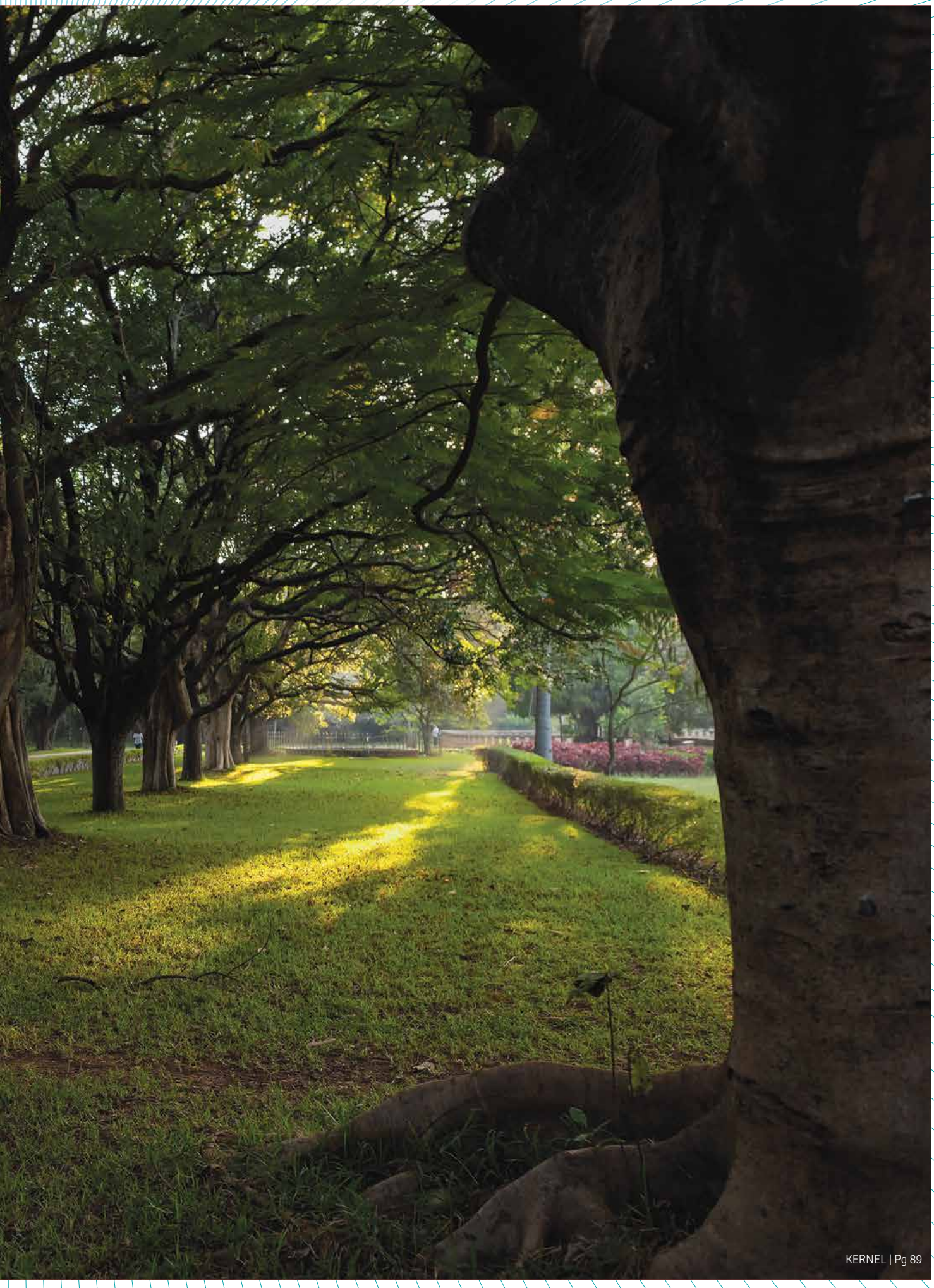

Skill Development Centre: Empowering Society

IISc, with support from Hindustan Aeronautics Limited (HAL), will establish the HAL-IISc Skill Development Centre at its Extension Projects campus in Challakere in Chitradurga district. The Bhoomi Pooja for the construction of the Centre was held on 27 October, 2016, in the presence of Anurag Kumar, Director, IISc, and T Suvarna Raju, Chairman and Managing Director, HAL. Also present on the occasion were senior HAL officials and many faculty members from the Institute.

The concept of a Skill Development Centre has been in the pipeline for nearly eight years at IISc. This socially important idea received further impetus when the Government of India recently prioritized skill development as part of its 'Skill India' initiative. However, in order for this vision to be realized, IISc needed a partner with a similar ethos. As an organization already committed to social projects of national interest, HAL came forward to support the infrastructure for this Centre under their Corporate Social Responsibility (CSR) initiatives.

Construction of the Skill Development Centre is scheduled to be completed in two years, and training activities are expected to begin by March 2019. The goal is to create a model facility that would provide skill development programmes for various beneficiaries – from unemployed youth and local community

As an organization already committed to social projects of national interest, HAL came forward to support the infrastructure for the Skill Development Centre

members to advanced engineering professionals. "This [the Skill Development Centre] will go a long way in recognizing and honing skills and providing opportunities for youth at various levels in line with the Government's 'Skill India' initiative," said Raju.

HAL has been supporting various community development activities over the years under CSR in areas such as infrastructure development, health, rural sports, women empowerment, education, skill development, drinking water, establishment of wind power project & solar power projects in schools, etc.

An architect's rendition of the proposed Skill Development Centre (left) and the hostels (right)

IISc's New Campus

In 2010, IISc began the development of its Extension Projects campus at Challakere. Many activities have been initiated at the 1500-acre campus, including the construction of the boundary wall and a peripheral road. The new campus has also seen the establishment of a climate research laboratory, a solar power research field, and a centre for low-carbon technologies based on bioenergy.

At Challakere, IISc has also been running the Talent Development Centre (TDC) for the past few years, where science and math teachers from government high schools and colleges are trained using hands-on experiments. More than 9000 teachers have been trained at TDC so far.

Collaborations:
Research Pacts with Tech Giants

A closer look at some of the steps IISc took this past year to broaden its engagement with the technology industry

During 2015-16, IISc signed several Memoranda of Understanding (MoUs) with companies specializing in technology and services. The initiatives are expected to boost research and development in areas that directly impact the quality of lives of people in India.

The first MoU was signed in October 2015 with **Bosch India,** a leading supplier of technology and services. The MoUs were exchanged in a ceremony at the Rashtrapati Bhavan in Delhi in the presence of the President of India, Shri Pranab Mukherjee.

"Based on this MoU we intend to develop solutions that address key India-centric requirements," Steffen Berns, President of Bosch Group in India, said in a press release. "Innovation has always been a special strength of Bosch. This partnership between industry and academia further enforces our ties with the IISc and underlines our commitment towards local innovations, according to our slogan 'Invented for life'. We expect to see positive results as we collaborate in research on areas of strategic interest, such as mobility, healthcare, energy and water," he added.

Over the past decade, IISc has worked closely with GE. This relationship was formalized when it entered into an agreement with **GE India Technology Centre** in December 2015.

"In India, we have a strategic vision to build long-term relations with the premier institutes and IISc is one of the top institutes we want to collaborate with," said D Umamaheshwar, Executive Chief Consulting Engineer at GE Aviation. "We have chosen IISc because of its reputation, talent, and high-end research

capabilities." IISc and GE India Technology Centre have very similar multidisciplinary research interests, he added.

As part of the agreement, several high-impact projects in identified areas will soon be launched under the aegis of IISc's Society for Innovation and Development (SID). Many of these areas – such as big data analytics and Industrial Internet – represent fields that GE is currently making strides and heavily investing in, apart from its core engineering focus, according to Umamaheshwar. "The talent and research infrastructure at IISc will be a great value-addition to GE, while IISc researchers will have an opportunity to leverage GE's expertise and industry insights," he said. IISc and GE also signed an agreement to implement Corporate Social Responsibility projects over the next three years.

The initiatives are expected to boost research and development in areas that directly impact the quality of lives of people in India

In March 2016, IISc signed an agreement with the **Tata Consultancy Services (TCS).** The collaborative programme will focus on setting up an IISc-TCS Innovation Lab at SID's Innovation Centre. Anurag Kumar, Director of IISc, and N Chandrasekaran, CEO and MD, TCS, are the co-chairs of the Joint Programme Committee. The focus of the lab will be Smart-X (where X represents Energy, Water, Transportation, Healthcare, Cities, etc.)

The enabling technologies and foundations would include Internet of Things, Big Data, devices, sensors, software, and materials, with emphasis on prototyping, product development and translation. The programme will also support a number of collaborative research projects spanning several areas in electrical, mechanical and interdisciplinary sciences. These collaborative projects will fall in three groups: fundamental science and engineering innovations required for the lab; futuristic, disruptive new technologies; and projects undertaken by third party organizations with support from the collaborative IISc-TCS ecosystem.

Anurag Kumar believes that these agreements will strengthen IISc's ability to play its part as an academic beacon in Bangalore, considered India's "Silicon Valley". Emphasizing the breadth of IISc's engagement with these technology companies, he said, "The MoUs cover a range of interactions such as participation in academic programmes, contract research, and joint research leading to co-innovation." He felt that the "agreement with General Electric will, in fact, open up the possibility of expanding our international research collaboration space as well."

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