DST@ 1971-2021

विज्ञान एवं प्रौद्योगिकी विभाग
DEPARTMENT OF SCIENCE & TECHNOLOGY

75 UNDER 50

SCIENTISTS SHAPING TODAY'S INDIA

Published by

VIGYAN PRASAR
1st Floor, New S&T Block 2
Technology Bhavan
New Mehrauli Road, New Delhi - 110 016
Phone: +91-11-26 511 192, 26 511 193
E-mail: *info@vigyanprasar.gov.in*
Website: *www.vigyanprasar.gov.in*

75Under50
Scientists Shaping Today's India

Editor-in-Chief
Nakul Parashar

Editor
Nimish Kapoor

Editorial and Production Coordination
Nandita Bhardwaj

Content and Production Assistance
Divyanshu Gupta

Concept & Design
PealiDezine

ISBN
978-81-7480-376-4

75 UNDER 50

SCIENTISTS SHAPING TODAY'S INDIA

Contents

डॉ0 जितेन्द्र सिंह
राज्य मंत्री (स्वतंत्र प्रभार),
विज्ञान एवं प्रौधोगिकी मंत्रालय;
राज्य मंत्री (स्वतंत्र प्रभार) पृथ्वी विज्ञान मंत्रालय;
राज्य मंत्री, प्रधान मंत्री कार्यालय;
राज्य मंत्री कार्मिक, लोक शिकायत एवं पेंशन मंत्रालय;
राज्य मंत्री परमाणु ऊर्जा विभाग तथा
राज्य मंत्री अंतरिक्ष विभाग
भारत सरकार

Dr. JITENDRA SINGH
Minister of State (Independent Charge)
of the Ministry of Science and Technology;
Minister of State (Independent Charge)
of the Ministry of Earth Sciences;
Minister of State in the Prime Minister's Office;
Minister of State in the Ministry of Personnel,
Public Grievances and Pensions;
Minister of State in the Department of Atomic Energy and
Minister of State in the Department of Space
Government of India

Message

Indian scientific community is the country's key strength. Their role in holding India's position on the global science map steadfastly needs to be acknowledged. Their successes, failures and indefatigable zeal need to be celebrated. The publication 75 under 50 Scientists Shaping Today's India recognizes the talent and achievement of 75 such men and women under the age of 50 shaping today's India.

The scientists profiled in this compendium play an important part in the life of a nation that has celebrated 75 years of Independence, thereby, bringing to us a sense of where we are headed. As the department has played a nodal role in promoting and nurturing S&T activities in the country since 1971, the featured scientists are affiliated to it in different capacities. The scientists featured in the publication are from a range as diverse as physics, material sciences, atmospheric sciences, life science to space and Nano science.

The profile of each scientist highlights their ground breaking work, gives an idea of what is happening in their field, as well as captures their trials and tribulations, successes and future course.

The publication is also a testament to passion, hard work and a belief in one's convictions. A journey in learning and relearning!

(Dr. Jitendra Singh)
MBBS (Stanley, Chennai)
MD Medicine, Fellowship (AIIMS, NDL)
MNAMS Diabetes & Endocrinology

Anusandhan Bhawan, 2, Rafi Marg
New Delhi-110001
Tel. : 011-23316766, 23714230,
Fax. : 011-23316745

South Block, New Delhi-110011
Tel. : 011-23010191 Fax : 011-23017931
North Block, New Delhi-110001
Tel. : 011-23092475 Fax : 011-23092716

सत्यमेव जयते

डॉ. एस. चंद्रशेखर
Dr. S. Chandrasekhar

सचिव
भारत सरकार
विज्ञान एवं प्रौद्योगिकी मंत्रालय
विज्ञान एवं प्रौद्योगिकी विभाग
Secretary
Government Of India
Ministry of Science and Technology
Department of Science and Technology

23rd Februrary, 2022

MESSAGE

It gives me immense pleasure to bring to you the publication "75 under 50 Scientists Shaping Today's India" in the series commemorating the Department of Science & Technology's Golden Jubilee Year.

Indian science has a rich history. We have witnessed several milestones that have been achieved by Indian scientists since independence. The Department of Science & Technology, since its inception in May 1971, has played a key role in nurturing, nourishing and supporting scientific endeavour in the country by setting up instititons and research facilities, providing opportunities for independent research or training, or through financial support.

The book highlights the exemplary work being done in Indian Science, as well as profiles of some of the Indian Scientists from the immense pool of talent, playing a vital role in building India's future. These torch-bearrers strengthen India's position as one of the top-ranking countries in the field of basic research. The role of these scientists is even more fundamental in the wake of the recent developments and the new demands being placed on science.

Above all, the publication aims to serve as an inspiration to all scientific fraternity, inculcate scientific temperament in others, and excite some to think innovatively.

(S. Chandrasekhar)

Technology Bhavan, New Mehrauli Road, New Delhi - 110016
Tel: 0091 11 26511439 / 26510068 | Fax: 00 91 11 26863847 | e-mail: dstsec@nic.in | website: www.dst.gov.in

A

DR AA KULKARNI
DR ABHIJIT MUKHERJEE
PROF. AMALENDU KRISHNA
PROF. AMIT DUTT
DR AMRITANSHU PRASAD
DR ANINDA SINHA
PROF. ANSHUMAN KUMAR
PROF. ANUP BISWAS
PROF. ANURAG AGRAWAL
PROF. APOORVA KHARE
DR AVINASH KUMAR AGARWAL

DR AA KULKARNI

Taking a Giant Stride Forward

Dr Amol A Kulkarni was born at Ambajogai, in Maharashtra. His parents, Arvind N Kulkarni and Saroja A Kulkarni, were teachers by profession. Years of schooling and junior college at Lal Bahadur Shastri Vidyalaya, in Udgir, were transformative owing to his passionate teachers. He recalls, during his school days, the state camp organized by NTSE (National Talent Search Examination) was an eye-opener. At the camp, he realized he must focus and work very hard. He also decided to become an engineer.

Dr Kulkarni joined the Department of Chemical Engineering at ICT, Mumbai, the first turning point in his life. This catalyzed him to further firm-up his mind on making research a career option. Hence, he completed his PhD from the same institute, in 2003, on the design of multiphase reactors followed by a post-doctorate from the Max Planck Institute for Dynamics of Complex Technical Systems (Magdeburg, Germany) as a Humboldt Fellow.

After completing his studies he joined the CSIR-National Chemical Laboratory (NCL). For the last 16 years, he has been working at the laboratory to improve the chemical processes in the Indian chemical industry. Combining insights from fluid dynamics and chemical reaction engineering, he has helped develop various design options, the simplest being a pinched tube flow reactor and a 3D-flow reactor.

Another important research Amol accomplished was development of scalable processes for various materials like mesoporous silica, copper oxide nanoparticles, silver nanoparticles, and silver nanowires. This has helped the Indian industry to enter this domain.

> **“Trust and give credit to everyone who works with you. It brings positivity and it makes every individual double their performance.”**

In the early part of his research at NCL, his team was planning to import a few micro-reactors as those were not available in India at that time. Economically unviable, this catalyzed his team to develop equally effective substitutes without compromising on the performance. To date over 100 industries have been using the flow reactors designed by CSIR-NCL, which are now licensed to two Indian industries.

One of the interesting aspects of his work has been to explore Gas-Liquid/Liquid-Liquid interfaces that are diffusive and reactive. He will continue to investigate this complex area of reactive interfaces as not many complexities are easily measurable and he is developing methods to achieve real-time measurement of certain properties

Receiving the VASVIK Award in Chemical Sciences & Technology, Mumbai, 2016

AWARDS

- Shanti Swarup Bhatnagar Award (2020)
- Dr AV Rama Rao Chair Professor, CSIR (2020)
- CPILA-Hamid Process of the Year Award (2019)
- Prof. CV Sheshadri Distinguished Memorial Lecture, IIT-Kanpur (2017)
- VASVIK Award for Chemical Sciences & Technology (2016)
- Swarnajayanti Fellowship (2015)

PUBLICATIONS

- 'Scalable, sustainable and catalyst free continuous flow ozonolysis of fatty acids'. *Green Chemistry* (2021).
- 'Heterogeneous Nucleation in Citrate Synthesis of AgNPs: Effect of Mixing and Solvation Dynamics'. *Chemical Engineering Journal* (2020).
- 'Continuous flow solvent free organic synthesis involving solids (reactants/products) using screw reactor'. *Green Chemistry* (2019).
- 'Pinched tube flow reactor: hydrodynamics and suitability for exothermic multiphase reactions'. *AIChE Journal* (2017).

Clockwise: Receiving the CSIR Young Scientist Award in 2011

Receiving the Dr RA Mashelkar Endowment's Scientist of the Year Award at National Chemical Laboratory in 2011

Receiving the OPPI Young Scientist Award in Mumbai in 2015

Prof. Kulkarni with his parents

With Prof. Klavs Jensen and Prof. Yoshida at Nancy France, two stalwarts in the field of microreactors, in 2014

Demonstrating the silver nanowires continuous technology to Dr S Mande, DG-CSIR in January 2020

Inset: Receiving the INAE Young Engineer Award in 2009 at IGCAR (Kalpakkam)

and phenomena that happen in a time scale of few milliseconds and over an area as small as 1 sqmm. He believes that along with his students he can understand the complexities of such systems.

A team player and a strong believer in collaboration, he thinks our academic and R&D institutes are fully equipped to work with our industries for a better tomorrow. A long-term plan must be drawn to achieve an impact of the investments made in the public-funded organizations on the Indian industries in almost every area. Among his publications, he specifically likes to draw attention to a recent paper on green chemistry where along with two of his students he showed how to perform 12 different kinds of reactions in an almost solvent-free manner yet in continuous mode. This is important when in India we import almost 65 per cent of our solvents, which are neither reactants nor find a place in the final product.

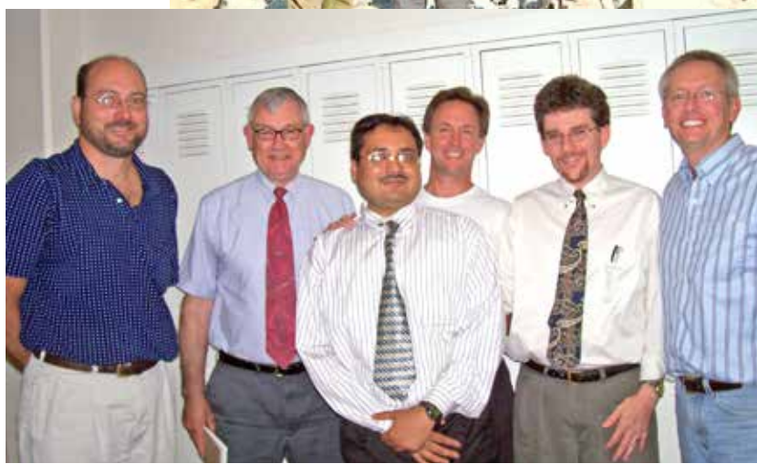
Focusing more on understanding the rate-controlling phenomena in reactions and processes in chemicals, materials, catalysts and biologics to develop highly efficient continuous processes will be his plan for the next few years. In general, the driving force for technology dissemination is the demand from the market/industry and he aims to retain this driving force by working in cutting-edge areas that can help generate jobs for the future. Dr Kulkarni also wants to explore the process-control aspects to understand the relevance of shape-controlled properties in the synthesis of functional nanomaterials. He feels that it will be fun to see how small changes in synthesis protocols can disrupt the changes at nanometer length scales and affect the properties of such materials.

Fortunate to be mentored by Prof. JB Joshi (UDCT, now ICT), Prof. Achim Kienle (MPI-Magdeburg), Late Dr BD Kulkarni (NCL) and Dr VV Ranade (NCL) and Prof. Klavs Jensen (MIT), he acknowledges the hard work of his students in his research work. He often sees that students have enormous energy and passion; it is just that we need to direct their energy in the right manner.

His interests are wide-ranging. At home he enjoys spending time with his family, watching TV serials or cooking shows, rustling up his favourite curries and pastas. He draws inspiration from stories of freedom fighters, social workers, scientists who have impacted our lives. He also likes to listen to TED talks and reading recent issues of *Harvard Business Review*. •

DR ABHIJIT MUKHERJEE

Leading by Example



Trained in classical hydrogeology and equipped with state-of-the-art analytical and numerical techniques, Dr Abhijit Mukherjee has always been keen to be involved in research that would benefit society. He has done extensive research on the availability and pollution of groundwater-sourced drinking water across the globe, with research sites across South Asia, North and South America and China. However, Dr Mukherjee is most well-regarded for his studies in delineating safe and sustainable groundwater-sourced drinking water availability across India.

Abhijit was born on 23 February in 1976 in Kolkata, India. His father, Barindra Lal Mukherjee has served as a Government mechanical engineer and his mother Kajali Mukherjee is a homemaker. Mukherjee did his BSc (Honours) in Geology in 1997 from Asutosh College, University of Calcutta. While pursuing his MSc in Geology from the University of Calcutta (1997-1999), Abhijit got simultaneously enrolled for a professional diploma in network-centric software engineering, which he completed in 2001.

In 2001, Abhijit travelled to USA for his MS (2001-2003) to join the University of Kentucky, in Lexington, Kentucky. He completed his PhD in 2006 in geology (hydrogeology) under the supervision of Prof. Alan Fryar. His dissertation research earned him the Best Graduate Research Award in 2004 from the Geological Society of America (GSA). Subsequently, Mukherjee got selected for the prestigious Earth Institute Fellowship of the Columbia University; however, he decided to join Prof. Bridget Scanlon at the Bureau of Economic Geology, Jackson School of Geosciences of the University of Texas at Austin for a Postdoctoral Fellowship (2006-2008). Between 2008 and 2010, he served as the Physical Hydrogeologist at the Alberta Geological Survey, Government of Alberta, Edmonton, Canada, where he was mentored by Prof. Jozef Tòth at the University of Alberta, regarded as the father of modern hydrogeology.

> **“Success lies in not being afraid of failures, rather using them as learning lessons.”**

In 2010, Dr Mukherjee returned to India to join the Indian Institute of Technology (IIT) Kharagpur, where he presently serves as an associate professor at the Department of Geology and Geophysics and School of Environmental Science and Engineering.

Dr Mukherjee has worked extensively to understand the decadal-scale groundwater quantity and quality changes over India, groundwater-seawater interactions at the Bay of Bengal, climate change impacts in the Sunderbans, and groundwater contamination (arsenic, nitrate, pesticides) in the Indus-Ganges-Brahmaputra river basins of India. Additionally, Dr Mukherjee has led one of the first urban geoscientific studies of India to understand the resource and resilience of future Indian cities (pilot study at Varanasi). The work involves subsurface geo-exploration along with studying the sustainability of the Ganga river.

Dr Mukherjee and his students’ recent work on groundwater quantity variation across India, specifically on recent groundwater rejuvenation in parts of the country, as a consequence of government policy interventions, has attracted global acclaim and media coverage. This research provided unprecedented support to the Government of India missions in evaluating outcomes of missions like

AWARDS

- Shanti Swarup Bhatnagar Prize (2020)
- Kharaka Award (2020)
- International Association of Hydrogeologist-INC Young Scientist Award (2015)
- National Geoscience Award (2014)
- Geological Society of America GRG Award (2004)

PUBLICATIONS

- 'Groundwater depletion causing reduction of baseflow triggering Ganges river summer drying'. *Scientific Reports* (2018).
- 'Plate tectonics influence on geogenic arsenic cycle: From primary source to global groundwater enrichment'. *Science of the Total Environment* (2019).
- 'Occurrence, predictors and hazards of elevated groundwater arsenic across India through field observations and regional-scale AI-based modeling'. *Science of the Total Environment* (2021).

Clockwise: With his MSc thesis supervisor, Prof. Arup Mitra, in Kalimpong, West Bengal (1998)

With PhD advisor Prof. Alan Fryar and Prof. William (Bill) Thomas, President of the GSA, Kentucky, USA (2006)

At field work, during deep subsurface exploration of Varanasi for Urban Geoscience studies

Receiving IIT Kharagpur Faculty Excellence Award 2018 from Director Prof. Partha Pratim Chakrabarti

Receiving Geological Society of America Graduate Research Award 2004 from Dr Chris Neuzil, Chair of Hydrogeology Division

President of India, Pranab Mukherjee, conferring the National Geoscience Award 2014

Inset: During his PhD field work in North 24 Parganas District, West Bengal (2004)

MNREGA on groundwater rejuvenation in parts of India. This work is believed to be one of the influential factors in the initiation of groundwater rejuvenation programmes across India. He is regarded as the leading groundwater pollution expert in the country and has served as an expert for the Ministry of Water Resources, RD and GR of the Government of India. This has also led to his invitation in 2014 as a Witness to the Estimate Committee of the Parliament of India, induction as a Fellow to the Royal Society of Chemistry, UK (2020) and the Geological Society of America (2021). Dr Mukherjee is also involved in studying the groundwater resources and resilience in high altitude areas of the Indus basin (Ladakh and Kargil).

Dr Mukherjee's recent studies on drying and pollution of the Ganga river has initiated an in-depth evaluation of the river and its flow by the Namami Gange mission. Also, his study of sanitation-sourced groundwater fecal pollution to address the UN Sustainable Development Goals (SDG) has been instrumental in evaluating the efficiency of the Swachh Bharat Mission. His most recent work on applications of Artificial Intelligence (AI) techniques to predict the groundwater pollution of India and adjoining countries are providing some of the baseline information for the Jal Jeevan Mission that ensures safe drinking water to every household of India by 2024.

As one of the first Indian scientists to propose a 'Water Security Bill' for India in 2014, Dr Mukherjee has convened a consortium called ĀPAH (Applied Policy Advisory in Hydrosciences) that includes scientists who apply earth-observation and geoscientific techniques, in a combination of statistical, econometric, big data analytics and AI techniques for present-day and potential, future impact of policy interventions on water resource availability of India.

A man with an all-encompassing personality, Dr Mukherjee is involved in organizing social events within his work institute, as well as in the society at large. For almost the last decade, he has been continuously organizing India's largest geoscience fest, PRITHVI, at IIT Kharagpur. Dr Mukherjee has also been active in sports and is a trained and graded martial (Karate) artist. In his leisure time, he likes reading books, listening to classical music and traveling to historical places. •

PROF. AMALENDU KRISHNA

Setting the Standard

Prof. Amalendu Krishna, a professor of mathematics at Tata Institute of Fundamental Research (TIFR), Mumbai, was born in Belarahi, a small village in Madhubani district, Bihar. His father, Prafulla Krishna, was an engineer and his mother, Shobha Kumari, is a homemaker. Amalendu moved to Patna from his village at the age of 7 where his father was employed as an engineer. He had his primary and secondary education in the schools run by the state of Bihar.

After his graduation, Amalendu moved to Tata Institute of Fundamental Research (TIFR), Mumbai to pursue a PhD in mathematics. After completing his doctorate, he took on the role of an Assistant Professor at the University of California in Los Angeles and later at the Institute for Advanced Studies at Princeton before returning to TIFR as a faculty member.

As a scientist, Prof. Krishna works in the area of algebraic geometry and K-theory. He studies geometric shapes arising in nature using a mathematical tool called K-theory. Krishna's first encounter with K-theory was when he was introduced to an unsolved problem in mathematics by his PhD advisor V Srinivas at TIFR. He later worked with his advisor to solve the problem using K-theory. This was a breakthrough in mathematics.

Extremely complex, the problem he solved was: In algebraic geometry, there is a theory of Chow groups of zero-cycles on an algebraic variety. These groups carry a lot of information about the variety. However, it is, in general, not easy to compute them. In the 1970s, mathematicians, S Bloch and V Srinivas, made a conjecture about the shape of this Chow group for an arbitrary variety. This conjecture predicted an explicit formula for the Chow group, which is useful in the study of varieties. This conjecture is famously known as 'the Bloch-Srinivas conjecture'.

It was instantly realized by the researchers in the field that a solution to the Bloch-Srinivas conjecture would have profound consequences in understanding the geometry of algebraic varieties.

> **"The only way to be successful in any field is to pursue it relentlessly and give one's best in it."**

During his PhD, Amalendu worked with Prof. V Srinivas to completely and affirmatively solve this conjecture. This work got him an assistant professorship at the University of California, Los Angeles, USA. This was a defining moment in Prof. Krishna's career.

Later, Prof. Krishna formulated several extensions and generalizations of the Bloch-Srinivas conjecture and solved them in many cases. This led to significant progress in the study of algebraic varieties of arbitrarily large dimensions. It also allowed the researchers in the area to have a better understanding of the algebraic K-theory.

While working on the generalizations of the Bloch-Srinivas conjecture, Prof. Krishna came across more unsolved problems in algebraic geometry each of which had outstanding consequences. These problems were so exceptional that their affirmative solution would have meant major advances in the study of algebraic varieties using K-theory.

One of these was posed to the world in the 1980s by the famous Indian mathematician Prof. MP Murthy, a professor at the University of Chicago. This problem is known in mathematics as Murthy's conjecture. It predicted that a certain piece of the algebraic K-theory of some algebraic varieties (called affine varieties) is the same as their Chow group. A statement of this kind has enormous consequences in mathematics because it makes two seemingly different mathematical objects equal. Prof.

AWARDS

- BM Birla Science Prize in Mathematics (2009)
- Swarnajayanti Fellowship (2011)
- Ramanujan Prize (2015)
- Shanti Swarup Bhatnagar Award (2016)
- Indian Academy of Science Fellowship (2016)

PUBLICATIONS

- 'Zero cycles and K-theory on normal surfaces'. *Annals of Math*. (2002).
- 'Additive higher Chow groups of schemes'. *J Reine Angew Math*. (2008).
- 'An Artin-Rees theorem in K-theory and applications to zero cycles'. *J Algebraic Geom*. (2010).
- 'The completion problem for equivariant K-theory'. *J Riene Angew Math*. (2018).
- 'Murthy's conjecture on 0-cycles'. *Invent Math*. (2019).

Clockwise: Receiving the Shanti Swarup Bhatnagar Award from Prime Minister Narendra Modi

The conjecture Prof. Krishna has solved is famously known as 'the Bloch-Srinivas conjecture'.

Prof. Amalendu Krishna with the Ramanujan Prize

With his daughter

During an interview with ICTP head after receiving the Ramanujan Prize

Prof. Krishna is currently working on several problems in the area of algebraic K-theory and algebraic geometry

Inset: Delivering a lecture

Murthy had already demonstrated that a positive solution to his conjecture would solve many other questions in the K-theory of affine varieties.

Murthy's conjecture was an exciting problem which Prof. Krishna was determined to solve. But it was a daunting task because it involved establishing a close relationship between two different mathematical invariants. Prof. Krishna was aware that many mathematicians had attempted this problem in the past without much success.

Not worried about the uncertainties and difficulties, Prof. Krishna began working to find a solution to Murthy's conjecture. After a year of dense and sustained research, he found a complete solution to the conjecture. The most amazing thing about his solution was that it produced new techniques, which could be used in solving many other problems in the subject of K-theory. This was another important milestone in his career.

Prof. Krishna is currently working on several problems in the area of algebraic K-theory and algebraic geometry. One of his goals is to discover techniques to compute the K-groups of algebraic varieties. Even if the K-groups carry almost every information about an algebraic variety, they are hard objects to compute. Mathematicians need to devise tools for this purpose.

A question in algebraic geometry that is analogous to the topological result of Atiyah and Hirzebruch is whether one can describe the K-theory of an algebraic variety in terms of its explicitly defined objects, such as the Chow groups. These Chow groups are the algebraic analogue of singular cohomology of topological spaces.

No answer to this question was known until the 1990s when several mathematicians independently provided a partial solution to this question. The consequence of their research was that it became possible to describe the algebraic K-theory of a variety in terms of its Chow groups under the assumption that the given variety is smooth, that is, it looks like a topological manifold. However, this problem is still elusive for general algebraic varieties.

A complete and unconditional solution to this problem is part of the current and future research plan of Krishna. He has already made substantial progress on this problem and hopes to find a solution soon in the future.

Whenever he finds some time, he likes to spend it with his family. A man of many hues, Prof. Krishna's interest in music is wide-ranging, at the same time, he also enjoys watching a variety of dance performances. He believes that an artistic mind is necessary to think mathematics. •

PROF. AMIT DUTT

Revolutionizing Research

Prof. Amit Dutt's excitement about science was piqued in the elementary school when he dreamt of being a scientist. His father's deep scientific mindset profoundly impacted him and set him on the quest to understand cancer. However, Shilpee Raghav, his junior during post-graduation, worked as a catalyst for him to pursue understanding the complexity of the biological phenomenon that could lead to better cancer care.

The impact of Prof. Amit Dutt's work has been published in several reputed scientific journals with over 8,000 citations to his work. Prof. Dutt's current *h-index* is 29, and the *i10 index* is 44: an international metric that places him among the top tier scientists of his age across the globe.

Prof. Dutt holds a rare accomplishment in the field with a double PhD in biology. His first formal introduction to basic cancer research happened during his second PhD at the Department of Cancer Research, University Hospital, University of Zurich. His seminal work put forward the first evidence for a serine protease ROM-1 mediated amplification of an EGF oncogenic signal in *Caenorhabditis elegans*, a genetic model system. His work led to an understanding of mechanistic genetic pathways underlying the amplification of the inductive EGF signal. Prof. Dutt's work modified and extended the textbook view of vulval development in *C elegans*. In recognition of the high quality and novelty of his thesis, he was invited for a plenary talk to present his findings at the most formal annual *C elegans* meeting in Los Angeles, USA.

Prof. Dutt is the recipient of the prestigious international postdoctoral fellowship from the Swiss National Foundation (SNF), Switzerland. With SNF fellowship, Prof. Dutt joined the leading laboratory of Dr Matthew Meyerson in Cancer Genomics at the Broad Institute of Harvard and MIT/Dana Farber Cancer Institute, Harvard Medical School to pursue translational cancer research.

"In research the decision should be organic and driven more by passion to understand the mechanism for several enigmatic processes."

In the US, Prof. Dutt led a project to analyze the biology of tyrosine kinase genes in endometrial cancers. He discovered recurrent oncogenic mutations in the fibroblast growth factor receptor 2 gene, *FGFR2* in roughly 10 per cent of the cases – that remains to date as the most promising therapeutic target – in endometrial cancer. Prof. Dutt and his colleagues published the first integrated analysis of genome-wide expression and copy-number profiles in endometrial cancer. His work led to the identification of novel candidate mutation in the pleckstrin homology domain of all the members of AKT family. These studies are an important step towards a comprehensive analysis of the endometrial cancer genome and its relation to clinical presentation.

After relocating to India, Prof. Dutt's most significant contribution in Medical Sciences, as an independent scientist ACTREC-Tata Memorial Centre, has been to decipher the role of tyrosine kinases in the pathogenesis of lung cancer with implications in therapeutics and diagnostics of the disease. Prof. Dutt described the first comprehensive landscape of actionable mutations across ~450 lung adenocarcinoma. His work using elegant genetic, biochemical and mouse-xenograft based mechanistic characterization has led to discovering novel *FGFR3* activating mutations in lung adenocarcinoma patients of Indian origin. Subsequently, he systematically described *EGFR*, *PIK3CA*, *KRAS* and *FGFR1* as a therapeutic target along

Clockwise: Receiving the prestigious SSB Award in Medical Sciences from Prime Minsiter Narendra Modi, 2017

With his parents and siblings (1985). Amit is on the far right

Receiving the distinguished alumni award, Jamia Millia Islamia, 2017

With his wife Shilpee Dutt and children Shwetna Dutt and Audvik Dutt

With Nobel Laureate Prof. David Baltimore, Mathematician and Geneticist Prof. Eric Lander and Biologist Prof. Bob Weinberg

Delivering a talk at the Karolinska Institute, Stockholm

Inset: Delivering a talk at MD Anderson Center, Houston, US

AWARDS

- Distinguished Alumni Award, Jamia Millia Islamia (2017)
- Shanti Swarup Bhatnagar Prize (2017)
- Wellcome Trust/DBT India Alliance Intermediate Fellowship (2011)
- Ramalingaswami Fellowship Award (2010)
- Swiss National Science Foundation Postdoctoral Fellowship (2004)

PUBLICATION

- 'Up-regulation of the kinase gene *SGK1* by progesterone activates the AP-1-NDRG1 axis in breast cancer cells'. *J Biol Chem*. (2018).
- '*ERBB2* and *KRAS* alterations mediate response to EGFR inhibitors in early stage gallbladder cancer'. *Int J Cancer* (2018).
- 'Drug-sensitive *FGFR3* mutations in lung adenocarcinoma'. *Ann Oncol*. (2017).
- 'NGS-based approach to determine the presence of HPV and their sites of integration in human cancer genome'. *Br J Cancer* (2015).
- 'Drug-sensitive *FGFR2* mutations in endometrial carcinoma'. *PNAS* (2008).

with a global landscape of alterations across ~450 Indian lung squamous cancer. Prof. Dutt's work shows that treatment of lung squamous cancer cells harboring focally amplified *FGFR1* and lung adenocarcinoma cells harboring *FGFR3* mutations when treated with *FGFR*-specific shRNAs or with the FGFR small molecule inhibitor leads to cell growth inhibition. These works open the possibility of subtype-specific lung cancer treatment by targeting FGFR family genes.

Additionally, Prof. Dutt addressed a basic deficiency in the field by profiling *EGFR* and *KRAS* mutation frequency in 1000 odd samples derived from Indian lung cancer patients, along with his clinical colleague Dr Kumar Prabhash. His work revealed 23% *EGFR* and 19% *KRAS* mutation with 74% clinical response to EGFR tyrosine kinase inhibitors, which is markedly distinct from the previously known Caucasian (10-15%) and East-Asian populations (30-50%). The work undertaken rationalizes targeted therapy among Indian lung cancer patients and led to the adoption of a genetic diagnostic test to genotype *EGFR* mutations at affordable pricing, remarkably reducing its cost from ~$200 (as in 2010) to $12 per test, as offered at TMH on a routine basis. These studies have been widely acknowledged globally, with over 700 citations in literature so far.

Beyond lung cancer, Prof. Dutt has made several seminal contributions advancing our understanding across several other cancers among Indian patients. In brief, Prof. Dutt's works demonstrate *NOTCH1* as a therapeutic target and *MMP10* as a predictive marker for metastases in tongue cancer. He described the presence of *KRAS* mutations might preclude gallbladder cancer patients to respond to anti-EGFR treatment, similar to colorectal cancer. In breast cancer, Prof. Dutt described the role of kinases that underlie the clinical outcome of pre-operative progesterone intervention. In addition, Prof. Dutt developed "TMC-SNPdb" – the first open-source Indian SNP database, "HPVDetector" to detect HPV in cancer, and an automated computational pipeline IPD, to understand the pathogens associated with human cancer. Prof. Dutt also contributed to the COVID research by developing a one-step, one-tube real-time RT-PCR based assay that was transferred to industry, and a novel Raman spectroscopy-based framework to detect RNA viruses in saliva.

Overall, Prof. Dutt has made phenomenal contributions in a field undergoing a revolutionary transformation in technology and ideas: the interface between cancer genomics and cancer targeted therapy. •

DR AMRITANSHU PRASAD

Knowledge is Power

'All mathematical reasoning is founded on certain simple principles, the truth of which is so evident that they are accepted without proof,' from *School Geometry* by Hall and Stevens. It was owing to this book, gifted to him by his father, that Dr Amritanshu Prasad first learnt to enjoy the mathematical process.

Born and raised in Bangalore, after completing his schooling, Amritanshu joined the BStat (Hons) programme at the Indian Statistical Institute, Calcutta. Teachers like Somesh Bagchi and Kalyan Mukherjea went out of their way to encourage and guide him to explore the world of research mathematics.

During his undergraduate days, he met professors VS Sunder and V Pati from ISI Bangalore at a summer workshop for college students. He learnt about differentiable manifolds from Prof. Pati and Prof. Sunder encouraged him to apply to The University of Chicago for the PhD programme.

Amritanshu joined the PhD programme at The University of Chicago in 1995 and worked under the supervision of Prof. Robert Kottwitz, one of the foremost authorities on the Langlands Program. Kottwitz's remarkable facility, as an advisor, to make aspects of this program concrete and accessible to young researchers made him popular with students.

After completing his PhD, Dr Prasad spent two years at the Centre for Mathematical Research (CRM) at the University of Montreal as a postdoctoral fellow in a research group headed by Prof. Henri Darmon. During this time, he also taught undergraduate courses at McGill and Concordia universities. And, he spent a summer at the Max-Planck Institute in Bonn, where he worked in Gunter Harder's group on automorphic forms, and autumn at the Institute Des Hautes Études Scientifiques near Paris.

Dr Prasad decided to return to India in 2003. He joined the Institute of Mathematical Sciences in December 2003. The institute was run by the charismatic and inspiring mathematician, R Balasubramaniam, who encouraged Dr Prasad to pursue his path in research. Prof. CS Seshadri, the founder of Chennai Mathematical Institute, wanted the best teachers to teach there, hence Dr Prasad volunteered to teach undergraduate analysis at CMI.

"Being engrossed in the process of mathematical discovery is in itself the greatest reward that a mathematician can seek."

Meanwhile, at IMSc, Prof. Prasad has worked in several areas of mathematics, including automorphic forms, harmonic analysis, representation theory, group theory and combinatorics. He has published his book *Representation Theory: A Combinatorial Viewpoint* part of the Cambridge Studies in Advanced Mathematics series in 2015, based on courses that he taught at IMSc and CMI, where he developed an approach to the subject.

In 2016-17, he published two papers in collaboration with Arvind Ayyer (IISc) and Steven Spallone (IISER-Pune), which generated great excitement in the community. Almost 50 years ago, Macdonald computed the number of odd-dimensional representations of the symmetric group using Frame, Robinson, and Thrall's ideas. Dr Prasad, and his collaborators, gave a structural explanation for this phenomenon by showing that the subgraph induced in Young's graph by odd-dimensional representations is an incomplete binary tree. Their work led to rapid developments on

AWARDS

- Fellow, Indian Academy of Science (2019)
- Swarnajayanti Fellowship (2014)
- Young Scientist Medal, Indian National Science Academy (2010)
- Associate, Indian Academy Science (2005)

PUBLICATIONS

- 'Representation Theory: A Combinatorical Viewpoint'. *Cambridge University Press* (2015).
- 'Schur algebras for the alternating group and Koszul duality'. *Pac J Math*. (2020).
- 'Representations of symmetric groups with nontrivial determinant'. *J Combin Th Ser A*. (2017).
- 'Odd partitions in Young's lattice'. *Sém Lothar Combin*. (2016).
- 'Similarity of matrices over local rings of length two'. *Indiana Univ Math J*. (2015).

Clockwise: Teaching modular origami

With his father, Prof. Phoolan Prasad, while working at the Max-Planck-Institut in Bonn

Teaching mathematics with origami models

Conducting paper-folding activity with students during Kanita-Kanagam in 2018

Conducting an origami workshop for school teachers

Inset: Working on the first calculations for his PhD thesis at The University of Chicago, 1998

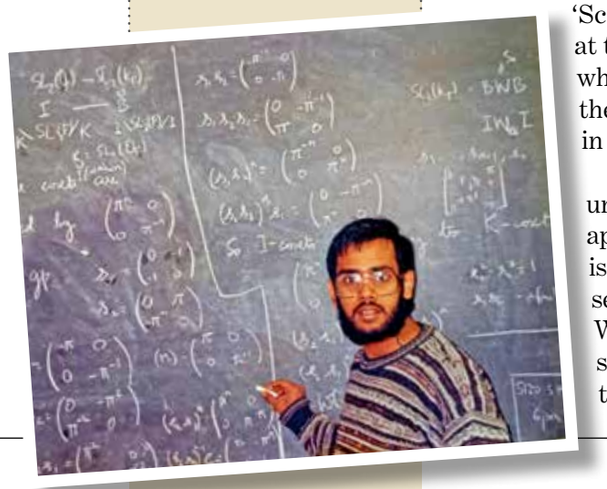
bijective aspects of the McKay correspondence by Bessenrodt, Gianelli, Kleshchev, Navarro, Olsson, Tiep, and others. In a second paper, they solved a much harder enumerative problem, counting the number of representations whose determinant was the sign character (chiral partitions).

One of his most long-term contributions has been to study matrix groups and rings over principal ideal local rings like integers modulo a prime power. Collaborations with Vaserstein, Onn, Singla, Spallone and others, over the years, have led to a revival of interest in what was considered to be a hopeless problem. Recent interest in this problem has been driven by conjectures of Larsen and Lubotsky on representation zeta functions, a complex-analytic approach to representation theory.

Along with Dr Kunal Dutta, Dr Prasad gave a simple complete decomposition of the Weil representation associated with any finite abelian group (Pacific J. 2015). This result was a vast improvement over earlier attempts by Prof. Gerald Cliff and his collaborators, who had obtained piecemeal results in a series of complicated articles. To carry this out, he developed a combinatorial theory of automorphism orbits infinite Abelian groups.

Dr Prasad enjoys popularizing mathematics through talks for varied audiences, sometimes using origami or software packages like Sage. He even ran an origami club in IMSc where members got together to fold mathematical shapes using modular origami. He used origami as a tool to teach group theory and symmetry to audiences ranging from school children to PhD scholars. He has been an enthusiastic contributor to the outreach programme of IMSc. He initiated and organized Kanita-Kanagam, an outreach programme for school children conducted primarily in Tamil. He has also delivered a talk at 'Science at the Sabha', conducted by IMSc at the iconic music academy in Chennai, where he tried to explain in layman's terms, the precise mathematics behind algorithms in cryptography.

Dr Prasad has been trying to better understand the restriction problem by applying two new lines of attack – the first is the idea of polynomial induction, and the second is the use of character polynomials. Working in collaboration with a team of students and postdoctoral fellows, he hopes to make more progress on this problem. •



DR ANINDA SINHA

Taming Infinities

Encouraged by his father to pursue a scientific career, Dr Aninda Sinha was fortunate to have inspiring teachers in school, like Mr Dias, Mr Pathrose and, at Jadavpur University, Dr Soumitra Sengupta and Dr Narayan Banerjee. Their conviction prompted him to pursue theoretical physics.

Aninda's ambition found its anchor in one of the inventors of string theory and Lucasian professor at the University of Cambridge, Professor Michael Green, who was his PhD advisor. He also found Cambridge an inspiring place with stalwarts at every corner!

At the same time, Aninda was interested in knowing the internal workings of nature. In particular, how nature works at the microscopic level, where it becomes important to talk about quantum effects. He felt, over the last century, quantum theory may have been understood well enough to explain many aspects of day-to-day observations, however, there remain huge gaps in its understanding. These are the mysteries that inspired him towards his current research. When one tries to explain detailed phenomena, for instance, light by light scattering, one encounters horrible infinities. As physicists, one has learnt to deal with these. However, this does demonstrate a major gap in understanding how nature works. Most physicists tend to ignore these difficulties despite acknowledging their existence. The result is a framework where the yet not well understood dark energy and dark matter together account for 95% of what is observed.

> **"Ignore noise (social media) around you and follow your target with single-minded dedication."**

The main contribution, Prof. Sinha an Associate Professor at Center for High Energy Physics, Indian Institute of Science-Bangalore, has made during the last five years has been in the setting up of a method by which one can understand several phenomena without encountering these infinities. In 2015, he read a paper which claimed, in 1974, Soviet physicist, Alexander M Polyakov, proposed a physics hypothesis indirectly related to these infinities that apparently no one understood, this paper had piqued his curiosity.

Prof. Sinha feels as research is important since it gives an alternative way to think about quantum theory when Einstein's theory of relativity becomes important. One application is to understand the so-called critical point of water (or superfluid helium as another example). Finding new phases of matter will be a potential application of these techniques. Even to completely understand the physics of black holes, these techniques may eventually prove useful. His work was published in the prestigious *Physical Review Letters* in 2017, with the referees terming it as a breakthrough. He has received several invitations to international conferences during the last several years to present his findings. The International Centre for Theoretical Physics (ICTP), Trieste, Italy awarded him the 2016 ICTP prize and CSIR bestowed the 2019 Shanti Swarup Bhatnagar prize for physical sciences partially in recognition of this line of research.

Prof. Sinha wants to investigate and set up a framework for quantum field theory without encountering the standard divergences that existing formalism leads to. He hopes that one-day similar techniques will shed light on the theory of quantum gravity that describes nature. Theoretical physicists do not make rapid progress most of the time. But when insight occurs, that moment is an experience

AWARDS

- Mayhew Prize (2001)
- Ramanujan Fellowship (2010)
- Swarnajayanti Fellowship (2015)
- ICTP Prize (2016)
- Shanti Swarup Bhatnagar Prize (2019)

PUBLICATIONS

- 'Conformal Bootstrap in Mellin Space'. *Phys Rev Lett*. (2017).
- 'On the Polyakov-Mellin bootstrap'. *Journal of High Energy Physics* (2018).
- 'Renormalized Circuit Complexity'. *Phys. Rev. Lett*. (2020).
- 'Universal Anomalous Dimensions at Large Spin and Large Twist', *Journal of High Energy Physics* (2015).
- 'Holographic c-theorems in Arbitrary Dimensions'. *Journal of High Energy Physics* (2011).

Clockwise: Receiving the 2016 ICTP Prize from Prof. F Quevedo, Director ICTP

With his parents during the Jadavpur University convocation 1999, who inspired him to pursue a career in science

With his advisor, Prof. Michael Green, one of the inventors of string theory and Lucasian professor at the University of Cambridge, UK

With wife and daughter

At King's College Cathedral, Cambridge University, 2018

At the Yukawa Institute, Kyoto, Japan

Delivering the ICTP Prize lecture, 2016

Inset: In his office at IISc, Bengaluru

In front of the Alice experiment, with Prof Tapan Nayak, during a visit to CERN, Geneva

of joy hard to explain in words. It is as if some deep truth has been revealed to you and for a moment you are the only one in the whole world who knows this – it is a feeling like no other!

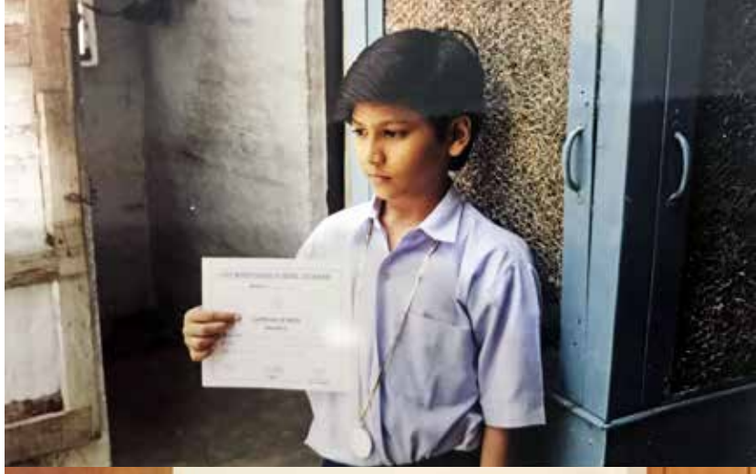
Sometimes his colleagues' reaction to his work or when wide-eyed youngsters' approach him makes him feel good! Prof. Sinha recalls, in 2016, around June, while he was visiting the Galileo Galilei Institute in Florence Italy for a conference he was stuck with a calculation related to his project. However, on the day of his talk, he woke up early in the morning and in desperation, tried out a seemingly random line of reasoning, which worked. The conference participants told him that the result was startling and no other existing had reached where his calculations had! This convinced him that this is the correct direction to pursue.

He shares that he has recently made a breakthrough in the line of research, which enables us to constrain physics happening at low energies using techniques that are more powerful than existing ones in the literature. And, looks forward to establishing it further.

In science, there are rare opportunities where one realizes that we are in pursuit of an objective that can reveal a deep, indelible truth about the workings of nature. As a physicist, he considers it a privilege to be in such a situation. There is no bigger excitement in research than understanding a small piece of the big mysteries that surround us. And, when he is not found on his desk unravelling these mysteries, Prof. Sinha can be found playing tennis or watching a science fiction horror film. •

PROF. ANSHUMAN KUMAR

In Pursuit of Science



Before starting his PhD, Anshuman was faced an existential dilemma – while he had developed a deep interest in fundamental physics, he also wanted to use his engineering training to solve relevant technological problems. After a series of discussions and brainstorming with his mentors at the Massachusetts Institute of Technology (MIT), he finally chalked out a plan for his research, which would be the best of both worlds.

Born in Lucknow to Meena Srivastava, who was a lecturer and Satish Kumar Srivastava, an agriculturist, Anshuman's parents inculcated an academic environment at home. Prompted by their unconditional support, he cleared the joint entrance exam and joined as an undergraduate student in Engineering Physics. After completing his degree at IIT Bombay, Anshuman joined Massachusetts Institute of Technology as a PhD candidate.

One of the most important questions that Anshuman addressed during his PhD was the role of electronic Berry curvature in monolayer transition metal dichalcogenides in their plasmonic response. Berry curvature has its origins in the work of Michael Berry and the Indian scientist Shivaramakrishnan Pancharatnam (1934–1969). In condensed matter systems, in simple words, this type of a curvature arises from the band structure of the material and leads to many well-known phenomena, such as anomalous Hall effect. On the other hand, another very important field of technological relevance for sensing, imaging and photovoltaics is plasmonics, which is about confining a light wave into nanoscale volumes. Prof. Kumar came up with a unique idea of bridging these two fields, proposing the so-called "valley plasmons".

As part of the graphene flagship project, Prof. Kumar developed a reference free precision metrology tool for experimental characterization of the cavity quantum yield of these two dimensional valleytronic quantum materials based on their integration with high-quality factor microcavities. This unique approach helped clarify the results of several controversial claims of lasing in two dimensional semiconductors. In another seminal work, Prof. Kumar explored the concept of tunable photonic topological transitions in the isofrequency surface (surface of allowed wave-vectors of light propagation) of hyperbolic phonon polaritons. Unlike conventional optical materials, which show an isofrequency surface which forms a closed surface such as an ellipsoid. Certain class of newly discovered 2D materials, such as hexagonal boron nitride shows an isofrequency surface which is open such as a hyperbooloid. This exotic topology, arising from the peculiar optical phonons in these materials, has a drastic impact on the optical response. Prof. Kumar was the first one to identify the electrostatic tunability of these hyperbolic phonon polaritons through integration with graphene.

Subsequently on joining his position as an Assistant Professor at IIT Bombay, the

> **"The most important thing in research is to be able to maintain curiosity and a sense of 'playfulness' regarding your research problem."**

Clockwise: Receiving a memento for his PhD defense

After winning the prize for best academic performance in school

Receiving the Silver Medal at IIT Bombay from the then Director, Prof. Devang Khakhar

Participating in a half marathon event at IIT Bombay campus

With new graduate students

Inaugurating his lab, LOQM, in presence of his students

During a discussion on quantum materials with peers and students

Inset: During coconut breaking ritual on first day of his lab LOQM

AWARDS

- Young Scientist Award, Indian National Science Academy (2021)
- Young Scientist Platinum Jubilee Award, National Academy of Sciences (2021)
- Marie Sklodowska Curie Fellowship (2016)
- Wunsch Foundation Award for Outstanding Thesis, MIT (2015)
- Institute Silver Medal Undergraduate Award, IIT Bombay (2010)

PUBLICATIONS

- 'High Temperature Mid-IR Polarizer via Natural In-Plane Hyperbolic Van der Waals Crystals'. *Advanced Optical Materials* (2021).
- 'Engineering valley quantum interference in anisotropic van der Waals heterostructures'. *Physical Review B*. (2020).
- 'Interlayer exciton valleytronics in bilayer heterostructures interfaced with a phase gradient metasurface'. *Applied Physics Letters* (2020).
- 'A Cyclical Deep Learning Based Framework for Simultaneous Inverse and Forward design of Nanophotonic Metasurfaces'. *Scientific Reports* (2020).

efforts to bridge these two fields have continued with several peer-reviewed publications exploring these ideas in the context of microcavities, metasurfaces and heterostructures in his newly established lab called the Laboratory of Optics of Quantum Materials. The most exciting part of his research at IIT Bombay according to him is the fact that he can work at the intersection of several traditionally non-overlapping fields. Two of his recent publications from IIT Bombay are about using deep learning for designing exotic optical response in artificial 2D systems called metasurfaces. These 2D systems have extremely low spatial footprint and are of great relevance for applications to space technologies where being lightweight is critical, to chipscale photonics, where every nanometer of saved space counts. In his dual role of an educator and a scientist, Prof. Kumar's passion according to him is to train his undergraduate and graduate students in developing innovative technologies in the lab.

In terms of the career graph, Prof. Kumar has been the recipient of several international fellowships and awards. Prof. Kumar has co-authored more than twenty scientific journal publications.

Prof. Kumar's source of inspiration consists of pioneers in his field including Prof. Andre Geim and Prof. Konstantin Novoselov, Physics Nobel prize awardees in 2010 for their work on graphene. In his day to day research, Prof. Kumar emphasizes the importance of creativity to derive the inspiration for which he looks outside his own field into areas as diverse as computer science and literature.

Prof. Kumar is a hands-on PhD advisor and can be seen several times in his lab helping students with their experiments. When not doing research, Prof. Kumar is usually seen running either a half marathon or just around the beautiful IITB campus. •

PROF. ANUP BISWAS

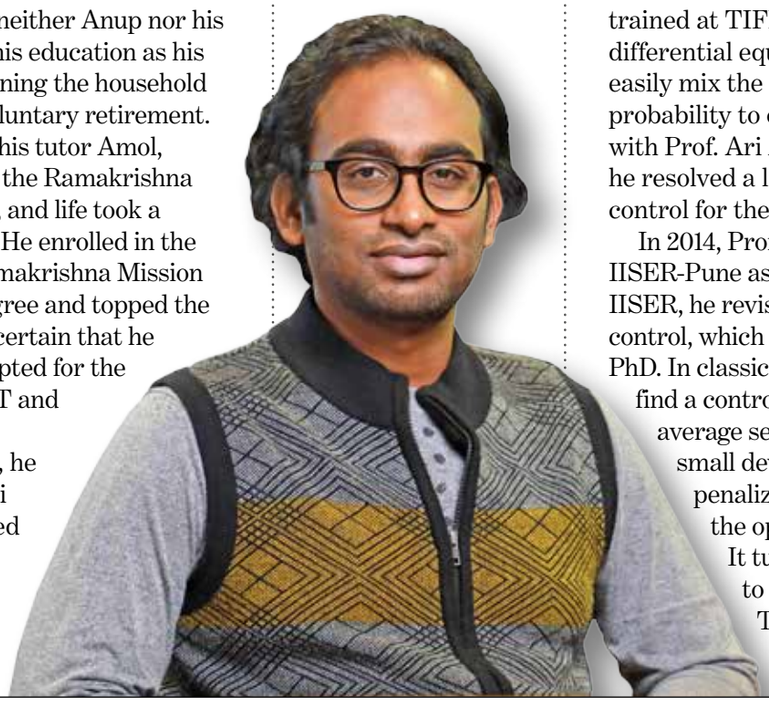
The Man of Many Possibilities

During the master's programme at Tata Institute of Fundamental Research, Anup Biswas, now Associate Professor and Deputy Chair–Mathematics at Indian Institute of Science Education and Research, Pune, attended a series of lectures by Prof. Jean Taylor on geometric measure theory and evinced an interest in the topic. But, since there was no active research at TIFR in this area, it was hard for him to pick a suitable topic for his master's thesis. One of his teachers, Prof. Adimurthi, suggested that he look into probability theory and advised him to work under the supervision of Prof. Vivek Borkar. Till that time, he did not know much about probability theory, but since measure theory played a prominent role in probability, he started to work on it. Things changed from there, Anup was hooked onto probability theory and even continued to work with Prof. Borkar for his doctoral thesis.

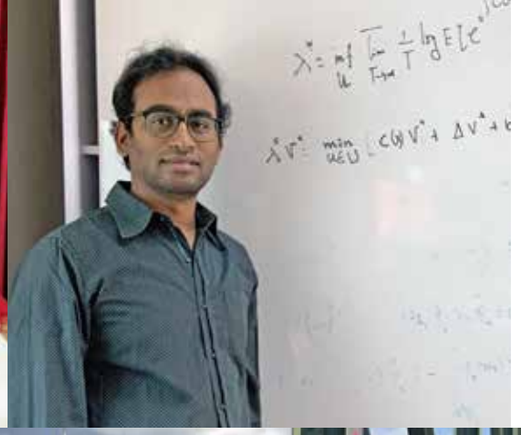
Born in Howrah in West Bengal, neither Anup nor his parents had big expectations from his education as his mother, Angurbala Biswas, was running the household single-handedly after his father's voluntary retirement. However, after his 10th class exam, his tutor Amol, encouraged him to get admission in the Ramakrishna Mission Vidyamandira, Belur Math, and life took a different course from that point on. He enrolled in the mathematics programme of the Ramakrishna Mission Vidyamandira for his bachelor's degree and topped the university exam. After graduation, certain that he wanted to be a mathematician, he opted for the master's programme at IISc, ISI, IIT and TIFR Bangalore.

Continuing to pursue excellence, he started his postdoc with Prof. Rami Atar at Technion, Israel, and worked on the queueing theory. Roughly speaking, the central problems in queueing theory are related to the optimization of the performance of the queueing system. This generally leads to optimal control problems. However, after spending two years at Technion, Anup thought of learning something new and started looking for a new postdoc position. He joined Prof. Ari Arapostathis at the University of Texas at Austin, US, as a postdoc, and together with Prof. Arapostathis started to work with Prof. Luis Caffarelli. This was a new chapter in his research. He learnt nonlocal partial differential equations. Having trained at TIFR-CAM, his background in partial differential equations was quite strong and he could easily mix the tools of differential equations and probability to obtain new interesting results. Jointly with Prof. Ari Arapostathis and Prof. Gordon Pang, he resolved a long-standing open problem on optimal control for the M/M/N+M queueing network.

> **"We should do what we love and hard work is the key. Without working hard nothing prospers."**



In 2014, Prof. Biswas came back to India to join IISER-Pune as an Assistant Professor. After joining IISER, he revisited the problem of optimal risk-sensitive control, which he had only partially solved during his PhD. In classical optimization problems, one tries to find a control that optimizes certain criteria in an average sense, whereas in risk-sensitive control, small deviations from the optimal policy are penalized using an exponential cost. This makes the optimal control more effective and robust. It turns out that these problems are related to nonlinear principal eigenvalue problems. Together with Prof. Arapostathis and Dr Saha, Prof. Biswas made a significant



AWARDS

- Associate Editor, *Annals of Applied Probability Journal* (2019)
- Swarnajayanti Fellowship (2021)
- INSA Young Scientist Medal (2017)
- INSPIRE Faculty Award (2014)
- Microsoft Research India Fellowship (2010)

PUBLICATIONS

- 'Maximum principles and Aleksandrov-Bakelman-Pucci type estimates for non-local Schrödinger equations with exterior conditions'. *SIAM J of Math Analysis* (2019).
- 'Strict monotonicity of principal eigenvalues of elliptic operators in Rd and risk-sensitive control'. *Journal de Mathématiques Pures et Appliquées* (2019).
- 'Controlled equilibrium selection in stochastically perturbed dynamics'. *Annals of Probability* (2018).

Clockwise: Receiving the INSA Young Scientist Medal, 2017

In front of office at IISER

In his office working on criticality theory

Family gives one strength: With his wife and child

Dr Biswas has made a significant contribution in the area of nonlinear principal eigenvalue problems by exploring a new notion of monotonicity of principal eigenvalues

During his visit to Frankfurt, Germany

Inset: There are two benefits in researching, first, you face new challenges in almost every project and, second, in trying to understand and resolve the problem you become a better mathematician

contribution in this area by exploring a new notion of monotonicity of principal eigenvalues. Over the last couple of years, they have answered almost all the important questions in the area of risk-sensitive optimal control of diffusions.

Another interesting outcome of this research was its connections to criticality theory. Criticality theory is a branch of applied mathematics that focuses on the study of the properties of eigenfunctions and their relation to nonlinear partial differential equations. Using a probabilistic representation of the principal eigenfunction, they established that the right monotonicity of the principal eigenvalue concerning the potential is equivalent to the minimal growth property. Around the same time, Prof. Biswas also started applying probabilistic tools to develop a theory for nonlocal operators. Nonlocal operators are generators of Lévy processes, and therefore, it is possible to obtain many new results of partial differential equations by using the properties of the underlying Lévy process. He has been quite successful in this programme and has been able to obtain several interesting results for nonlocal operators from a probabilistic viewpoint. His approach was well-received by the community.

What he finds interesting is that his research mixes tools from two different branches of mathematics and creates a new theory. In the future, he plans to concentrate more on the development of the theory of nonlocal operators as a lot more can be done when both analytical and probabilistic tools are used.

In his opinion, there are two benefits in researching: first, you face new challenges in almost every project and in trying to understand and resolve the problem you become a better mathematician. After all, as they say, loved art is repetition. The second advantage is that you get acquainted with the scientific community.

Surprisingly enough, he rarely carries his research home. When at home, he likes to spend time with his family or read books, mostly on world history and the history of civilizations. Other than that, he also enjoys cooking and watching detective movies. •

PROF. ANURAG AGRAWAL

At the Forefront

Prof. Anurag Agrawal is the Director of the CSIR Institute of Genomics and Integrative Biology. After completing graduate medical education at the All India Institute of Medical Sciences, Delhi (1994), he further trained in Internal Medicine, Pulmonary Disease and Critical Care at Baylor College of Medicine, Houston, USA (2003), followed by a PhD in Physiology from Delhi University. His work in understanding the pathobiology of asthma, public health studies to define the current and projected burden of respiratory diseases, and efforts towards smart deployment of emerging technologies in artificial intelligence, digital health influence by spouse and genomics have been appreciated globally.

Around 2,700 years ago, the Greek poet Archilochus wrote, 'The fox knows many things; the hedgehog one big thing.' Anurag plans to continue to evolve as a generalizing specialist, more fox than hedgehog, helping to link ideas that have not yet met. He believes that focusing on the intersection of medicine with emerging technology will drive innovation in how we perceive, design and implement health systems.

Prof. Agrawal is passionate about seeing connections between things. This has importantly determined the course of his career as a polymath, with multiple dimensions to his work. He sees these connections as a continuum from cells to societies and is a passionate advocate of interdisciplinary engagement to further advance the frontiers of medical science.

As a physician-scientist, Prof. Agrawal works on the future as well as the present of biomedicine. While working to understand the genesis, prevention, and treatment of lung diseases using state-of-the-art biology tools, he was also providing lung function testing service and deploying eHealth centres to provide healthcare access to rural areas without adequate healthcare. This integrated solution used telemedicine, cloud-based electronic workflow and automated analysis of the data, for various levels of decision-support.

"Have depth in at least one field, continuously learn new things, and work at the intersections."

His family was his biggest source of inspiration, his role models being his father, uncle and grandfather – all well-known scientists. His father, Dr Krishna Prakash Agrawal, was a physician-scientist who established new methods and devices in lung physiology. The apple did not fall very far from the tree in that respect, with a shared love for working at the intersections. His maternal grandfather and uncle, Profs Panchanan and Satish Maheshwari, eminent botanists, were inspirations for a general love of science beyond applications. Professional mentors in

AWARDS

- Lady Tata Young Researcher Award (2010)
- Swarnajayanti Fellowship (2010)
- Shanti Swarup Bhatnagar Prize (2014)
- National Bioscience Award (2015)
- Sun Pharma Research Award (2020)

PUBLICATIONS

- 'Integrating Health Care Delivery and Data Collection in Rural India Using a Rapidly Deployable eHealth Center'. *PloS Medicine* (2013).
- 'Exosome-enclosed microRNAs in exhaled breath hold potential for biomarker discovery in patients'. *J Allergy Clin Immunol*. (2013).
- 'Miro1 regulates intercellular mitochondrial transport & enhances mesenchymal stem cell rescue efficacy'. *EMBO J*. (2014).
- 'Determinants of adolescent lung function in Indians: race, nutrition and systemic inflammation'. *Am J Resp Crit Care Med*. (2021).
- 'Genomic characterization and epidemiology of an emerging SARS-CoV-2 variant in Delhi, India'. *Science* (2021).

Clockwise: With President of Germany Frank Walter Steinmeier at CSIR-IGIB, 2018

Being felicitated with the Shanti Swarup Bhatnagar Prize for Medical Sciences in 2014

Receiving the Joe Rodarte Award for best research in pulmonary diseases at Houston in 2003

Speaking at a side meeting of the United Nations General Assembly, New York, 2019

With his family on a seaplane trip in Alaska during 2009

With Narayana Murthy at National Aeronautics Laboratory, Bengaluru, 2019

With his father and Dr Abdul Kalam (the then Scientific Advisor to Defence Minister), 1995

Creating state-of-the-art live imaging facilities at CSIR-IGIB, 2012

Inset: Speaking to young investigators about career building, 2016

India and USA, Prof. Samir Brahmachari and Burton Dickey, taught him how to translate a love of science into a scientific career. Dr Anjali Agrawal, his spouse and classmate from AIIMS, is one of the first global teleradiologists in India. This has led to a deep and personal connection to the digital health revolution.

Prof. Agrawal does not really consider himself multifaceted beyond science, with many interests but few skills. However, he is an avid reader who continues to prefer fiction to non-fiction, a foodie who would travel the world to explore cuisines, a tennis and cricket enthusiast with more passion than skill, and a father of two brilliant young girls who ensure he does not take himself too seriously.

With over 150 publications, an h-index of 49, and over 20,000 citations, Prof. Agrawal is well published. His lab has been at the forefront of deciphering the cross-talk between metabolic health and respiratory disease, with an emphasis on the key role of mitochondria. A key finding has been that stem cells are mitochondrial donors and can reverse mitochondrial damage. Mitochondrial targeted therapies have been shown by his lab to be potentially useful in preventing or treating lung diseases, with one molecule having entered clinical trials. This molecule is derived from gut bacteria, evolutionary cousins of mitochondria, and a possible connection between gut health and mitochondrial health is being explored. He is particularly intrigued by the low lung function of Indians and has warned in seminal publications that this is not normal, reflects early life adversities such as chronic gut infections and inflammation, and is likely to have wider implications for wellness and cardio-respiratory-metabolic risks in later life. While this is a hypothesis, it has enormous implications and is being taken up for deeper study in cohorts. His other key area of work has been in optimal generation and use of biomedical data at scale, with applications of data-science towards novel insights and public health. He is a member of numerous collaborations at this intersection and has been actively investigating the development and use of artificial intelligence tools for next-generation medicine. •

PROF. APOORVA KHARE

Natural-born

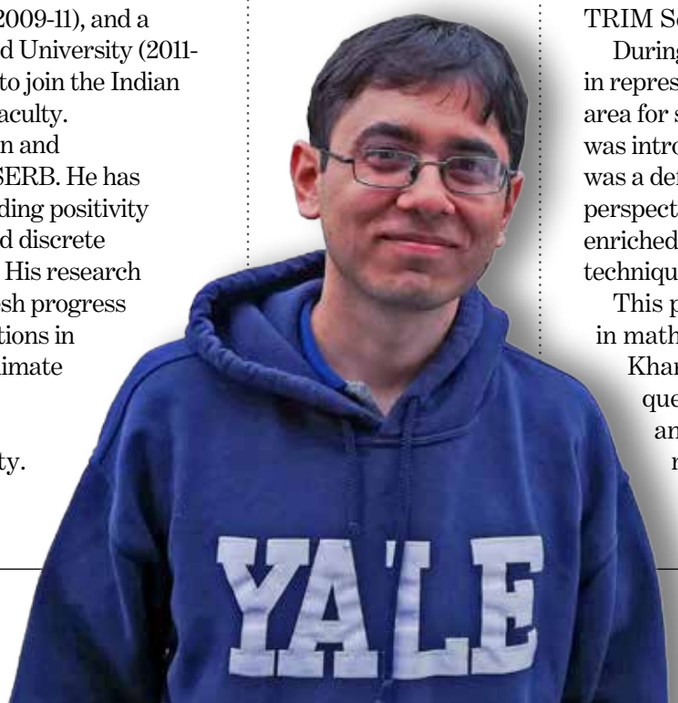
Prof. Apoorva Khare's (Associate Professor of Mathematics at the Indian Institute of Science, Bengaluru) father, Professor Avinash Khare, is a particle physicist and his mother, Professor Pushpa Khare is an astrophysicist. Growing up in Bhubaneswar, Odisha, Apoorva's parents instilled in him a love for puzzles and problem solving, often going beyond the school syllabus to more advanced topics. He was one of 30 students all over India selected for the International Math Olympiad Training Camp in 1996. The rigorous training there exposed him to some of the leading mathematicians in India, as well as the brightest students. Around the same time, he wrote his first paper on divisibility tests, in an undergraduate journal. These two events cemented his desire to convert his love for puzzles into a career in mathematics research.

Apoorva joined the Indian Statistical Institute, Kolkata, for a BStat. During this time, he attended summer nurture programmes in mathematics at TIFR, Mumbai. After completing college, Apoorva went to the University of Chicago for graduate study. He completed his PhD in representation theory under the guidance of Professor Victor Ginzburg. This was followed by a post-doctoral position at the University of California at Riverside (2006-09), a lecturership at Yale University (2009-11), and a Research Associate position at Stanford University (2011-17). Prof. Khare then returned to India to join the Indian Institute of Science as a mathematics faculty.

He has been awarded the Ramanujan and Swarnajayanti fellowships from DST/SERB. He has diverse interests in mathematics, including positivity and analysis, representation theory, and discrete mathematics, including combinatorics. His research connects all these interests, making fresh progress in a classical area with modern applications in various 'big data' problems including climate change and disease detection.

Prof. Khare's work has been favourably received in the community. Apart from seminars at universities (including MIT, Stanford, Yale, Chicago, Berkeley, CalTech, and UCLA), he has also spoken at numerous prestigious international conferences. These include invitations to plenary talks at the premier conferences on matrix theory (Brazil, 2019) and combinatorics (India, 2022) and in North/South Americas (Canada, 2017). His work has been published in several leading journals. Prof. Khare has also received grants from DARPA, NSF and the American Institute of Mathematics (US), and ICMS (UK) among others. He serves on the editorial boards of the *Indian Journal of Pure and Applied Mathematics* and three international journals, and the TRIM Series of books.

> **"One always remains a student of science, and should continually strive to learn and grow as a researcher."**



During his PhD years, Apoorva started his research in representation theory and continued to focus on this area for several years. When he moved to Stanford, he was introduced to a rich, interdisciplinary culture. This was a defining moment for him as a researcher. This new perspective inspired him to explore additional areas that enriched his research, which now combines tools and techniques from multiple sub-fields of mathematics.

This philosophy of reaching across specific domains in mathematics led to an interesting project. Prof. Khare's work in probability led him to raise a question connecting algebra, analysis, geometry, and probability. He asked several experts, with no success. During a 2017 US trip, Prof. Khare visited his collaborator, UCLA professor (and Fields Medalist) Prof. Terence Tao – and

AWARDS

- Fellow, Indian Academy of Sciences (2022)
- Ramanujan Fellowship (2018)
- Swarnajayanti Fellowship (2020)

PUBLICATIONS

- 'Matrix positivity preservers in fixed dimension'. *Advances in Mathematics* (2016).
- 'Faces of highest weight modules and the universal Weyl polyhedron'. *Advances in Mathematics* (2017).
- 'The Hoffmann-Jørgensen inequality in metric semigroups'. *Annals of Probability* (2017).
- 'On the sign patterns of entrywise positivity preservers in fixed dimension'. *Amer. J. Math.* (2021).
- 'Moment-sequence transforms'. *J. Eur. Math. Soc.* (Forthcoming).

Clockwise: Receiving the Tarun Tejankit Award in Mumbai in 2019

Delivering a plenary talk (LAMA Lecture) at ILAS 2019 in Rio de Janeiro, Brazil

Being felicitated after delivering Plenary LAMA Lecture in ILAS 2019 in Rio de Janerio, Brazil

Explaining mathematics to students. Prof. Khare is particularly excited by the connections to works of past experts, as well as to other sub-fields of mathematics.

Attending maths conference in the Dartmouth University, USA, in July 2018

Inset: During a visit to Times Square in New York

During a visit to the Arthur Ashe Stadium in New York

posed this question to him. Prof. Tao then posted the question on his very popular blog, while Prof. Khare boarded a 15-hour flight back to India. Upon landing, he was surprised to see a lot of activity on Prof. Tao's blog in those few hours! This led to the successful 'Polymath' project – a crowd-sourcing approach to collaborative research. The problem was solved at a breakneck pace in less than a week by mathematicians in India, Canada, Germany, and USA!

Today, Prof. Khare works on fundamental questions and objects studied by some of the leading mathematicians in 19th and 20th-century analysis: Laguerre, Polya, Schur, Schoenberg, Rudin, and Loewner, among others. He is particularly excited by the connections to works of past experts, as well as to other sub-fields of mathematics. For example, he has provided a novel formulation of weak majorization (involving basic inequalities of real numbers) using Schur polynomials (algebraic objects from representation theory).

Of course, mathematics research goes hand-in-hand with teaching and mentorship. Apoorva has taught more than 50 courses at Chicago, Riverside, Yale, Stanford, and IISc. He currently advises several PhD students and postdocs. At Yale, Prof. Khare created and taught a new mathematics course for non-math majors. From the golden ratio that is ubiquitous, to the geometric series in fractals and coastlines, to everyday mathematics involving mortgage payments and compound interest, Apoorva's course is an exposition of the beauty and power of mathematics in the real world. With this course, Apoorva hoped to persuade students to shed their 'math-phobia'. This course was a success, and it continues to be taught annually ever since at Yale. Prof. Khare has co-authored the textbook for it, with the hope of reaching out to readers regardless of mathematical background.

From childhood, Apoorva used to imagine mathematics as consisting of puzzles to solve, as well as patterns to discover and appreciate. This is equally true today. Of course, one's skill-set and toolbox, experience and domain knowledge keep increasing, which helps in research. The evergreen area of mathematics in which he works, and the continuous search for connecting novel research to both results of old masters, as well as other areas of mathematics and the broader sciences, is something that excites him tremendously.

Outside mathematics, Prof. Khare was always interested in music. While in high school, he completed his Sangeet Visharad in Hindustani vocal, and continues to sing. And likes to spend time with his family. •

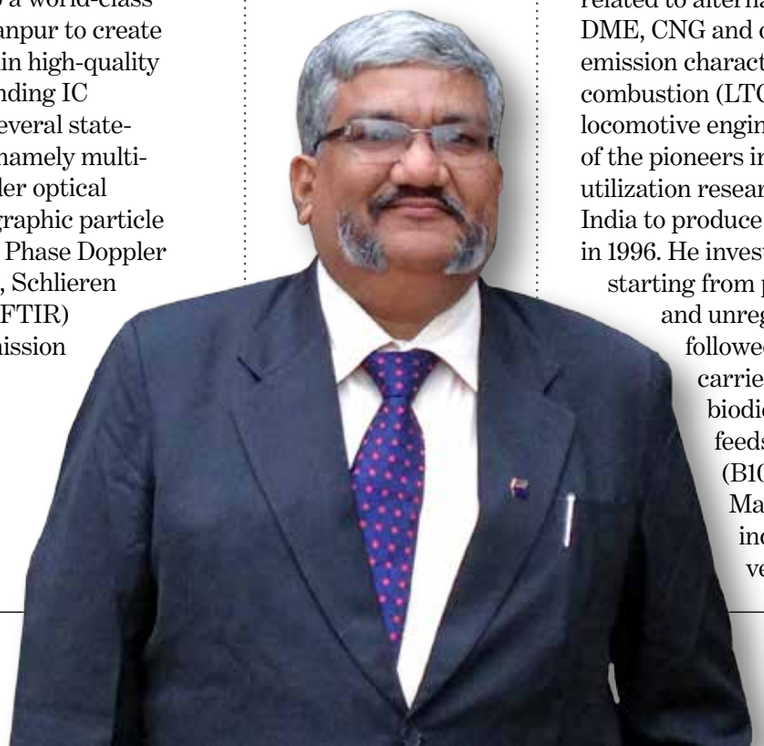
DR AVINASH KUMAR AGARWAL

At Full Blast

IC Engine Man of India, more formally known as Prof. Avinash Kumar Agarwal, a mechanical engineer, tribologist, and SBI Endowed Chair Professor at the Department of Mechanical Engineering, Indian Institute of Technology–Kanpur, was born in Karauli in Rajasthan in 1972. Avinash discovered his passion for research early on under the guidance of Prof. Swadesh Gupta, his mentor at Malviya Regional Engineering College, Jaipur, during his undergraduate days. After that, he chose to go to the Centre for Energy Studies, IIT Delhi, to pursue his MTech and PhD degrees in IC engines under the mentorship of Prof. LM Das. Immediately after his PhD thesis submission at IIT Delhi in August 1999, a post-doctoral fellowship offer from Engine Research Center, University of Wisconsin, Madison, USA, and a faculty position offer from IIT Kanpur were made to him. He took them both and went to ERC, UW Madison for the post-doctoral fellowship from August 1999–February 2001 and then joined IIT Kanpur on 20th March 2001 to start his professional career.

The main area of research of Prof. Avinash Kumar Agarwal was sustainable transport. Therefore, he embarked upon the mission to develop a world-class Engine Research Laboratory at IIT Kanpur to create promising engine technologies and train high-quality human resources to undertake outstanding IC engine research in India. He created several state-of-the-art research facilities in his lab namely multi-cylinder engine test cells, single-cylinder optical research engines, transient and tomographic particle imaging velocimetry (PIV), 2D and 3D Phase Doppler Interferometry (PDI) for dense sprays, Schlieren imaging, Fourier Transform Infrared (FTIR) emission analyzer, raw exhaust gas emission analyzers, transient and eddy current dynamometers, two-wheeler chassis dynamometer, and nano-particle size analyzer. He undertook experiments for developing fundamental understanding of in-cylinder flows and fuel droplet size distribution in the engine cylinder using optical research engines by employing 2D, 3D, and tomographic PIV and PDI techniques. Prof. Agarwal performed fundamental investigations of laser ignition of hydrogen-air and methane-air mixtures in a customized constant volume combustion chamber (CVCC) and then successfully developed and demonstrated a laser ignited engine prototypes fuelled by hydrogen, HCNG, and CNG. His research on laser ignition paved the way for developing the next-generation automotive hydrogen/CNG/HCNG engines with a potential for commercialization.

> **"India's growth story depends on the development of efficient, emission compliant engines, powered by low carbon fuels, produced locally."**



Prof. Agarwal has carried out applied research related to alternative fuels (biodiesel, ethanol, methanol, DME, CNG and other gaseous fuels), particulate emission characterization and control, low-temperature combustion (LTC), and electronic fuel injection (EFI) locomotive engine development. Prof. Agarwal is one of the pioneers in biofuels, biodiesel, and methanol utilization research in India. He was the first person in India to produce biodiesel through transesterification in 1996. He investigated biodiesel comprehensively, starting from production to engine testing, regulated and unregulated emissions, particulates, followed by field trials of the vehicles. He carried out extensive research studies on biodiesel production from different Indian feedstocks. The field trials of biodiesel (B100) fuelled SUVs for Mahindra and Mahindra boosted Indian automotive industry's confidence in biodiesel's vehicular applications. He has published

Clockwise: Receiving the Shanti Swarup Bhatnagar Prize from Prime Minister Narendra Modi, 2019

Demonstrating agricultural engine research to former Union Minister Arun Shourie, during his visit to ERL, IIT Kanpur, 2007

Prof. BN Suresh, President INAE inducting Prof. Agarwal to INAE fellowship at DIAT, Pune, 2015

With his wife at AVL headquarters, Austria, 2013

Dr AK Sood, President INSA awarding Rajib Goyal Prize to Prof. Agarwal, Kurukshetra University, 2017

Receiving Clarivate Analytics India Citation Award from Dr R Chidambaram, PSA, GoI, 2017

Inset: Receiving SAE Ralph R Teetor Educational Award from Dr TW Ryan, President SAE International, Detroit, US, 2008

AWARDS

- Shanti Swarup Bhatnagar Prize (2016)
- Clarivate Analytics India Research Excellence – Citation Award (2017)
- NASI-Reliance Industries Platinum Jubilee Award for Application Oriented Innovations in Physical Sciences (2012)
- INAE Silver Jubilee Young Engineer Award (2012)
- Ralph R Teetor Educational Award (2008)

PUBLICATIONS

- 'Spray Droplet Size Distribution and Droplet Velocity Measurements in a Firing Optical Engine'. *Physics of Fluids* (2020).
- 'In-cylinder spray and combustion investigations in a heavy-duty optical engine fueled with waste cooking oil, Jatropha, and Karanja biodiesels'. *ASME Journal of Energy Resources Technology* (2019).
- 'Mutagenicity and Cytotoxicity ofParticulate Matter Emitted from Biodiesel-Fueled Engines'. *Environmental Science and Technology* (2018).

numerous influential technical papers in the field of IC engines and biofuels. He has recently developed several prototype two-wheelers running on M85 and M15, displacing a large fraction of gasoline (85% & 15% v/v) by methanol produced from low-value biomass and high ash coal. He has also developed prototype generators, where 85% v/v diesel was successfully displaced by methanol. Development of these prototypes was done in collaboration with respective manufacturers in his laboratory, and the products are expected to be available in the Indian market shortly. He is assisting NITI ayog in ushering 'Methanol Economy' in India. Prof. Agarwal led the development of EFI system prototype for the ALCO-DLW locomotives, the main workhorse of the Indian Railways. Prof. Agarwal has carried out extensive research related to the physical and chemical characterization of particulates and their control. He has characterized nano-particle emissions from alternative fuel-powered engines as well. He has also conducted experiments to understand the primary and secondary particulates and their mutagenicity and cytotoxicity using human cell lines. He developed low-cost diesel oxidation catalysts (DOC) to control particulate emissions and their toxicity. Non-noble metal-based catalysts were coated on the ceramic substrates and characterized for DOC development for the retro-fitment of the after-treatment devices. Prof. Agarwal played a significant role in developing the HCCI engine and its closed-loop control, which led to >95% particulate and NOx emission reductions with excellent fuel economy improvement. His work led to the development of technology for controlling lubricating oil consumption in the engine combustion chamber for the first time. Five of his students are faculty in IITs, doing IC engine related research. More than 380 international journal research papers and book chapters in top journals/books, 11,300+ Scopus and 17,300+ Google Scholar Citations are a testimony of his high-quality work. He has completed more than 35 sponsored research and consultancy projects in collaboration with highly reputed international research groups and automotive companies. One of his single-authored papers is among the top ten most highly cited articles (2,200+ Scopus citations) published from India in the engineering domain, as per NSTMIS, DST, and Thomson Reuters Report-2015.

Prof. Agarwal intends to develop newer technologies to make the transport sector more energy efficient and less polluting while using domestic fuel resources, especially methanol generated by converting waste into wealth. •

B

PROF. BALASUBRAMANIAN GOPAL
PROF. BASUDEB DASGUPTA
PROF. BEDANGADAS MOHANTY
PROF. BIMAN B MANDAL
DR BORNALI BHATTACHARJEE
PROF. BUSHRA ATEEQ

PROF. BALASUBRAMANIAN GOPAL

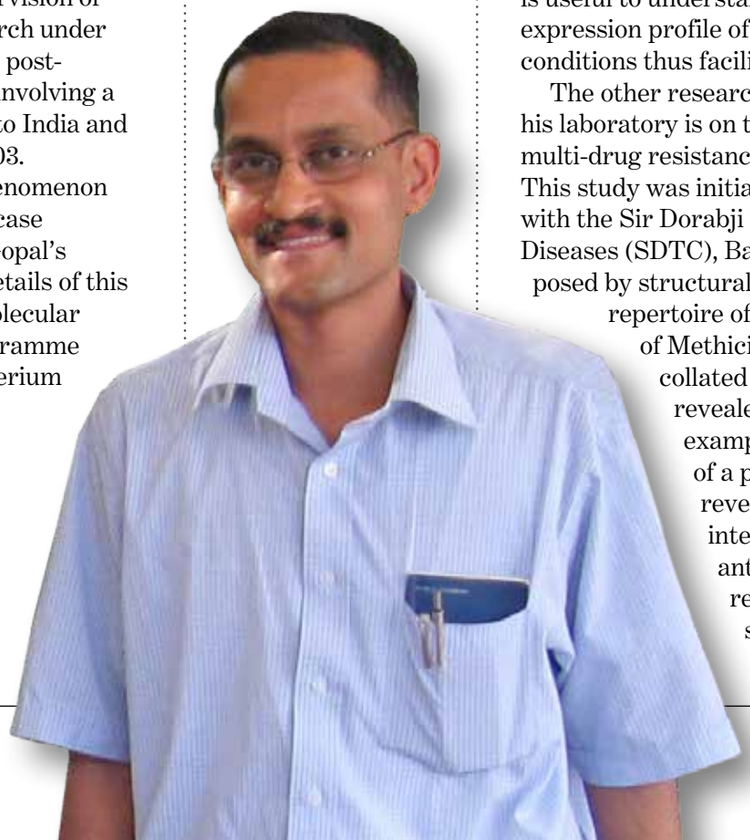
Leading Transformation

Prof. B Gopal was born in Nagpur, Maharashtra, his father, R Balasubramanian, worked for the Military Engineering Services and his mother, B Kalyani, was a teacher. He studied at the Maharashtra Education Society, Pune, before obtaining his master's degree in physics from the Indian Institute of Technology, Kanpur. This phase of his education was inspired by the atmosphere that cherished the ideals and values of the founder of the Maharashtra Education Society, Vasudev Balwant Phadke – a freedom fighter and social activist. After a brief stint with the R&D unit of a pharmaceutical company (Torrent Pharmaceuticals, Ahmedabad), he completed his PhD from the Indian Institute of Science. He, subsequently, went to the MRC-National Institute for Medical Research in London where he was involved in structural biology research under the supervision of Prof. Guy Dodson and mycobacterial research under Dr Jo Colston. After an industry-partnered post-doctoral stint at the University of Chicago involving a start-up, GeneFormatics, Inc, he returned to India and joined the Indian Institute of Science in 2003.

Bacteria change their phenotype – a phenomenon that is of great relevance especially in the case of pathogenic bacteria. Researchers in B Gopal's laboratory aim to understand molecular details of this phenotypic switch using structural and molecular biology methodologies. This research programme focuses on two model systems – Mycobacterium tuberculosis and Staphylococcus aureus (human pathogens).

The focus of his recent work has been on the structural and mechanistic investigations on the transcription initiation factors, also known as σ factors, from Mycobacterium tuberculosis. The structural and functional studies on M. tuberculosis σ factors provide an insight into the diverse regulatory mechanisms that govern σ factor activity. Having determined structures of several M. tuberculosis σ factors – alongside biochemical and mechanistic studies – provided a hint, for the first time, into the diverse mechanisms that govern gene expression in this pathogen. These studies over the past two decades have led to a comprehensive data-set that is useful to understand factors that change in the expression profile of M. tuberculosis under different conditions thus facilitating the phenotypic switch.

> **"An important part of this journey is our interactions with co-workers who contribute in their own distinct ways."**



The other research question being addressed in his laboratory is on the molecular mechanisms of multi-drug resistance in Staphylococcus aureus. This study was initiated as a collaborative effort with the Sir Dorabji Tata Center for Infectious Diseases (SDTC), Bangalore. Mechanistic hypothesis, posed by structural data, are examined using a repertoire of laboratory and clinical strains of Methicillin-Resistant S. aureus (MRSA) collated by SDTC. This strategy revealed several practical insights, for example, structure-function analysis of a penicillin-binding protein (PBP4) revealed a hitherto unsuspected interplay between b-lactam antibiotics and antimicrobial resistance in S. aureus. An off-shoot of this was the development of a cost-effective detector

AWARDS

- BM Birla Science Prize in Biology (2006)
- International Senior Research Fellow of the Wellcome Trust (2006)
- Organization of Pharmaceutical Producers in India (OPPI) Scientist Award (2010)
- DBT National Bioscience Award for Career Development (2010)
- Shanti Swarup Bhatnagar Prize (2015)

PUBLICATIONS

- 'Molecular Basis for the role of Penicillin Binding Protein 4 in the interplay of σ-lactam antibiotics and antimicrobial resistance in Staphylococcus aureus'. *J Bacteriology* (2010).
- 'Structural and biochemical basis for the redox sensitivity of Mycobacterium tuberculosis RslA'. *J Mol Biol*. (2010).
- 'Mycobacterium tuberculosis RsdA provides a conformational rationale for selective regulation of σ factor activity by proteolysis'. *Nucleic Acids* (2013).
- 'The fused Snoal_2 domain of the Mycobacterium tuberculosis sigma factor σ J modulates promoter recognition'. *Nucleic Acids* (2017).

Clockwise: Receiving the Shanti Swarup Bhatnagar Award from Dr Harsh Vardhan, Minister for Science and Technology

During the first phase of setting up of an independent laboratory

At the X-Ray facility for macromolecular crystallography

At the initiation ceremony as a Fellow of the Indian National Science Academy, New Delhi

In the x-ray laboratory with Professor Dorothy Hidgkin and Professor M Vijayan

During an inspection at the Elettra Sincrotrone, Trieste

Inset: Receiving the Organization of Pharmaceutical Producers of India Award from Maharashtra CM, Prithviraj Chavan, 2010

for MRSA strains using titania nanotube-modified screen-printed carbon electrodes. Over the years, work in his laboratory led to a start-up biotechnology company involving the structure-based rational design of enzymes involved in the manufacture of active pharmaceutical ingredients. This work – aided by the Ucchatar Aavishkaar Yojna – led to an enzyme library for the biosynthesis of Active Pharmaceutical Ingredients (APIs). More recently, his group has focused its attention on making synthetic microbes that can produce select phytochemicals – a research theme aided in part by their earlier work on bacterial gene expression profiling and molecular microbiology.

This research programme was primarily initiated by a generous grant from the Wellcome Trust, United Kingdom (International Senior Research Fellow of 2006-2011). The Department of Science and Technology (DST) has been a constant source of support for this programme from its inception. A mentor who substantially shaped this phase was Professor M Vijayan – a towering personality who laid the foundation for structural biology research in the country.

Prof. Gopal was influenced to a great extent by his PhD thesis examiner Prof. Guy Dodson, who later became his post-doctoral mentor and then moved on to being a friend, philosopher and guide in later years. Prof. Vijayan has been his closest colleague with whom he has had the fortune to interact closely for over two decades. These associations have enriched him immensely.

As might be the case with 'career' scientists, the workplace also often doubles up as a location to meet and interact with people. Apart from research and teaching, Prof. Gopal has an interest in reading and learning about entrepreneurship and research-driven companies in the biotechnology sector. Serving as a consultant to some of them provides an opportunity to understand their thought processes and perspective.

Enthused by the possibilities that synthetic biology has to offer, he looks forward to working more in this area with potential applications that might lead to transformative technologies.

While he never had the opportunity to learn music, he appreciates both classical Hindustani and Carnatic music. •

PROF. BASUDEB DASGUPTA

Following in Big Footsteps

Prof. Basudeb Dasgupta is a theoretical physicist at the Tata Institute of Fundamental Research (TIFR) in Mumbai. His specialization is in the field of neutrinos, dark matter, stars, and black holes. Leading a partner-group of the Max Planck Institute for Physics (MPI), he is active in training doctoral and postdoctoral researchers and communicating science to the public at large.

Basudeb was born in Khetri – a small town in Rajasthan where Swami Vivekananda had found the patronage of the ruler of Khetri for his momentous journey to the West. Basudeb's parents, Ratna and Hari Ratan Dasgupta, moved to Kolkata soon after he was born. Upon finishing school, he enrolled for a BSc in Physics at Jadavpur University, where he found a number of extraordinary teachers. Encouraged further by a KVPY fellowship awarded by the DST, he decided to pursue a career in scientific research.

Basudeb joined the PhD program at TIFR, and worked for his PhD under the supervision of Prof. Amol Dighe. During his PhD, he produced world-class work on how neutrinos inside a supernova change their flavour in a collective manner. He then held postdoctoral assignments at the MPI in Munich, at the Ohio State University, and finally at the ICTP in Trieste, before joining TIFR as a member of its faculty.

Prof. Dasgupta works in the field of theoretical astroparticle physics. How do massive stars explode? What impact do neutrinos, those tiny elusive particles, have on these massive astronomical fireworks? What role do they play in the Universe? What is dark matter? How can we infer its properties? What are black holes made of? These are questions that have occupied him for the past two decades.

Prof. Dasgupta has played a leading role in understanding collective neutrino oscillations in dense astrophysical environments. Neutrinos come in three flavours, and usually these neutrinos change their flavour at a rate proportional to their mass-squared divided by energy, which is typically less than once per kilometer. This can increase to several times per centimeter when the density of neutrinos is large. Dasgupta and his students addressed this highly nonlinear problem. They identified the simplest situation that allows these faster oscillations and solved it. In work that has followed, they have showed how these oscillations lead to a mixing of all the neutrinos, which has major consequences for how supernovae explode. Observations made using large detectors such as DUNE, Super/Hyper-K, and IceCube, may be able to detect neutrinos from a supernova explosion in and around our galaxy. Or perhaps, one might be able to see more neutron star mergers using LIGO and follow-up observations. All these have the potential to reveal important and unexplored aspects of neutrino oscillations inside stars, which will test the theories and possibilities so-explored.

He has also made insightful contributions towards identifying

> **"Science is the greatest wonder of the world. It is our duty to further its unmatched legacy."**

Clockwise: Interacting with young children at the Times Litfest 2016 in Mumbai

In a discussion with Prof. Alexei Smirnov (left), a neutrino physics researcher and one of the discoverers of the MSW Effect, during Neutrino 2008 in New Zealand

Basudeb Dasgupta- In his office

During formative years as a KVPY Fellow

With students and visitors including Prof. Georg Raffelt, Max Planck Institute for Physics, Munich, Germany

With Prof. Valery Rubakov, renowned theoretical physicist, and students during 2005

During a workshop

Inset: Delivering a lecture at the Vigyan Samagam 2019

AWARDS

- ICTP Prize (2019)
- Swarnajayanti Fellowship (2020)
- Max Planck Partner – Group Leader (2016)
- Ramanujan Fellowship (2015)
- INSA Young Scientist Medal (2011)

PUBLICATIONS

- 'Fast Flavor Depolarization of Supernova Neutrinos'. *Phys Rev Lett 126* (2021).
- 'Low Mass Black Holes from Dark Core Collapse'. *Phys Rev Lett 126* (2021).
- 'Neutrino and positron constraints on spinning primordial black hole dark matter'. *Phys Rev Lett 125* (2020).
- 'A Selection Rule for Enhanced Dark Matter Annihilation'. *Phys Rev Lett 118* (2017).
- 'Fast Neutrino Flavor Conversions near the Supernova Core with Realistic Flavor-dependent Angular Distributions'. *JCAP 1702* (2017).

the particle nature of dark matter. This includes theoretical ideas, as well as experimental strategies to test the ideas. His most recent works present remarkable neutrino and positron-based constraints that disfavour the possibility that miniscule black holes from the Big Bang may contribute significantly to the still unidentified dark matter. Instead, they show that sub-solar mass black holes, violating the naïve Chandrasekhar limit, can be produced by the accretion of dark matter in neutron stars. Upcoming observations, including LIGO, and SKA will shed light on these tantalizing predictions.

Prof. Dasgupta has been recognized as an outstanding scientist in India and abroad. He has published over 50 research papers in top journals such as the Physical Review Letters, and he is frequently a plenary speaker at major international conferences. He has been awarded the Young Scientist Medal for 2011 by the Indian National Science Academy, and the Ramanujan Fellowship and the Swarnajayanti Fellowship of the Department of Science and Technology (DST). The Abdus Salam International Center for Theoretical Physics in Trieste, awarded him the ICTP Prize for 2019.

Upon being asked, what attracts him to astroparticle physics, Prof. Dasgupta says that he finds the symphony of the very small and the very big very exciting. At the smallest distances, much smaller than atoms, the relevant laws of nature are those of particle physics. At the largest distances, almost everything is controlled by gravity. Astroparticle physics is about the interplay of these different forces at different distance and time scales, and encompasses a wide variety of beautiful phenomena. Legendary Indian scientists, Bhabha, Chandrasekhar, and Saha, have all made monumental contributions that have strong connection to astroparticle physics. It is, therefore, a great privilege to have the opportunity to follow in their footsteps.

Outside of science, Prof. Dasgupta enjoys travel, food, art, and music. •

PROF. BEDANGADAS MOHANTY

Going the Limit

Fascinated by the mysteries of dark matter in the universe, Prof. Bedangadas Mohanty, Professor and Dean of Faculty Affairs at National Institute of Science Education and Research, has started a detector R&D programme in technical collaboration with other groups to reach the best limits of detection sensitivity for dark matter searches. In addition, he is exploring to conduct such search by building experiments in India.

One of his key passions has been to interact with young minds and contribute towards institute building. He has devoted significant amount of effort and time in building the academic programme, administrative structure, and scientific/health infrastructure at National Institute of Science Education and Research. Not limiting himself, he has extended help to neighbouring organizations in Odisha, like Indian Institute of Science Education and Research Berhampur, Utkal University, Ravenshaw University, Department of Higher Education and State Higher Education Council, Odisha, Regional Institute of Education and those outside Odisha like the Homi Bhabha National Institute and IIT Gandhinagar. His constructive involvement with experimental facilities abroad and their development, has led to his nomination as a memberof the advisory committee of CERN users and he was executive member of the relativistic heavy ion collider (RHIC) users committee.

Working from India and using experimentalfacilities at the CERN, Geneva and Brookhaven National Laboratory (BNL), New York, Prof. Mohanty has made significant contribution to the understanding of the phase diagram of strong interactions, one of the four basic interactions in the universe. He has contributed towards the establishment of a primordial state of matter, free state of quarks and gluons (QGP), in laboratory similar to a microsecond old Universe. The experiments are required to heat ordinary matter to more than trillion degree kelvin to melt to its fundamental constituents.

"The journey towards achieving the science goals is more important than the goal itself and requires plenty of patience and resilience."

He along with his collaborators was the first to carry out a direct comparison of the experimental data and fundamental theory of strong interactions in a paper published in Science (Science 332 (2011) 1525), which according to the 'physics world' is considered among the 10 best works in the year 2011. The QGP has been found to be a perfect and most vortical fluid found in nature.

He is one of the key people to have initiated a new experimental programme to establish the phase diagram of strong interactions (proposed to the community in 2009 summary talk in the top-most conference of field – Quark Matter, Knoxville, USA), called the beam energy scan program, at RHIC facility at BNL. His work hasled to an exciting possibility of the existence of a critical point in the phase diagram. His papers on critical point search in the femto-scale systems are considered as a landmark work in the field. The phase diagram of strong interactions when established is likely to find a place in the textbooks in schools alongside the phase diagram of water.

Prof. Mohanty as the physics analysis coordinator and later as deputy spokesperson of the STAR experiment, a multi-institutional and multi-nation collaboration, led a team that discovered the heaviest known anti-matter nuclei the anti-alpha (consisting of two anti-protons and two anti-neutrons) in the laboratory (Nature 473(2011) 353) and the heaviest strange anti-matter nuclei (Science 328 (2010) 58). Normal nuclei are formed only of protons and neutrons. Hyper-

AWARDS

- Fellow, American Physical Society (2020)
- Fellow, Indian National Science Academy (2016)
- Shanti Swarup Bhatnagar Prize in Physical Sciences (2015)
- JC Bose National Fellowship (2017)
- Swarnajayanti Fellowship (2011)

PUBLICATIONS

- 'Scale for the Phase Diagram of Quantum Chromodynamics'. *Science Science* (2011).
- 'Observation of the antimatter helium-4 nucleus'. *Nature* (2011).
- 'Nonmonotonic Energy Dependence of Net-proton Number Fluctuations'. *Physical Review Letters* (2021).
- 'Evidence of Spin-Orbital Angular MOmentum Interactions in Relativistic Heavy-Ion Collisions'. *Physical Review Letters* (2020).
- 'Multiplicity and pseudorapidity distributions of photons in Au + Au collisions at 62.4-GeV'. *Physical Review Letters* (2005).

Clockwise: Receiving the Shanti Swarup Bhatnagar Award in Physical Sciences from Union Minister of Science and Technology Dr Harsh Vardhan

Receiving the Department of Atomic Energy Young Scientist Award from Dr APJ Abdul Kalam and Director-BARC Dr Srikumar Banerjee

Being felicitated by Chief Minister of Odisha, Naveen Patnaik

In front of detector at CERN

Being felicitated by the Governor of Odisha, Senayangba Chubatoshi Jamir

Being felicitated by Director NISER on receiving SSB Award

Inset: At the detector laboratory for ATLAS experiment in Geneva

nuclei are made up of proton, neutron and a hyperon. The anti-hypertrion, nuclei consists of anti-proton, anti-neutron and anti-lambda (a strange hadron). It has implications for neutron stars and also understanding of the nuclear force. To study nuclei, scientists arrange the various nuclides into a two-dimensional table of nuclides. On one axis is the number of neutrons, and on the other is the number of protons. Owing to the discovery of anti-hyperon, it introduces a third axis (strangeness) and the table has become three-dimensional.

During his PhD years, JD Bjorken, Frank Wilczek (Nobel Laureate) and collaborators had advocated the existence of Disoriented Chiral Condensates (DCC) due to chiral phase transitions in Quantum Chromodynamics (QCD, theory of strong interactions) matter. These domains, which are analogous to misaligned domains of a ferromagnet, relax back to ground state configuration by emitting pions of particular species. Towards this goal and since neutral pion readily decays to photons, Prof. Mohanty took up the challenge of finding DCC's in high energy nuclear collisions using detectors built in India. He is the lead author of the Physical Review Letters paper on inclusive photon production in heavy-ion collisions using the Indian detector. His pioneering contribution to the physics of DCC in heavy-ion collisions led to the invitation from the editorial board of Physics Reports to write a review article, at the young age of 30 years.

Recently, he got the prestigious scientific associate position at CERN and currently is the spokesperson of India-STAR-ALICE collaboration. His group found the evidence of spin-orbital angular momentum interactions in QCD matter produced at Large Hadron Collider, which may open up new sub-fields in the area. In physics, the spin-orbit coupling has led to the discovery of the shell structure of nuclei in nuclear physics, the fine structure in atomic physics and is a key ingredient in the field of spintronics in material sciences. The work published in Physical Review Letters was chosen by the editors to be highlighted, featured in CERN Courier and Prof. Mohanty was invited to present the findings at CERN main auditorium (2020).

A multi-faceted person, with outstanding contributions to frontier area of science research, inspirationalcontribution to science education, he has played a role in development of science, science policy (part of drafting committee of Mega Science Vision 2035 conducted bythe PSA office, standing committee of young scientists of DST, Member of DAE-DST committee on CERN projects) and science infrastructure (DST-FIST, SERB school in EHEP) in the country. Apart from regular duties, he takes a very active part in science popularization activities. •

PROF. BIMAN B MANDAL

The Sky is the Limit

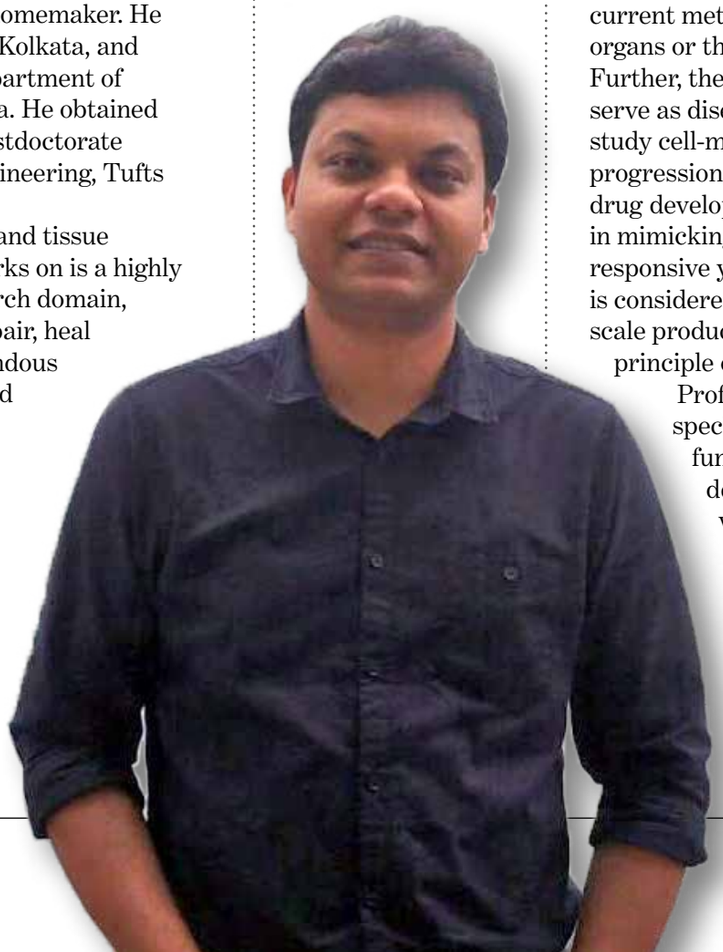
Drawn to the applicability of science to solve real-life problems led Prof. Biman B Mandal to research on lab-grown bioengineered tissues/organs as promising substitutes to save precious lives. One got a reflection of his inquisitive mind during his school days when, apart from science subjects, he preferred 'SUPW or Socially Useful Productive Work', where there was ample scope to nurture innate curiosity by making scientific models or creating useful things out of waste.

Prof. Mandal is a Professor at the Department of Biosciences and Bioengineering and Centre for Nanotechnology, IIT Guwahati and he also holds the Associate Dean, Academics (Undergraduate) position. Born in Purulia district of West Bengal, his father, Satyabrata Mandal, was in government service and mother, Shanti Rani Mandal, a homemaker. He graduated from Presidency College, Kolkata, and completed his master's from the Department of Biotechnology, HP University, Shimla. He obtained his PhD from IIT Kharagpur and postdoctorate from Department of Biomedical Engineering, Tufts University, Boston, USA.

The topic 'regenerative medicine and tissue engineering' which Prof. Mandal works on is a highly interdisciplinary translational research domain, which deals with body's ability to repair, heal and regenerate. The field has tremendous applicability being directly associated with human health, welfare and has the potential to contribute towards addressing an unmet world problem related to 'organ shortages'.

Acute shortage of matching organs and tissue donors have created a never-ending queue for patients and increased fatality rates. Except finding compatible donor's there is no current alternative to allow patients a healthy life. Thus bioengineered lab-grown organs could come a long way in saving millions of lives every year once successful. Research in this domain has made tremendous progress in a short span in understanding the cellular requirements to create such functional alternatives. However, current methods are not fullproof in fabricating whole organs or their large-scale affordable production. Further, the lab grown in-vitro tissues/organs can serve as disease model and as a great platform to study cell-material-cell interactions, emulate disease progression, help explore newer pathways aiding drug development. Innovative design parameters in mimicking native structures and choosing cell responsive yet low cost immune-compatible materials is considered essential to attain affordability, large-scale production and total functionality akin to the principle of 'form follows function'.

> **"Trust your crazy ideas and keep working hard as sky is the limit."**



Prof. Mandal's laboratory at IIT Guwahati specifically focuses on recreating these functional tissues/organs using naturally derived silk biomaterials in combination with cells and added supportive factors using latest 3D bioprinting and other conventional techniques. The team also creates in vitro 3D disease models, for example, osteoarthritic, liver cirrhosis, cancer tumor as an alternative to existing animal models. Such in vitro model promises as a great platform to study cell-material-cell interactions,

Clockwise: Receiving the NASI-SCOPUS Award in Medicine from DST Secretary, Dr Ashutosh Sharma

Receiving the NASI Young Scientist Medal from Prof. Manju Sharma, President and Executive Director, IIAR

During his post-doc days at the Tufts University. No 'boundary of subjects' was the coolest thing during his research, he feels

With his wife Dr Nandana Bhardwaj

With Prof. CP Sharma

With Prof. Robert Langer of Massachusetts Institute of Technology

Inset: With Prof. Nadrian Seeman, the father of DNA Nanotechnology

AWARDS

- Swarnajayanti Fellowship (2020)
- S. Ramachandran National Bioscience Award (2020)
- BM Birla Science Award (2018)
- INSA-Medal for Young Scientists (2015)
- NASI-Young Scientist Platinum Jubilee Award (2013)

PUBLICATIONS

- '3D printed silk-based biomimetic tri-layered meniscus for potential patient specific implantation'. *Biofabrication* (2020).
- 'Non-mulberry Silk Based Ink for Fabricating Mechanically Robust Cardiac Patches and Endothelialized Myocardium-on-a-chip Application'. *Advanced Functional Materials* (2020).
- 'Silk-based multilayered angle-plyannulus fibrosus construct to recapitulate form and function of the intervertebral disc'. *PNAS* (2018).
- 'Immunomodulatory injectable silk hydrogels maintaining functional islets and promoting anti-inflammatory M2 macrophage polarization'. *Biomaterials* (2018).

recapitulate human disease phenotype and emulate disease progression. In future, this would help explore newer pathways aiding drug development and high throughput screening by pharmaceutical companies in a cost effective manner without harming animals.

To build a tissue or an organ in lab, Prof. Mandal uses a 3D platform or 'scaffold' for cells to grow on and organize in a controlled environment using specialized bioreactors. The protein silk scaffold being degradable gets broken down and used up as amino acids and subsequently replaced by cellular matrix secreted by own body cells as it matures. Without the 3D scaffold which fulfils certain parameters, cells alone cannot form a tissue in vitro. Prof. Mandal's lab is one of its kind in the country and internationally recognised for their work in the field of tissue engineering which uses natural bioresource 'silk' from Indian wild endemic varieties i.e. Tasar (A. mylitta), Muga (A. assama), Eri (P. ricini). The silk varieties have been proven to be superior with special cell binding RGD sites material properties making them ideal for such bioengineering applications. The groups published research articles have ushered a new global interest in Indian silk bioresource as a potential biomaterial apart from its known conventional use as a textile fiber and has been covered by BBC India, *Scientific American* and *New Scientist*.

As an outcome of their research endeavour at IITG, Prof. Mandal and his team could develop a number of affordable tissue engineered prototypes/products which are in various phases of lab/animal validation. These include, smart wound dressings for treating chronic and diabetic foot ulcer wounds, small diameter blood vessels as graft for by-pass surgery, beating cardiac patch for treating myocardial infarction, bioartificial skin grafts for burn injury, implantable bioartificial pancreas releasing insulin for type-1 diabetes, intervertebral disc grafts for spinal injury, corneal grafts for vision restoration, meniscus grafts for knee injury, bioartificial liver devices for liver cirrhosis, bone and cartilage grafts for osteochondral repair, minimally invasive drug eluting injectable gels for targeted cancer therapy, lab-grown meat and in vitro disease models for drug-screening applications.

The group has published 145 highly cited high impact research articles in prestigious journals, filed 19 patents and licensed 3 technologies. Prof. Mandal draws inspiration from his family, teachers and mentors, including Prof. SC Kundu (PhD) and Prof. David L Kaplan (Post-doc). No 'boundary of subjects' is the coolest thing in his research, he feels. •

DR BORNALI BHATTACHARJEE

Making Headway

Growing up in a quiet and picturesque town was a pleasant experience for Dr Bornali Bhattacharjee in spite of financial hardship. Born in Shillong, Meghalaya, to Bimal Kanti Bhattacharjee, a small-time stationery goods' store owner, and Kalyani Bhattacharjee, a housewife, she attributes her success to the discipline that her parents practiced at home, as well as the sacrifices they made to be able to support her education. After, completing her BSc from Shillong, she shifted to Kolkata to pursue her master's in biochemistry from the University of Calcutta. She cracked the NET and the Indian Statistical Institute (ISI) fellowship exams and qualified for both the fellowships to join ISI, Kolkata, in 2002, and thus began her research career under the mentorship of Prof. Sharmila Sengupta and Prof. Chandralekha Duttagupta.

Dr Bhattacharjee's domain of interest during her PhD was pathogen evolution, especially those affecting women like human papilloma viruses and cytomegalovirus and bacterial infections that affect the neonates, especially those born before term. She completed her PhD training on the molecular epidemiology and genomics of human papillomavirus (HPV) infections in cervical cancer in 2008. Under the supervision of Prof. Sharmila Sengupta, Dr Bhattacharjee worked on HPV 16 associated cervical cancer (CaCx). Her work focused on understanding the role of viral load, haplotype variations and viral genome methylation patterns in cancer. High viral loads and HPV integration leading to the loss of an inhibitor E2 were considered to be the only path towards abrogated and high expression levels of the E6 and E7 onco-proteins. These proteins are known to be the key modulators of CaCx causation. With their research, they were able to show for the first time the presence of distinct methylation patterns in E2 binding sites, which significantly contribute to abnormal levels of E6 and E7 proteins leading to CaCx formation. They were also able to identify patient specimens with low viral loads and integration, while the presence of episomal DNA was associated with high viral loads. They further worked across different ethnic groups and identified the role of viral genomic variability. All of these findings made significant contributions to the understanding of HPV associated cervical cancer and led to the publication of 4 first authored and two second authored articles in peer-reviewed journals.

> **"Discipline, diligence, and a positive attitude is what one needs to pursue a career successfully."**

To extend her understanding of the molecular mechanisms contributing to the replication of DNA viruses, she joined the laboratory of Prof. Timothy F Kowalik [University of Massachusetts Medical School (UMass), Worcester, as a postdoctoral fellow in 2009. The first line of research in the laboratory is to elucidate the role of DNA damage response in human cytomegalovirus (HCMV) infection. Her presence and expertise in clinically oriented viral genomics helped redirect the laboratory's focus towards defining the role of herpes viruses in human diseases, such as symptomatic congenital infections and malignant gliomas. The first project she took up can be best described as Novel

AWARDS

- Ramanujan Fellowship (2015)

PUBLICATIONS

- 'Association of clade-G SARS-CoV-2 viruses and age with increased mortality rates across 57 countries and India'. *Infection, Genetics and Evolution* (2021).
- 'Prevalence of Colistin Resistant, Carbapenem-hydrolyzing Proteobacteria in Hospital Water bodies and Out-falls of West Bengal, India'. *International Journal of Environmental. Research and Public Health* (2020).
- 'Bactericidal activity of Lactic acid against clinical, carbapenem-hydrolyzing, multi-drug resistant Klebsiella pneumoniae planktonic and biofilm-forming cells'. *Antibiotics (Basel)* (2019).
- 'Extensive genome-wide variability of human cytomegalovirus in congenitally infected infants'. *PLoS Pathogens* (2011).

Clockwise: With her students

In her office. Dr Bhattacharjee's long-term goal is to develop genome-based 'anticipatory' diagnostics of bacterial and viral infections that can help in the prescription of more resilient antimicrobial treatments

Early years as a student (an image taken at Massachusetts, USA during her postdoctoral training)

Standing with her mentors Dr Chandralekha Duttagupta and Prof. Sharmila Sengupta

With Nobel Laureate Prof. Harold E Varmus, virologist and former Director of NIH

During a Panel Session at the Kolkata Chapter of YIM

During a discussion with school students at IISF, Kolkata

Inset: An exhibit of her work on bacteria

anti-CMV immunotherapy for glioblastoma (GBM), which directly fitted with her interest in identifying the role of viral infections in cancer. This project gave her the opportunity to work under the joint supervision of Prof. Kowalik and Prof. Trudy Morrison (UMass, Worcester). Presence of human cytomegalovirus in GBM had been a topic of contention in the scientific community. Her work in GBM patient specimens emphasized the existence of HCMV in glioma tissues and the presence of a cascade of viral protein expression typical of a replicative virus. He also found evidence of cancer-associated viral coding region (pp65) genotypes. The presence of elevated tri-allelic and tetra-allelic sites in the cancer-associated, HCMV genome sequences further argued towards the presence of distinct cancer-associated mutation rates within the viral genomes in comparison to human genomes. They, along with Robert Kalejta at the McArdle Laboratory of Cancer Research, Wisconsin, were the first to identify the presence intact and complete HCMV genomes with the potential to replicate in GBM. As a postdoctoral fellow she has contributed to research leading to five publications with above 600 citations.

She currently holds an Associate Professor position at the Amity University, Kolkata. Her long-term goal is to develop genome-based 'anticipatory' diagnostics of bacterial and viral infections that can help in the prescription of more resilient antimicrobial treatments especially among neonates and infants. In the last five years, her research focus has been on understanding the impact of early use of antibiotics on nasal microbial colonization among preterm neonates, constructing resistome maps and characterizing the plasticity and dynamics of these resistomes among nosocomial bacterial pathogens using next generation approaches, and on repurposing of drugs for biofilm remediation and has had 7 senior author publications so far. •

PROF. BUSHRA ATEEQ

Striking the Right Balance

Passion powers hard work, determination, and creativity that make great accomplishments possible and when one is paid for what one really enjoys doing, it's a win-win situation. Prof. Bushra Ateeq is one such person who has been able to strike that balance.

Born in Bareilly, she is the eldest child of Mohammad Ateeq and Aqeela Khatoon, a lecturer in a government college in Bareilly, who was a huge influence on her and a constant source of inspiration in her formative years. Bushra was an inquisitive child whose favourite playthings were magnets, kaleidoscope, seashells and wooden blocks. From early childhood, she was more inclined towards sciences, and her biology teacher in high school, Mrs Kumudh Johri, further piqued her interest in Biology.

For Bushra, to become a scientist was not a sudden decision, she joined Aligarh Muslim University for senior secondary education, and continued to pursue graduation and PhD at the university. She completed her doctoral studies, under the supervision of Prof. Waseem Ahmad (Faridi), on chromosome aberrations and DNA damage caused by environmental mutagens, which inculcated in her an interest in cancer biology. Her doctoral research was on understanding the genotoxic effects of herbicides and weedicides, most of which are known carcinogens. She next decided to investigate the biology behind cancer and understand its underlying molecular mechanisms to come up with possible treatment strategies.

After her PhD, she joined Prof. Neeta Singh's laboratory at AIIMS, New Delhi, wherein, she attempted to understand the molecular basis of lung cancer. Subsequently, she received the CSIR-Research Associate Fellowship, and joined Prof. Amitabha Mukhopadhyay's group at the National Institute of Immunology, New Delhi.

> **"Have a positive attitude towards life, determination and resilience to be successful."**

A year later, supported by the Skeletal Health Research fellowship from the Canadian Institute of Health Research, Prof. Ateeq studied epigenetic mechanisms that operate in cancer progression and metastases in Prof. Shafaat Rabbani's group at the McGill University, Montreal. While in McGill she recognized the massive potential of the emerging field of genomics and the associated advances in high throughput technologies. To gain an exposure to this rapidly evolving field, she moved to the US, and joined the University of Michigan as a postdoctoral fellow under Prof. Arul Chinnaiyan. In 2013, she decided to start an independent research career, and moved back to India to join IIT-Kanpur as an assistant professor. With generous support from India Alliance DBT/ Wellcome Trust, she was able to take a vertical step forward to set up her own laboratory, work on dream projects, undertake new collaborations, and systematically initiate translational research to define rational therapeutic targets for prostate and breast cancers. Her research involves exploration of the genetic and epigenetic changes that initiate cancer and its progression. The group is also focusing on understanding the molecular events that define resistance towards chemotherapeutic drugs. The major research

Clockwise: In deep conversation with her PhD students in 2020

A glimpse of the newly setup laboratory with members of the Department Review Committee, first batch of students and postdoctoral fellows in 2014

At the Johnson Space Center, US, in 2018

With graduating MTech students in 2016

During a discussion with her PhD students in 2021

Inset: With her mother, who is a huge influence on her and a constant source of inspiration in her formative years, after a seminar for faculty position in 2011

AWARDS

- Shanti Swarup Bhatnagar Prize (2020)
- S. Ramachandran-National Bioscience Award (2020)
- Basanti Devi Amir Chand Prize in Biomedical Sciences (2019)
- CSIR-Central Drug Research Institute Award (2020)
- Sayeeda Begum Women Scientist Prize (2019)

PUBLICATIONS

- 'Transcriptional network involving ERG and AR orchestrates Distal-Less Homeobox-1 mediated prostate cancer progression'. *Nature Communications* (2021).
- 'Androgen deprivation upregulates SPINK1 expression and potentiates cellular plasticity in prostate cancer'. *Nature Communications* (2020).
- 'Epigenetic silencing of miRNA-338-5p and miRNA-421 drives SPINK1-positive prostate cancer'. *Clinical Cancer Research* (2019).
- 'Targeting NF-kappa B signaling by Artesunate restores sensitivity of castrate-resistant prostate cancer cells to anti-androgens'. *Neoplasia* (2017).

undertakings are to comprehensively understand the wide spectrum of molecular aberrations that occur in prostate cancer patients, particularly in India.

She is investigating the causative genetic factors that determine the severity of the disease, for instance, what determines that a cancer would be aggressive as it progresses or would remain indolent. She is currently carrying out a systematic investigation, wherein she is integrating transcriptomic, genomic, and epigenomic data to come up with a list of more effective diagnostic biomarkers and drug targets. She has created a strong research cluster at IIT-Kanpur of clinical oncologists over the last few years. Prof. Bushra has fostered successful collaborations with clinicians from several medical institutions, as well as with collaborators overseas. Such integrated efforts have empowered her to spearhead highly translational biomedical-clinical research that will define new therapeutic strategies for cancer patients.

Unlike the West, majority of Indian prostate cancer patients (~60-70%) come with advanced-stage metastatic disease at initial diagnosis, and unfortunately surgical castration is often considered as the treatment option for these patients. Considering these ambiguities, her team is exploring the mutational spectrum of these patients, which will deliver critical information about the disease pathobiology. Since, multiple genetic, or demographic factors including age, genetic susceptibility and race, contribute to the variability in a patient's genomic makeup, thus a comprehensive understanding of the genetic landscape of these patients is critical in determining the molecular alterations involved in disease pathogenesis. With this vision, Dr Ateeq has established an interdisciplinary team, in which the members with diverse expertise are working together to integrate their perspectives in a single research endeavour, and deliver solutions to not only better treatment strategies, but also improved and early diagnostics for cancer.

The team has an ambitious plan to map genetic aberrations specific to Indian cancer prostate patients, and develop a 'Clinical Diagnostic Test' based on the custom-designed targeted gene panel. They are also working to develop low-cost diagnostics, and develop technologies to systematically interrogate the genomes of tumors to elucidate meaningful and actionable aberrations with the ultimate goal of identifying rational cancer therapeutics.

Even though Dr Ateeq is hard pressed for time, she makes it a point to cook her own meals as she finds it therapeutic. She also likes to read and spend time outdoors. •

C–G

DR CHANDRA SHEKHAR SHARMA
DR D SRINIVASA REDDY
PROF. DEBASHISH GOSWAMI
DR DIBYENDU DAS
DR DURBA SENGUPTA
DR EKAMBARAM BALARAMAN
DR GITANJALI CHAWLA
DR GOPALJEE JHA

DR CHANDRA SHEKHAR SHARMA

From Strength to Strength

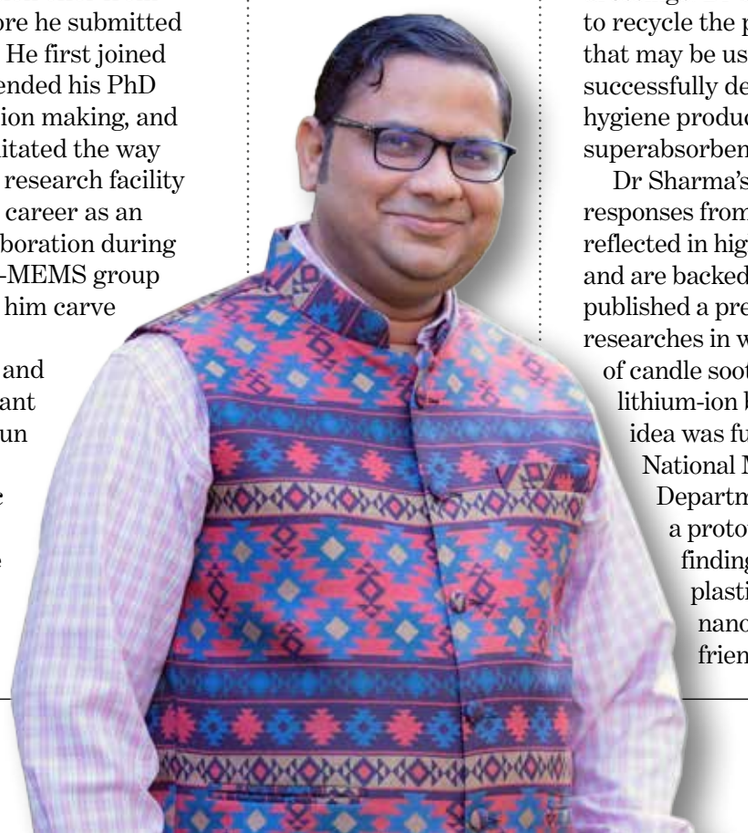
Dr Chandra Shekhar Sharma's research is not restricted to a specific kind of application domain but is centred around carbon nanomaterials. Chandra Shekhar was born in Aligarh, Uttar Pradesh, to Sriniwas Sharma, a banker, and Saroj Sharma, a homemaker. Dr Sharma gives utmost credit to one of his mentors, Prof. OP Bansal, for developing his deep interest in organic chemistry. Prof. Bansal's guidance influenced his decision to pursue chemical engineering from Zakir Hussain College of Engineering & Technology, Aligarh Muslim University.

A life-changing challenge can transform an ordinary life into an extraordinary one. His teacher during his graduation, Mrs Sheeba Jilani, ignited his thirst to excel. Just after his BTech, he joined IIT-Kanpur for a PhD in chemical engineering.

Dr Sharma received a faculty position offer from IIT Hyderabad in May 2010 even before he submitted his PhD thesis – a rarity in academia. He first joined as a postdoctoral fellow and then defended his PhD thesis! His proactive role, quick decision making, and a clear roadmap for his research facilitated the way for him to establish a state-of-the-art research facility at IIT Hyderabad very early on in his career as an independent academic. As close collaboration during his PhD with Prof. Marc Madou's Bio-MEMS group at the University of California helped him carve out a niche for himself.

Dr Sharma through his innovative and creative research has made a significant contribution in the areas of electrospun polymer and carbon nanofibers, nanostructured carbon and inorganic materials, and nature-inspired functional surfaces with a wide range of applications in domains, such as energy storage, environmental remediation, and healthcare.

> **"The clarity in thought, early planning, and timely execution pave the way to success."**



In present times, when fossil fuels are depleting sharply, an efficient energy storage system like a battery and/or supercapacitor is much needed. As Li-ion batteries have limited energy density, therefore, Dr Sharma's research on next-generation Li-S batteries and supercapacitors is quite timely.

Further, Dr Sharma's group is actively engaged in using nanofibers as a carrier for sustained release of drugs for the treatment of Leishmaniasis in the form of oral tablets and also as herbal drugs for wound dressings. Dr Sharma has developed a technology to recycle the polystyrene plastic waste into a fabric that may be used for oil-spills remediation. He has successfully demonstrated nanofibers-based feminine hygiene products that are free from non-biodegradable superabsorbent polymers.

Dr Sharma's research has received overwhelming responses from his peers. His works are regularly reflected in high-impact journals and publications and are backed by funding agencies. Notably, Elsevier published a press release on one of his breakthrough researches in which Dr Sharma demonstrated the use of candle soot carbon as the electrode to develop lithium-ion batteries for the electric vehicle. This idea was further financially supported by IMPRINT National Mission by the Ministry of Education and Department of Heavy Industries for developing a prototype. Besides, several of his research findings, such as direct recycling of polystyrene plastic waste using citrus fruits peels waste, nanofibers based environmental and user-friendly feminine hygiene products, and

Clockwise: Receiving the INAE Best Innovative Project Award, 2011

Receiving the IITK Excellence Award at the IIT 2011 Convocation

During the inauguration of CARBON lab with Prof. UB Desai, Director, IIT Hyderabad

Dr CS Sharma during an international conference in San Diego, US

At a meeting with Prof. Ashutosh Sharma, Secretary, DST

Leading the Indian delegation during the China InnoTour in Kunming, September 2019

Inset: Receiving the IEI Young Engineer Award-2016

AWARDS

- IIT Kanpur Excellence Award for Community Services (2011)
- NASI Young Scientist Platinum Jubilee Award for Physical Sciences (2017)
- DAE Young Achiever Award (2019)
- IITH Inaugural Faculty Research Excellence Award (2020)
- Swarnajayanti Fellowship in Engineering Sciences (2020)

PUBLICATIONS

- 'Candle soot carbon cathode for rechargeable Li-CO2-Mars battery chemistry for Mars exploration: A feasibility study', *Materials Letters* (2021).
- 'High absorbency cellulose acetate electrospun nanofibers for feminine hygiene application'. *Applied Materials Today* (2016).
- 'Candle soot derived fractal-like carbon nanoparticles network as high-rate lithium ion battery anode material'. *Electrochimica Acta*. (2015).

nano-fiber-based seed storage bags were highlighted in national and international media.

Yet another quantum leap from his CARBON Lab is the use of CO_2 as an energy carrier to develop indigenous Metal-CO_2 batteries for India's Mars mission. Dr Sharma's research involves utilizing the excess CO_2 from the earth's atmosphere to balance the CO_2 emissions that cause global warming and related climate changes. For his outstanding study, Dr Sharma was recently awarded the Swarnajayanti Fellowship in 2020.

Li-ion batteries are used in these space missions. However, these batteries have very limited energy density and capacity that, eventually, increases the overall weight (due to mass and volume constraints) and mission cost. These space operations critically require energy storage systems with specific yet higher capacity and energy densities to reduce the overall mission launch cost, increased payload, and science capabilities in space missions. Moreover, there is a need for a higher energy density storage system that can utilize the resources available on the Martian land for long-term operations. The metal CO_2 batteries can come as a rescue for all the above restrictions.

Dr Sharma's group, CARBON Lab, has been actively engaged for the last several years with the development of nanostructured electrode materials for energy storage devices. In recent times, they have extended their capabilities to develop Li-ion battery prototypes for electric vehicles with higher capacity and fast-charging capability. However, the same may not be applicable for use in extreme environments like in space missions. Therefore, after a serious brainstorming about the potential of new alternative chemistries, CARBON Lab is now focusing to develop the metal-CO_2 battery, which may not only offer significantly high energy density but also may work in extreme environments like Mars atmosphere. Metal-CO_2 battery by utilizing CO_2 as an energy carrier can also take care of the earth atmosphere by mitigating CO_2 emissions.

One thing that drives him is the passion, interest, and feel of satisfaction in his work. Even today, Dr Sharma feels the same enthusiasm for his research and his lab as he did ten years back during his days as an independent researcher. He also believes in popularizing science by communicating it to the common man and younger generation through social media and outreach events. As an additional responsibility of Chairperson of India's only recognized young scientist's academy, the Indian National Young Academy of Sciences (INYAS), he is actively working to promote it as a platform for young scientists to network and exchange ideas. •

75 UNDER 50

DR D SRINIVASA REDDY

In Pursuit of Excellence

Dr Dumbala Srinivasa Reddy hails from Shobhanadripuram in Telangana. His father Dumbala Narsimha Reddy was a farmer and his mother Vinoda, a housewife. He did most of his early education at Ramannapet, from where he moved to Hyderabad to complete his graduation from Sardar Patel College in 1991, and subsequently, his postgraduation in organic chemistry from Osmania University, Hyderabad, in 1993.

With a strong will to research in chemistry, he joined an eminent organic chemist Prof. Goverdhan Mehta's group at the University of Hyderabad and later at IISc. During this period, he met Vidya Ramadas who was also pursuing her PhD in the same research group and later married her. Dr Reddy feels fortunate that he found his life partner from the same background with good personal chemistry. After receiving his PhD, he moved to the US to pursue his post-doctoral research at the laboratories of Prof. Sergey A. Kozmin (University of Chicago) and Prof. Jeffrey Aubé (University of Kansas). On his return to India, he joined Dr Reddy's Laboratories, Hyderabad. However, he took the risk of moving from a corporate setup to academics, when, in 2010, Dr Reddy joined CSIR-National Chemical Laboratory, Pune, as a senior scientist. This was a turning point in his career. In 2020, he took over as the Director of CSIR-Indian Institute of Integrative Medicine (IIIM), Jammu.

Dr Srinivasa Reddy is best known for his application-oriented organic synthesis towards well-being of humans. He has made outstanding contributions in the challenging field of natural products synthesis and medicinal chemistry with the ultimate aim of discovering new drugs. In addition, the work carried out by his group on crop protection is worth highlighting.

> **"Work hard and work smart. No pain, no gain."**

Dr Reddy's research group has accomplished the total synthesis of more than 35 natural products with impressive biological properties. Unlike many others in the field, Dr Reddy's group can conceptualize schemes and choose the targets not only to provide the natural products in sufficient quantities but also to make focused libraries of compounds around the same scaffold. This strategy provides ready access to compounds from the same family for biological profiling, which helps in understanding quick Structure-Activity Relationships (SAR). Another strategy his group uses is a simplification of complex structures of natural products along with the introduction of appropriate groups to improve their druggable properties, such as absorption, distribution, metabolism, elimination and toxicity (ADMET). This strategy was demonstrated by his group on five different natural product scaffolds, such as peribysin, solomonamide, hunanamycin, cladosporin and nitrosporesine. Since, half of the marketed drugs, directly or indirectly, are derived from natural products total synthesis and evaluation of natural products and their analogues towards potential therapeutics is a promising area of research.

With his experience in the pharma industry, Dr Reddy initiated medicinal chemistry programmes

Clockwise: Dr D Srinivasa Reddy (left) receiving the prestigious Shanti Swarup Bhatnagar Award in chemical sciences, 2015

With his wife with their mentor Prof. Goverdhan Mehta

Receiving the NASI-Reliance Industries platinum jubilee award for the application oriented innovations in the area of physical sciences, 2015

With his research group (PhD students, postdocs, project assistants) at CSIR-National Chemical Laboratory, Pune

Receiving the Sun Pharma Research Award in the field of Pharmaceutical Sciences, 2018

Inset: Receiving appreciation from Padma Shri Dr Nitya Anand, eminent scientist and ex-director Central Drug Research Institute, Lucknow

using the 'Silicon incorporation approach'. This is a very useful strategy in medicinal chemistry, in particular during the lead optimization stage which helps in modulating lipophilicity, cell permeability, efficacy, selectivity and pharmacokinetic profiles. In addition, it gives intellectual property (IP) space and freedom to operate as most of the patents do not claim silicon derivatives. A relatively new space, Dr Reddy is the first one to initiate this concept in India and has identified three different chemical series. Findings from Dr Reddy's group in pre-clinical species suggest that silicon incorporation is highly useful in improving brain exposures. Overall, this particular concept has huge potential in discovering drugs in a short time with less expenditure as they use proven drugs or drug scaffolds to incorporate silicon.

His group identified a few novel compounds (design based on natural product nootkatone scaffold), which showed more than 6 hours of protection from mosquitoes (A. aegypti), a vector responsible for spreading the dengue/zika virus. In addition, these compounds also kill mosquitoes in a few minutes. The work was carried out in collaboration with Dr Sen, entomologist and also patents were filed.

In general, his research work is collaborative. He collaborates with different research groups and industries within India and outside. Dr Reddy strongly believes that any chosen research project should have a purpose. He feels lucky that he had highly motivated and dedicated group of students in his group.

AWARDS

- Shanti Swarup Bhatnagar Prize (2015)
- Sun Pharma Research Award (2018)
- NASI-Reliance Industries Platinum Jubilee Award (2015)
- OPPI Scientist Award (2017)
- CRSI Bronze Medal (2016)

PUBLICATIONS

- 'Overturning the Peribysin Family Natural Products Isolated from Periconia byssoides OUPS-N133: Synthesis and Stereochemical Revision of Peribysins A, B, C, F, and G'. *Org Let*. (2020).
- 'Specific Stereoisomeric Conformations Determine the Drug Potency of Cladosporin Scaffold against Malarial Parasite'. *J Med Chem*. (2018).
- 'Repurposing of a drug scaffold: Identification of novel sila analogues of rimonabant as potent antitubercular agents'. *Eur J Med Chem*. (2016).

His research efforts have made a significant impact in the field of organic chemistry and medicinal chemistry and has been acknowledged by the experts. As the majority of his work is based on application-oriented organic synthesis, it has clearly shown an impact on other fields as well. Recently, his group developed novel and improved process routes for drugs Ivacaftor (cystic fibrosis) and Lifitegrast (ophthalmic). Process development of drugs is expected to have an impact on API pharmaceutical industry, reduce import dependency and be an initial step towards Make-in-India initiative of the Government of India.

Dr Reddy's contributions are highly beneficial to society and have direct relevance to immediate needs. One of the molecules (Licogliflozin) discovered while he was a project leader in the industry is currently in human clinical trials (Phase-II). His research findings have resulted in more than 100 publications in reputed journals, 30 patent filings and a dozen PhD holders in the field. For his contributions, Dr Reddy received several national and international recognitions including the prestigious Shanti Swarup Bhatnagar Award in chemical sciences. Dr Reddy likes to unwind by playing tennis and badminton as well as listening to music. •

PROF. DEBASHISH GOSWAMI

At the Pinnacle of Success

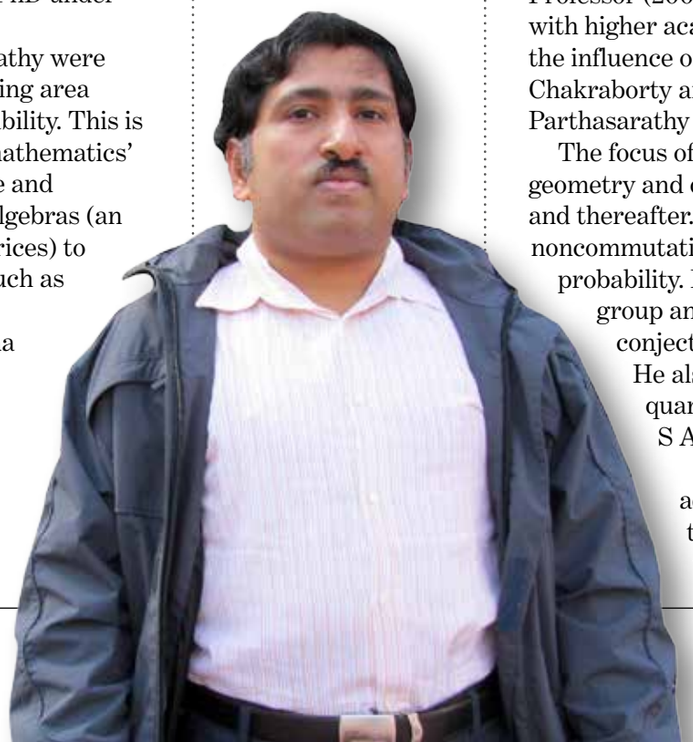
An only child of his parents, Prof. Debashish Goswami was born in Barasat, a town near Kolkata. His father Subhash Chandra Goswami taught commerce at a college and his mother Mukti Goswami was a teacher of Sanskrit in a school. Although, he liked both literature and science almost equally, it was quite early on that he identified mathematics was his calling. A defining moment, during this time, was the experience to learn the basic idea of limit in calculus from a book called *Teach Yourself Calculus*.

It was no surprise when he chose to study at the Indian Statistical institute (ISI). His academic career at ISI was full of accolades, including the ISIAA awards for securing highest marks both for BStat and MStat and also the PC Mahalanobis Symposium Award for the most outstanding student of MStat. He was fascinated with operator algebras and quantum probability pursued by Prof. KR Parthasarathy and Prof. KB Sinha and decided to work for a PhD under Prof. Sinha.

Prof. KB Sinha and Prof. KR Parthasarathy were among the pioneers of the new and emerging area called quantum or noncommutative probability. This is a part of the so-called 'noncommutative mathematics' where the basic idea is to use the language and techniques of noncommutative operator algebras (an infinite dimensional generalisation of matrices) to study diverse branches of mathematics, such as probability, topology, and geometry.

Prof. Goswami's thesis under Prof. Sinha solved an important problem of quantum probability, which helped him get a prestigious Alexander von Humboldt Fellowship to work as a post-doc at the University of Bonn following his award of the PhD degree in 2000. He spent one year there, followed by a brief stint at ICTP (Trieste) and then returned to India to join as a permanent faculty member at the level of Assistant Professor in August 2002. He became Associate Professor (2006), full Professor (2011), and professor with higher academic grade (2018). He acknowledges the influence of his mentors, notably his aunt Lakshmi Chakraborty and professors KB Sinha and KR Parthasarathy at ISI.

> **"Follow your mind to choose the path of research, instead of being influenced by what is 'fashionable'."**



The focus of his research was non-commutative geometry and quantum groups during his post-doc and thereafter. He is one of the pioneers in connecting noncommutative geometry with noncommutative probability. He formulated the first quantum group analogue of the famous Baum-Connes conjecture in a joint work with AO Kuku. He also contributed to some problems of quantum computation in collaboration with S Albeverio and SM Fei.

Perhaps the most-recognised achievement of Prof. Goswami is the theory of quantum isometry groups, which is still a significant part of his

Clockwise: Explaining a subtle point. He is exploring potential applications of quantum symmetry to diverse areas of physics, chemistry and other fields of natural and social sciences

Delivering a lecture at ISI Bangalore

Working at home. The most-recognised achievement of Prof. Goswami is the theory of quantum isometry groups, which is still a significant part of his research interest

During a conference at SN Bose Centre Kolkata

With supervisor, student and grand-student

Inset: Delivering a lecture at Instituto Nacional de Matemática Pura e Aplicada, (IMPA), Brazil

AWARDS

- Shanti Swarup Bhatnagar Award (2012)
- Swarnajayanti Fellowship (2009)
- INSA Young Scientist Medal (2004)
- BM Birla Prize (2006)
- JC Bose National Fellowship (2016; 2021)

PUBLICATIONS

- 'Non-existence of genuine (compact) quantum symmetries of compact, connected smooth manifolds'. *Adv Math.* (2020).
- 'Non-existence of faithful isometric action of compact quantum groups on compact, connected Riemannian manifolds'. *Geom Funct Anal.* (2018).
- 'Existence and examples of quantum isometry groups for a class of compact metric spaces'. *Adv Math.* (2015).
- 'Quantum isometry group of isometries in classical and noncommutative geometry'. *Comm Math Phys.* (2009).

research interest. This is a generalisation of the classical group of Riemannian isometries in the framework of non-commutative geometry. He brought the existing theory of quantum permutation groups and quantum symmetry or automorphism groups on finite sets, finite graphs, finite metric spaces and finite dimensional matrix algebras (pioneered by S Wang, T Banica, J Bichon, following the general ideas of Manin and Connes) to a geometric, infinite-dimensional setting by proving the existence of a universal object in the category of compact quantum groups (a la Woronowicz) acting on a noncommutative Riemannian manifold given by a spectral triple which in a suitable sense 'commutes' with the associated 'Laplacian'. This pioneering work attracted attention of several people from around the world, as can be seen by the flurry of papers on different variants of quantum isometry groups (the 'quantum groups of orientation preserving isometries', quantum isometry group of classical metric spaces and so on) and explicit computations of many examples.

The deepest and most surprising result proved by Prof. Goswami is the non-existence of a smooth compact quantum symmetry of a classical, compact, connected smooth manifold (that is, a faithful co-action by a compact quantum group on the continuous function algebra of such a manifold which is smooth in a natural sense). This was at first conjectured by him looking at the computations of several explicit examples, but it took quite a few years to finally prove the result, partly in collaboration with a PhD student S Joardar. The proof is a beautiful and nontrivial combination of ideas from geometry, functional analysis and quite surprisingly, classical probability theory.

At present, he is looking at potential applications of quantum symmetry to diverse areas of physics, chemistry and other fields of natural and social sciences. He strongly believes that this would eventually lead to real-life applications, although precise applications may be difficult to predict now.

A Fellow of the Indian Academy of Sciences (Bengaluru), he has been invited to lectures at many institutes and universities around the world. He has published more than 50 research articles in premier journals and conference proceedings and co-authored two books.

He also loves to paint, play the tabla and write and translate poems. His wife Gopa Mukherjee and daughters Samyosree and Srijani are his greatest sources of inspiration. •

DR DIBYENDU DAS

Propelled by Curiosity

Since his early years, Dr Dibyendu Das has had an aptitude for the sciences, which thrived during his school years especially his curiousity about how living systems work. Born in Guwahati and raised by his mother, Dibyendu was a sincere student with a keen interest in sports and extracurricular activities. Although he started his initial training in the field of chemistry with a specialization in organic chemistry from the University of Calcutta, his love for the cross-disciplinary sciences of chemistry, biology and chemical biology kept growing. After receiving his master's degree, he began his journey towards the world of scientific research by joining the Indian Association for the Cultivation of Science, Kolkata, West Bengal.

Fuelled by his passion, Dibyendu picked the interdisciplinary field of bio-organic, biophysical and chemical biology for his Phd under the supervision of Prof. Prasanta Kumar Das. After finishing his doctoral studies with significant contributions in supramolecular chemistry and biophysical studies of enzymes, he embarked upon the postdoctoral experience at the Emory University, Atlanta Georgia, US, in the field of amyloid fibrillization under the guidance of Prof. David Lynn. A couple of years of stay at Emory University equipped him for an independent career. He was first granted the INSPIRE Faculty Fellowship and, later, joined the Institute of Nano Science & Technology, Mohali, Punjab, and gathered knowledge and carried out scientific research for two years publishing works in top journals of chemistry. Next, he moved his lab to the Indian Institutes of Science Education and Research (IISER)-Tirupati as Assistant Professor, finally moving to IISER-Kolkata as Assistant Professor. His passion for science and state-of-the-art training has moulded him as one of the leading young researchers in the field of supramolecular chemistry in India.

> **"Find something you are passionate about and be good at it."**

Dr Das feels that as at the beginning of his academic career, he had equipped himself with basic science and fundamental concepts of supramolecular, these laid a strong foundation for a career and a base to study complex concepts of living systems and systems chemistry. His career took a decisive turn after his post-doctoral thesis which dealt with questions of the origin of life and where he got the opportunity to work with luminaries and pioneers of systems chemistry.

By starting a career in a relatively nascent field of systems chemistry and the chemical origins of life, Dr Das has fulfilled his dreams of pursuing something novel. Initially starting with a small group of students, he went on to explore new horizons, subsequently, reaching newer heights. Dr Das now has a research group of 10 bright young PhD candidates who are working with the same zeal and energy as him.

Apart from regularly publishing in top journals of international repute, he is also on the advisory boards of prestigious journals on chemistry. His work was recognized further when he was conferred with the prestigious Swarnajayanti Fellowship.

An exciting structural and functional overlap of synthetic organic chemistry with nanomaterials and biomolecules is being observed in Dr Das's lab, in particular, synthesis and applications of functional amyloids. The struggle of weak forces creates some of the most robust functional structures

AWARDS

- Indian Peptide Society-Young Scientist Award (IPS-YSA) for Excellence in Peptide Research (2021)
- Advisory Board of *Materials Horizons* (2021)
- Swarnajayanti Fellowship (2020)
- Advisory Board for *Journal Chemical Reviews* (2020)
- Associate, Indian Academy of Sciences (2019)

PUBLICATIONS

- 'Complex Cascade Reaction Networks via Cross Amyloid Nanotubes'. *Angew Chem Int Ed*. (2021). (Early View)
- 'Non-Equilibrium Polymerization of Cross-β Amyloid for Temporal Control of Electronic Properties'. *Angew Chem Int Ed*. (2020).
- 'Covalent Catalysis by Cross β-Amyloid Nanotubes'. *J Am Chem Soc*. (2020).

Clockwise: With Prof. Prasanta Kumar Das, Prof. Arabinda Chaudhuri and his group members. Dr Das's lab utilizes short peptide-based cross-β amyloid nanotubular hybrids that can promote different kinds of cascade reactions, from simple two-step, to multistep, to complex convergent cascades

Being felicitated by Prof. Sourav Pal, Director, IISER Kolkata for research output

Showcasing the poster he presented at INST Mohali

With his group members in 2019

With his group members at IISER Kolkata

Inset: At work at IISER, Kolkata

known in Nature-taking a leaf out of nature's book, soft nanostructures with patterned cross β-facets will be created with properties resonating with diverse fields. Self-constructing peptide lipid chimeras capable of accessing diverse nanophases will be designed. These dynamic nanostructures connected by a network of thermodynamic equilibria will be scored for unique emergent properties. Soft materials will be fabricated from unique molecular Lego pieces encoded (installed) with specific moieties for diverse functions: from energy transfer to enzyme matrices. Biocatalytic reaction networks integrate complex cascade transformations via spatial localization of multiple enzymes confined within the cellular milieu. Inspired by nature's ingenuity, Dibyendu's lab utilize short peptide-based cross-β amyloid nanotubular hybrids that can promote different kinds of cascade reactions, from simple two-step, to multistep, to complex convergent cascades.

As chemical systems can show complex behaviour that is not seen in individual molecules or reactions, systems chemistry is a new frontier in molecular sciences, focusing on (multi-) functional behaviour that emerges from ensembles of molecular component. Creating systems of molecules can establish behaviour that goes beyond the sum of the individual elements — while taking advantage of well-established methods and traditional chemistry approaches for the study of individual molecules and reactions. The energetically uphill processes of self-assembly often seen in nature will be foreshadowed in synthetic systems. Consumption of energy will give rise to structures with functional properties with an added dimension of time. Filamentous proteins seen in cytoskeleton display out-of equilibrium generation of polymeric phases and dissipate energy by virtue of accelerated catalysis from the polymerized states. Realization of such temporal structures with ability to perform functions will be targeted.

The positive effects of his mentors, teachers, and colleagues also have played a major role in his scientific career. Not just blessed with a curious mind, he is also bitten by the travel bug. He likes to cook Indian and fusion food. Swimming and cross country drives also excite him a lot. Above all, he is a doting father to a daughter, who keeps him busy when he is at home! •

DR DURBA SENGUPTA

A Cut Above the Rest

While growing up in Delhi, in an academic environment, Dr Durba Sengupta had an early insight into the world of science. Her mother, Krishna was a physics teacher and her father, Santanu, an engineer. Her bachelor's degree in chemistry, meanwhile, paved her way into research. She joined IIT Bombay, for her master's where she eventually topped her class and won the Institute medal.

She continued on her research journey and pursued her doctoral work at the University of Heidelberg, Germany, with Prof. Jeremy Smith and Prof. Matthias Ullmann. For this she was awarded the Daimler Benz doctoral fellowship. It was in Heidelberg that she started getting introduced to the fascinating world of cell membranes that form the border between the outside and inside of the cell. After the successful completion of her PhD, she started her postdoctoral research at the University of Groningen, the Netherlands, with Prof. Siewert-Jan Marrink. Here, she continued her work in the general area of membrane proteins – this time using multi-scale simulations. She focused on antimicrobial peptides (AMPs) and how they form pores in membranes as a mechanism to kill bacteria by targeting their membranes. Surprisingly, they saw a large disorder in how these peptides form pores – much more than expected! Her work was well-received and resulted in several highly-cited research articles. To gain such an unprecedented molecular view, she needed to improve the way these calculations were done and helped to develop better water models that capture the electrostatics required for AMP action. The work on these AMPs continues in her research group even now. She has teamed up with collaborators and with her expertise has helped to design 'improved' AMPs that have been recently granted US and world-wide patents. Perhaps, if there is an antibiotic resistant bacterial pandemic, these AMPs can come to the rescue!

> **"Keep doing what you enjoy, keep reading what the world is suggesting and keep a lot of time to think."**

Immediately on her return to India, she was awarded the Ramanujan fellowship and the Ramalingaswami fellowship and joined National Chemical Laboratory in Pune. The major focus of her research continues to be membrane and receptor function. Using a 'computational' lens her research group looks at the physico-chemical principles that govern complex membrane processes. They have been able to provide a 'high-res' picture at the molecular level, beyond the reach of experimental methodologies today. Although each piece of this jigsaw puzzle is important from a fundamental perspective, as well as in drug design, they hope that by putting these pieces together they will finally be able to identify general biological and mechanistic principles.

The largest impact of their work has been to understand different aspects of receptor function. These receptors are proteins on the cell membrane that

AWARDS

- NCL Best Scientist Award (2019)
- Ramalingaswami Fellowship (2011)
- Ramanujan Fellowship (2011)
- Institute Medal for Outstanding Performance in Biotechnology (2001)
- Sanwa Bank Scholarship for Academic Excellence (1999)

PUBLICATIONS

- 'Conformational plasticity and dynamic interactions of the N-terminal domain of the chemokine receptor CXCR1'. *PLoS Comp Biol*. (2021).
- 'Dynamic Protein Interfaces and Conformational Landscapes of Membrane Protein Complexes'. *Curr Op Struct Biol*. (2020).
- 'Interplay Between Membrane Curvature and Cholesterol: Role of Palmitoylated Caveolin-1'. *Biophys J*. (2019).
- 'Exploring GPCR-Lipid Interactions by Molecular Dynamics Simulations: Excitements, Challenges and the Way Ahead'. *J Phys Chem B*. (2018).

Clockwise: Receiving the NCL Best Scientist Award on Foundation Day 2019

With Prof. SJ Marrink, Professor of Molecular Dynamics, University of Groningen, in 2008

Explaining her work to an attendee during a YIM Meeting in Bhubaneswar, Odisha, in 2011

During her PhD convocation at University of Heidelberg in 2005

Being felicitated in Indian National Young Academy of Science during 2018

With her research group in 2019

Inset: Standing in front of Robert Bunsen statue during her visit to Germany in 2018

govern traffic and signalling in a cell and determine how a human cell responds to external stimuli, such as hormones and neurotransmitters. They focus on three important aspects that are often neglected by others so that they are able to provide a holistic picture of receptor function. In the first part, they have identified molecular signatures of lipids and have shown how cholesterol and other lipids can directly or indirectly modulate receptor dynamics and association. These lipids change in our cells with age, organ, tissue and even diet and her work has highlighted how lipid effects cannot be neglected for the next-gen drugs! The second aspect about these receptors is the population-level polymorphisms that affect drug response, for instance, the different inhaler-based drugs in asthma. Her research group has painstaking analyzed each of the common variants found and how they would (if at all) alter response to common drugs. They hope to take this work ahead towards the clinic within the general framework of personalized medicines. And, finally, they have analyzed how large signaling proteins bind these receptors and switch them "on". Although this part of the work is just starting – it will have implications in developing biological therapeutics. The unique aspect of their work is that they combine chemistry, physics, biology and computing and provide new ways of looking at biomolecules at the nanoscale. So where does all this lead? She hopes that one day they would be able to (virtually) examine the entire cell at high resolution and over a long period of time!

Dr Sengupta's research group, with a special emphasis on her first doctoral student Xavier, was the focus of a short documentary supported by Vigyan Prasar (*https://www.youtube.com/watch?v=59r66qt9ZQY*). The work in her group has been supported by grants from DST, SERB, DBT and CSIR. Some of her recent grants include that from the National Supercomputing Mission to develop multi-scale methods and from CSIR as a part of its covid drug discovery programme. Her work at NCL has led to publications in chemistry, biology and physics journals, and invitations for several review articles and book chapters. In appreciation of her work, she has been invited to several national and international conferences. She is the editor of *J. Membrane Biology* (Springer) and a member of the editorial board of PINSA (Proc. of Indian Nat. Acad. Sci.). She hopes that in the future she can continue on this exciting journey in membrane research and discover new frontiers in membrane biology. •

DR EKAMBARAM BALARAMAN

Man with a Mission

Dr Ekambaram Balaraman's, an Assistant Professor at IISER-Tirupati, research primarily focuses on generating resources for green energy and recycling atmospheric waste. More specifically, he works on the design and development of catalytic materials for hydrogen generation from feedstock chemicals, sustainable chemical synthesis, and conversion of CO_2 to value-added chemicals. He is also interested in the development of new electron-donors for Ziegler-Natta olefin polymerization catalysis.

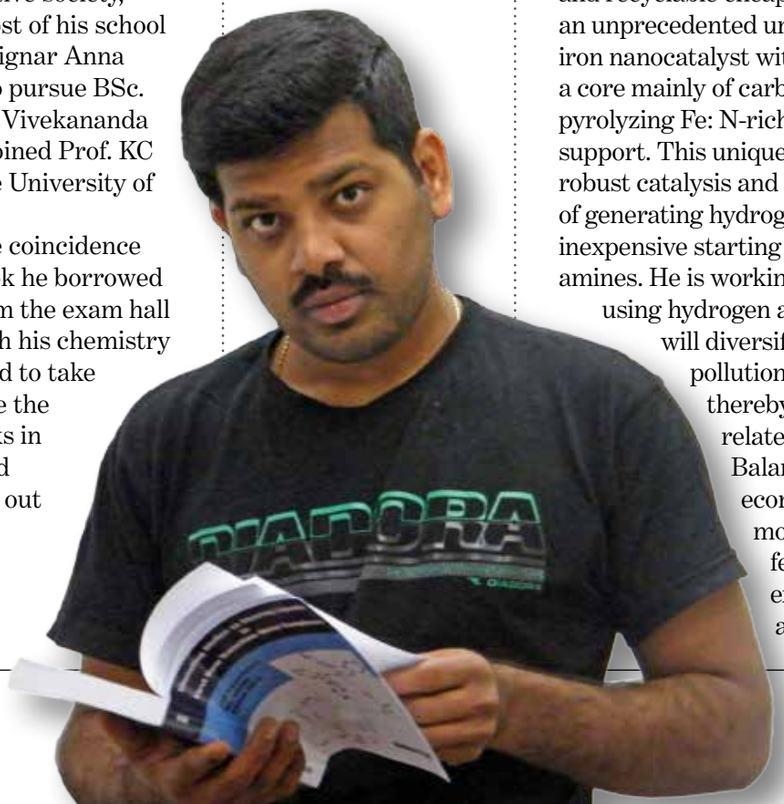
The most fascinating aspect of Dr Balaraman's research is that it seamlessly integrates unravelling the fundamental aspects of chemistry and solving real-world problems with an emphasis on health and safety. His futuristic outlook in terms of coming up with long term, sustainable, eco-friendly solutions serves as an inspiration for researchers to think of day-to-day problems as a blessing in disguise for innovation.

Born to T Ekambaram and E Pushpavathi in Ayyangarkulam in Kancheepuram, Tamil Nadu, his father was employed with the co-operative society, while his mother was a homemaker. Most of his school education was in Tamil till he joined Arignar Anna Government Arts College in Cheyyar to pursue BSc. After MSc, from Ramakrishna Mission Vivekananda College, Chennai, in 2002, Balaraman joined Prof. KC Kumara Swamy's research group at the University of Hyderabad to pursue a PhD.

Dr Balaraman recalls an unfortunate coincidence when a loose sheet in the logarithm book he borrowed from his friend, led to his expulsion from the exam hall during a chemistry exam. However, with his chemistry teacher's intervention, he was permitted to take the exam in the last 45 minutes. Despite the constraints, he scored the highest marks in the class. This propelled his passion and interest in chemistry, which has turned out to be a lifelong affair.

In his endeavour for green energy, Balaraman has invested heavily in using hydrogen as an alternative to non-renewable sources of energy. Upon combustion hydrogen releases water, thereby minimizing environmental hazards with zero carbon footprint after fuel usage. However, the economics of hydrogen production is dependent on the raw materials and the process. To find cost-effective raw materials, he turned to abundantly available bio-derived feedstock chemicals, for instance, molasses and chemical industrial waste. Having found abundant and cheap raw materials, he next concentrated on developing thrifty and recyclable cheap metal catalysts. He has invented an unprecedented unique core-shell architecture of iron nanocatalyst with a shell comprising oxide and a core mainly of carbide synthesized by thermally pyrolyzing Fe: N-rich ligand on a graphitic oxide support. This unique microstructure facilitates robust catalysis and sustainable chemical synthesis of generating hydrogen from abundantly available inexpensive starting materials, such as alcohols and amines. He is working towards realizing his dream of using hydrogen as an alternate energy source as it will diversify energy sources and will reduce pollution and greenhouse gas emissions, thereby simultaneously solving issues related to energy and the environment. Balaraman's inventions of the economically viable and eco-friendly mode of producing hydrogen from feedstock chemicals have received extensive public acclaim through articles in leading publications and

> **"Be true to acknowledge the problem, be honest to address it, and be sincere in working and refining the solution."**



Clockwise: Receiving the AV Rama Rao Young Scientist Award, 2018

With BSc classmates in 2000

Showcasing the ICC Award 2016 received, as part of the Reliance Industries Ltd R&D team, for the development of indigenous technology

With post-doc mentor, Prof. David Milstein, at the Weizmann Institute of Science, Israel (2010)

With team members involved in 'New Approach for Producing Hydrogen Gas'

With delegates during the conference on Sustainable Catalysis held at NCL, Pune

Inset: Receiving Bronze Medal from the Chemical Research Society of India (2020)

AWARDS

- Swarnajayanti Fellowship (2020)
- Bronze Medal, Chemical Research Society of India (2020)
- Asian and Oceanian Photochemistry Association Prize for Young Scientists (2019)
- Fellow, Royal Society of Chemistry (FRSC-2020)
- AV Rama Rao Young Scientist Award (2018)

PUBLICATIONS

- 'Insights into the nature of self-extinguishing external donors for Ziegler-Natta catalysis: A combined experimental and DFT study'. *Chem Cat Chem*. (2021).
- 'Room temperature catalytic dehydrogenation of cyclic amines with liberation of H2 using water as a solvent'. *Green Chem*. (2019).
- 'Iron-based nanocatalyst for the acceptorless dehydrogenation reactions'. *Nature Commun*. (2017).
- 'Reversed reactivity of anilines with alkynes in the rhodium-catalysed C–H activation/ carbonylation tandem'. *Nature Commun*. (2015).

scientific blogs. Most importantly, his research work on 'Catalytic materials for Sustainability' aligns with different national missions, such as Make-in-India, Innovate-in-India, Healthy and Clean India.

Dr Balaraman is involved in developing processes to utilize carbon dioxide as a raw material for the bulk synthesis of biodegradable plastics. This circular economy programme is a result of his creative vision to curtail the steep increase in CO_2 footprint contributed by industries and automobiles to reduce the alarmingly high plastic landfilling and save the environment. His approach to producing biodegradable polymers from carbon dioxide has austere simplicity with minimal additional energy input and greater control.

Dr Balaraman has been successful in transiting his inventions from academics to applications. The electron-donor molecule required for Ziegler-Natta polymerization for manufacturing products based on polyolefins is being extensively imported by Indian industries at a bulk scale. He has invented a novel green and innovative process by which the electron-donor molecule can be synthesized on a bulk scale in India. His indigenous process has the potential to reduce the cost of the electron-donor molecule and associated imports significantly. Dr Balaraman's contribution in atom-, step-economical chemical product development is of high impact leading to developed molecules, with 'safety' as an outlook.

Dr Balaraman's research has been well-received by different strata of society. His research work on sustainable catalysis has received several accolades from academic researchers and has attracted financial support from industries. Importantly, his research accomplishments have propelled students to think globally and act locally.

Dr Balaraman aims to contribute to the development of innovative new catalytic systems with direct and long-term benefits to the chemical manufacturing sector and the broader knowledge-based economy in India. Through innovations, he aims to reduce imports, clean chemical synthesis from feedstocks, and achieve the goal of making manufacturing an eco-benign process for healthy living at reduced costs.

From his formative years, he has been a vivid reader of the research work of Dr S Sivaram, currently at IISER, Pune, who has been truly inspirational in Dr Balaraman's journey of balancing academic and application-oriented research. Outside research, Dr Balaraman spends time travelling and visiting places, interacting with peers, students, and persons from different walks of life to understand how they approach life. He believes that the answers to some imposing long-pending questions and problems often emerge from social settings and unexpected quarters. •

DR GEETANJALI CHAWLA

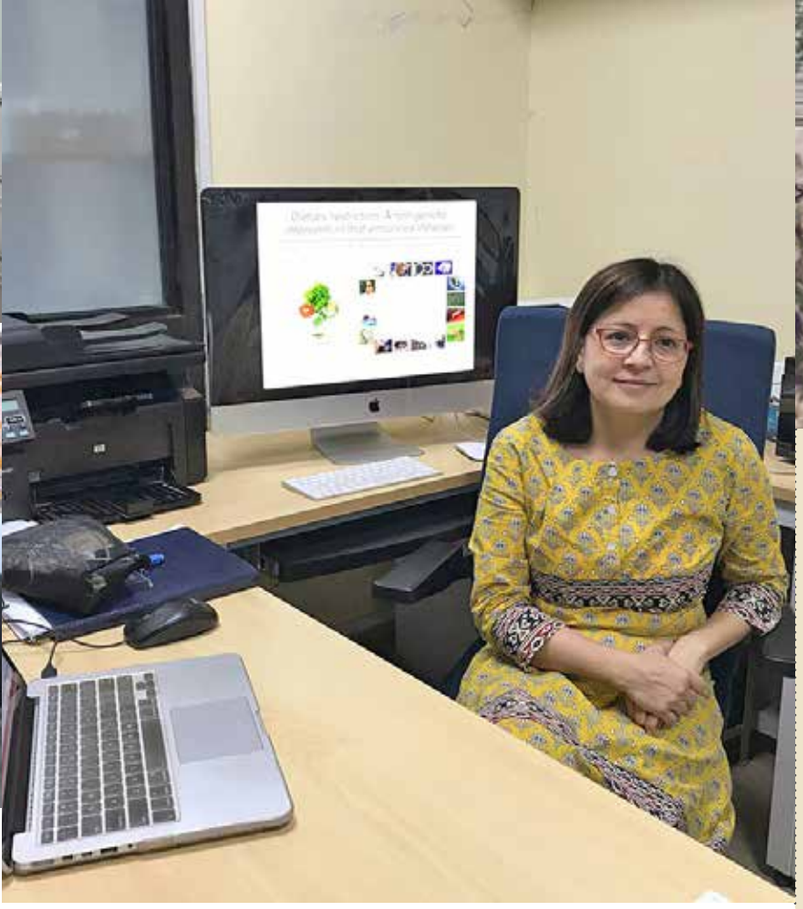
Overcoming Challenges

There are no negatives in life only challenges to overcome that will make you stronger. Despite being from a non-scientific background, Geetanjali's family supported her decision to pursue medicine or science field. Her mother Kaushalya Chawla is a retired history teacher and her father Radhe Krishan Chawla was a manager in a company. Geetanjali received her undergraduate degree in biochemistry and went on to earn a master's degree in biotechnology. Geetanjali's doctoral studies focused on the molecular genetic analysis of a protein that was involved in precursor messenger ribonucleic acid (pre mRNA) splicing. After completing her PhD studies from the Indian Institute of Science, Bengaluru, Dr Chawla moved to the Howard Hughes Medical Institute at the University of California, Los Angeles (UCLA) to study the role of RNA binding proteins in neuronal alternative splicing. As a postdoctoral fellow in Prof. Douglas L Black's laboratory, Dr Chawla used the mammalian cell culture model system to study the functioning of RNA processing factors in mammalian neurons. One of these studies showed that the RNA binding protein Sam68 is required for normal differentiation of neuronal progenitors. In addition, this work also provided the scientific community with a list of novel target mRNAs of Sam68. Dr Chawla's interest in understanding the functional role of non-coding RNAs prompted her to join the newly set-up laboratory of Dr Nicholas S Sokol, situated in Indiana University (2008) where she was promoted to the rank of Research Assistant Professor in 2012.

As a research scientist at Indiana University, Dr Chawla focused on understanding the mechanisms that regulate the temporal and spatial expression of a conserved class of small non-coding RNAs referred to as microRNAs (miRNAs) in the fruit fly, *Drosophila melanogaster*. Her work has shown that the fly *let-7-Complex gene* is regulated by the steroid hormone, Ecdysone (20E). In addition to transcriptional regulation of *let-7-Complex* miRNAs, Dr Geetanjali Chawla also participated in other studies that characterized the role of post-transcriptional regulators like ADAR and Pasha in modulating the expression of this conserved cluster of miRNAs. Another of her studies identified the role of a highly conserved miRNA, *miR-125* in aging and maintenance of neuronal integrity. This work forms the basis of her current research programme. Manipulating molecular pathways that impinge on nutrient sensing and restricting nutrient intake (also referred to as dietary restriction) can not only extend lifespan in diverse species but can also promote 'healthspan', by delaying onset of age-related chronic conditions.

> **"Like what you do and never give up!"**

Dr Geetanjali Chawla's study and those from other laboratories have linked miRNA function to organismal aging. These studies have emphasized the utility of the *Drosophila* model to understand miRNA mediated mechanisms involved in the biology of aging. In contrast to the protein machinery that represents only ~2% of the transcribed genome, the expansion of the noncoding transcriptome in higher eukaryotes reflects greater regulation of cellular processes through control of protein function. The central hypothesis



AWARDS

- DBT-Wellcome India Alliance Intermediate Fellowship (2018)
- Ramalingaswami Re-entry Fellowship (Relinquished) (2017)
- Visiting Student Scholarship (2000)
- Dr Manasi Ram Memorial Award (1999)
- Ben Barres Spotlight Award (2021)

PUBLICATIONS

- 'Evaluating the beneficial effects of dietary restriction: A framework for precision-nutrigeroscience'. *Cell Metabolism* (2021).
- 'From bench side to clinic: Potential and challenges of RNA vaccines and therapeutics in infectious diseases'. *Mol Aspects Med*. (2021).
- '*miR-125-chinmo* pathway regulates dietary restriction dependent enhancement of lifespan in *Drosophila*'. *eLife* (2021).
- 'Healthy Aging research in India'. *Journal of Experimental research on human growth and Aging* (2019).

Clockwise: Showcasing achievements of RCB at IISF Kolkata 2019

With her lab members

In her office. Dr Chawla's study and those from other laboratories have linked miRNA function to organismal aging

The team at the Microbiology and Cell biology Lab when the Nobel Laureate Dr JD Watson, an American microbiologist and geneticist, visited IISc

With lab members

Inset: A Letter of Appreciation showcasing her involvement in mentorship program. Dr Chawla has trained and supervised research personnel from diverse backgrounds and different scientific levels

of Dr Chawla's group is that microRNA mediated mechanisms regulate protein homeostasis during aging and dietary restriction. Hence, her laboratory is characterizing age- and dietary restriction-modulated miRNAs in *Drosophila* to illuminate miRNA-mediated networks that operate during dietary restriction. Her group is utilizing molecular, genetic, proteomic and metabolomic approaches to test the efficacy of miRNAs as dietary mimetics with the goal of developing broad-spectrum RNA-based therapies to promote health in aging individuals and prevent age-associated disorders.

Her group recently identified *miR-125* and *let-7* as conserved effectors of the dietary restriction pathway. Lipid metabolism plays an important role in the aging process and pharmacological, dietary, and genetic interventions that extend lifespan often cause changes in lipid metabolism. Analysis of loss of function *miR-125* mutants indicated that *miR-125* was required for the increase in lipid turnover under dietary restriction that is an essential prerequisite for lifespan extension upon dietary restriction. Dr Chawla's group showed that upregulation of the human ortholog of *miR-125* in the fat tissue was able to enhance lifespan in a diet-independent manner. Future work may be required to determine the optimum duration and dose of *miR-125* required to maximize health span in higher organisms, nevertheless this analysis provides several avenues that can be explored for testing this miRNA as a dietary restriction mimetic and sets the stage for evaluation of *miR-125* and other conserved miRNAs as candidates for developing therapeutics that promote healthy aging and prevent/delay late-onset diseases.

Dr Chawla is currently working towards identifying relevant microRNAs that can enhance healthy lifespan using the *Drosophila* model system and hopes to test these candidates in the mouse model. Her long-term goal is to develop miRNA-based therapeutics that mimic the beneficial effects of dietary restriction. She is working towards getting RNA-based therapeutics in clinical trials with specific age-related disease indications.

Dr Chawla currently leads the RNA Biology Laboratory at the Regional Centre for Biotechnology in Faridabad, Haryana, and the main focus of her laboratory is to characterize post-transcriptional mechanisms involved in aging and dietary restrictions.

As a scientist, teacher, and group leader, Dr Chawla has trained and supervised research personnel from diverse backgrounds and different scientific levels. Other than research, Dr Chawla enjoys gardening and cooking. •


CSIR-SUMMER RESEARCH TRAINING PROGRAM
(CSIR-SRTP)2020 ONLINE

LETTER OF APPRECIATION

We thank you DR. GEETANJALI CHAWLA for your contribution to the success of the CSIR-Summer Research Training Program (CSIR-SRTP) 2020 online during June to August, 2020 coordinated by CSIR-NEIST, Jorhat

DR GOPALJEE JHA

Charting a New Course

When Gopaljee Jha had an opportunity to attend a seminar organized by Gargi College, Delhi University, where stalwarts such as Dr G Talwar, Dr Lalji Singh, Prof. SK Sopory, were speaking about various expects of biotechnology, he was excited. His interest in the subject was further spurred when he visited the Department of Biotechnology stall at a book fair in Delhi. These two events firmed up his mind to pursue a career in science. To chase this passion, first, he took admission in MSc in biotechnology at Guru Nanak Dev University in Amritsar and then pursued a PhD from Centre for Cellular & Molecular Biology, Hyderabad, where he had the privilege of working with Dr Ramesh V Sonti, NIPGR Director. During his PhD, he was fascinated by the dynamics of plant-pathogen interactions and their contribution towards plant protection.

Dr Jha, who is a scientist at the National Institute of Plant Genome Research, was born in Arer, a small village, in Madhubani district, Bihar, to Bibhuti Chandra Jha, an officer in Bihar government and a gold medallist in mathematics and Kalindi Devi, a housewife. After he finished schooling, he came to Delhi and took admission in BSc (Botany Hons.) in a college in Delhi University.

Dr Jha, and his group, work in the area of plant-microbe interactions. Preventing crop yield loss due to various phytopathogens remains a challenge for ensuring food security and sustainable agriculture. Although plants mount a strong defence response that is akin to a human innate immune response, to defend themselves from potential pathogens, the pathogens actively suppress the host defence to cause disease. In the lab, they work on sheath blight disease of rice, which is caused by a fungal pathogen, Rhizoctonia solani. Globally, significant yield loss (up to 70%) can occur due to this disease in rice and fungicides that are currently used to control the disease adds to the negative trade value. They are currently focusing on understanding the intricacies of rice-R. solani interaction and utilize the leads to develop strategies to control the disease. They have identified important pathogenicity determinants of R. solani and are developing means to down-regulate the expression of these genes during the infection process to prevent the disease. We have also identified certain rice genes that are highly upregulated during R. solani infections. They anticipate that some of these genes may serve as host susceptibility factors and are required for the pathogenesis of R. solani. They are editing these genes to prevent pathogen mediated host hijacking to impart tolerance against this disease.

> **“Trust no future, however, pleasant! Let the dead past bury its dead! Act - act in the living Present! Heart within and God overhead.”**

While studying the rice-R. solani interactions, they came across an endophytic bacterium of rice, which prevented the R. solani to grow on laboratory media. They observed that this bacterium has an unusual property to feed on R. solani. They have identified the bacterium as Burkholderia gladioli strain NGJ1 and observed that besides R. solani, it can feed on a wide range of fungi, including various important phytopathogens

Clockwise: During a demonstration to show how a tiny bacteria can feed on fungi to the DBT officials

At the All India Radio for a recording to explain sheath blight disease in rice

Working in laminar-hood to culture microbes under sterilized condition

In Mandi, Himachal Pradesh

During a vacation in Himachal Pradesh

Discussing science with a foreign delegate and Dr Ramesh Sonti, former Director, NIPGR

Inset: With the Director of Central Drug Research Institute, Lucknow, during the India International Science Festival

AWARDS

- Swarnajayanti Fellowship (2019)
- Young Scientists Medal, Indian National Science Academy (2010)
- Platinum Jubilee Young Scientist Award, National Academy of Sciences (2007)
- BOYSCAST Fellowship (2010)
- Gold Medal in MSc Biotechnology, Guru Nanak Dev University (2002)

PUBLICATIONS

- 'Immunity proteins of dual nuclease T6SS effectors function as transcriptional repressors'. *EMBO reports* (2021).
- 'RS_CRZ1, a C2H2 type transcription factor is required for pathogenesis of Rhizoctonia solani in tomato'. *Molecular Plant-Microbe Interactions* (2021).
- 'A prophage tail-like protein is deployed by Burkholderia bacteria to feed on fungi'. *Nature Communications* (2017).
- 'Alterations in rice chloroplast integrity, photosynthesis and metabolome associated with pathogenesis of Rhizoctonia solani'. *Scientific Reports* 7 (2017).

along with Candida which is an opportunistic human pathogen. This serendipitous observation has opened up a new arena of research in the laboratory. They were fascinated to witness that a tidy bacterium can eat the multicellular fungus. This phenomenon is known as bacterial mycophagy, however, the molecular mechanism remains largely unknown. In a seminal work, they demonstrated that the NGJ1 bacterium utilizes a specialized protein secretion system (known as Type III secretion system) to deliver certain effector proteins including a prophase tail-like protein (Bg_9562) into fungal cells to kill and feed on them. The purified Bg_9562 protein demonstrates broad-spectrum antifungal activity and the group have obtained a patent-protected variant of this protein to utilize it through varied means to control sheath blight disease of rice. Recently, they have figured out that besides mycophagous ability, the NGJ1 bacterium also demonstrates broad-spectrum antibacterial activity. They endeavour to identify the antifungal, as well as antibacterial proteins, peptides, and metabolites from the NGJ1 bacterium to utilize them to control important fungal diseases of plants and animals, including human.

Their current focus is to develop sheath blight disease tolerance in rice through a multi-pronged approach. The group is developing RNAi, transgenic, as well as genome-edited rice lines with enhanced sheath blight tolerance. Further, they are concentrating on developing dsRNA and antifungal peptide-based formulations to control sheath blight disease in an eco-friendly manner. Besides this, the group is interested in understanding the antifungal and antibacterial property of Burkholderia gladioli strain NGJ1. This would enable them to identify novel anti-microbial compounds and utilize them to control bacterial and fungal diseases of plants and animals. Dr Jha's ambition is to characterize rice associated microbiome and bio-prospects the beneficial microbes for sustainable rice cultivation. The long-term goal in this regard is to identify the genetic loci that facilitate the association of beneficial microbes with rice and utilize the knowledge for breeding rice lines that can be cultivated with minimal use of agrochemicals (fertilizers, fungicides). •

H-M

DR HUMIRA SONAH
DR JYOTIRANJAN S RAY
DR JYOTIRMAYEE DASH
PROF. KANISHKA BISWAS
DR MAMONI DASH
PROF. MANAS KULKARNI
DR MANDAR MADHUKAR DESHMUKH

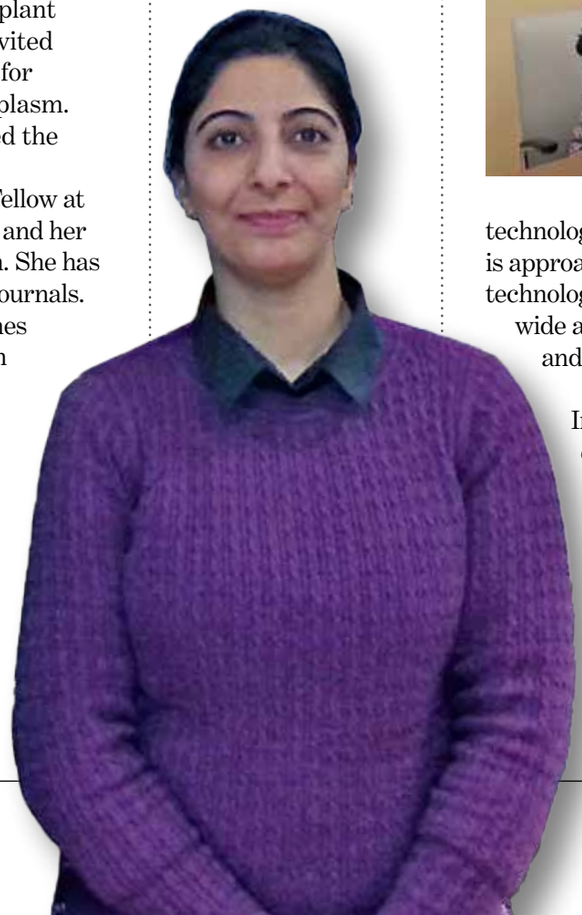
DR HUMIRA SONAH

From the Ground Up

Dr Humira Sonah, popularly known as as Dr Huma, is a plant biology scientist. Born in Srinagar, Kashmir, she spent her childhood on the banks of the Dal Lake, a paradise on earth. After completing her schooling from Srinagar, she took admission in agriculture at the Purvanchal University, Varanasi. Subsequently, she did her master's in agriculture biotechnology from Indira Gandhi Agriculture University, Raipur. While working at the National Institute on Plant Biotechnology, she completed her PhD from Banasthali University; and her work was on sheath blight disease in rice. She identified the genomics, which govern the sheath blight resistance trait in rice. Soon after her PhD, she joined the University Laval, Canada, as a postdoctoral researcher where she developed a genotyping-by-sequencing method useful to accelerate crop improvement. Due to her expertise with plant genomics, the University of Missouri, USA, invited her to work with Prof. Nguyen's group known for whole-genome resequencing of soybean germplasm. After completing her research work, she joined the university as a Visiting Professor.

At present, Dr Sonah is a Ramalingaswami Fellow at the National Agri-Food Biotechnology Institute and her group is working to develop food-grade soybean. She has published more than 80 papers in high impact journals. Dr Sonah's research group is also developing lines adaptable to the Himalayan and Sub-Himalayan Range. Food grade soybean is specifically important for India where a large share of the population is vegetarian and malnutrition is rapidly increasing. Dr Humira's expertise and experience towards soybean improvement while working as Visiting Professor at University Laval Canada inspired her to take these two challenging tasks. The cold weather in Canada is much difficult than in Himachal, Uttarakhand, and Kashmir, even though soybean productivity in Canada is very high. Her work on soybean with cutting-edge technology is helping to achieve the goals. Dr Humira is approaching soybean improvement with advanced technology like multi-target genome editing, genome-wide association studies (GWAS), genomic selection, and induced mutagenesis approaches.

> **"Following science with passion and universal humanity are the mantras for success."**



Continuously, increasing malnutrition issues in India made Dr Sonah take food-grade soybean development as her career goal. In addition, recent initiatives from the Government of India like Phosan Abhiyan encouraged her to dedicate her efforts towards nutritional quality improvement in soybean. The major constraints to include soybean in daily diet as a staple include the presence of anti-nutritional compounds and unpleasant beany-flavour. Making soybean anti-nutritional compound free will help to improve the

Clockwise: Working on computational genomics aspects of soybean at the Laval University, Canada

Receiving a memento during an international workshop conducted under DST-SPARC Project at Hisar, India

In her greenhouse, evaluating whole-genome sequenced soybean lines

In the field, evaluating traditional rice cultivars

With Dr Francois Belzile and other colleagues in Quebec, Canada

With her PhD students in a conference

Being felicitated at 106th Indian Science Congress in Punjab

Inset: In the field, evaluating genome-edited soybean plants being developed in her laboratory

AWARDS

- Ramalingaswami Award (2018)
- PhytoSciences Award, Sherbrooke University (2015)
- Research Excellence Award (2012)
- Research Excellence Award (2015)

PUBLICATIONS

- 'An improved genotyping by sequencing (GBS) approach offering increased versatility and efficiency of SNP discovery and genotyping'. *PloS One* (2013).
- 'Identification of loci governing eight agronomic traits using a GBS- GWAS approach and validation by QTL mapping in soya bean'. *Plant Biotechnology Journal* (2015).
- 'New evidence defining the evolutionary path of aquaporins regulating silicon uptake in land plants'. *Journal of Experimental Botany* (2020).

nutritional values. Kunitz trypsin inhibitor (KTI) is one of the most significant anti-nutritional compounds, which adversely affects the digestibility of protein from soy-based food. To develop KTI-free soybean lines two major approaches are being used in Dr Sonah's laboratory. The first approach includes the screening of diverse germplasm and mutant lines to identify KTI free genotypes which will be used for the breeding programme. The second approach includes the use of genome editing technology. A state-of-the-art technology is being used for simultaneous editing of several genes responsible for the nutritional quality of soybean. Genome-editing will develop customized and precisely tailored soybean varieties, which will serve as an excellent protein source for the vegetarian population worldwide. Providing a vegetarian source of high-quality protein at a low cost will help people to live a healthy and sustainable vegetarian life.

For the adaptation of soybean lines in new areas, Dr Sonah has developed a set of about 400 diverse soybean lines originated from different countries and climatic zones. These lines are being evaluated in Himachal Pradesh and Kashmir. The selected lines will be developed as a novel variety for these states.

Dr Sonah's career goal is to improve the nutritional quality of soybean and tailor it as per the Indian consumer preference so that it can be adopted as a staple food in the daily diet. In the process, several milestones have been achieved but still, the long journey ahead keeps her motivated.

Her work provides an excellent opportunity to use science to address real-life issues, as well as teaching and training PhD students. When she is not working, she likes to read about people who have inspired the world. She enjoys educating herself about mythology, myths, and beliefs and connecting them to present scientific understanding. •

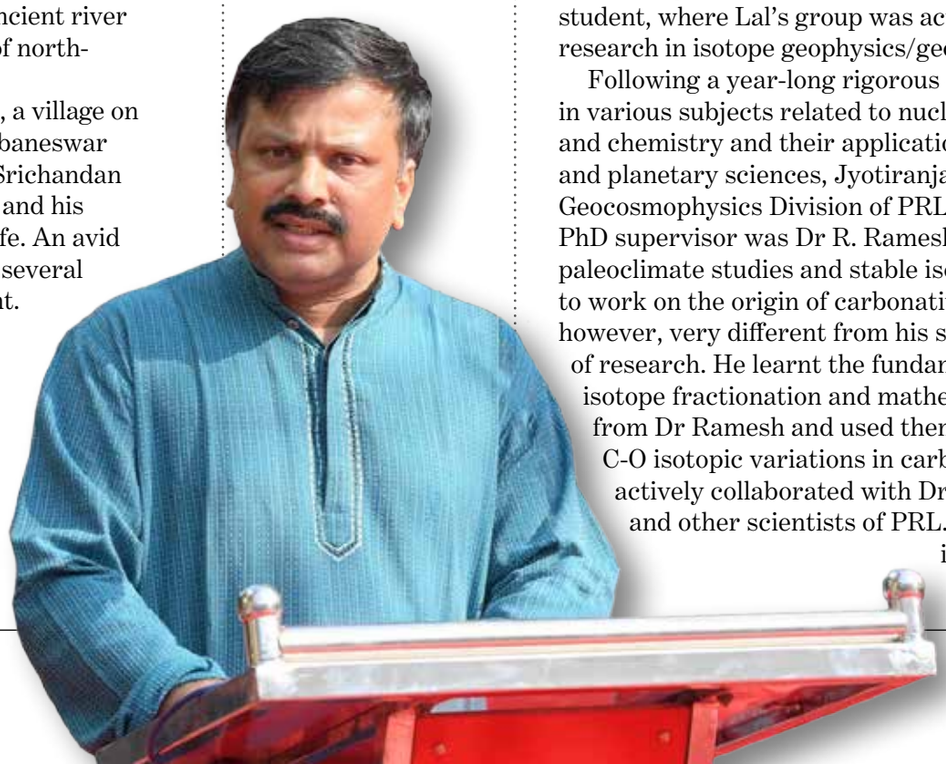
DR JYOTIRANJAN S RAY

Rising to the Challenge

Dr Jyotiranjan S Ray likes a challenge, which is evident in his work. Some of Dr Ray's important contributions include mathematical models to treat stable isotopic fractionation during processes that involve multiple sources, the evolution of radiogenic isotopic compositions during magmatic processes that generate carbonatites and associated silicate rocks, and elemental and isotopic changes during fluid-rock interaction processes. His other important contributions to the Indian geology have been the determination of ages of the rocks of the Vindhyan mountains, the Sylhet Traps, many Indian carbonatites and rocks of India's only active volcano, Barren Island. He has also significantly added value to the understanding of sources and depositional pathways of sediments in numerous ancient and modern sedimentary basins of India and the records of climate change and tectonics preserved in them. One of his most recent discoveries has been the establishment of the existence of the ancient river Saraswati in the Harappan heartland of north-western India.

Jyotiranjan was born in Naharkanta, a village on the eastern outskirts of the city of Bhubaneswar in Odisha. His father, Prafulla Kumar Srichandan Ray was a teacher and an educationist and his mother, Kamal Kumari Ray, a housewife. An avid debater in his school days, he received several scholarships from the state government. After finishing his college education, he joined the University of Roorkee for a master's degree in applied geology in 1989. At Roorkee, he was motivated by his teacher Prof. S. Balakrishnan to aim for a research career in geochemistry, as he was immensely fascinated by the science of isotopes and their applications.

> **"The ultimate success for a researcher is to get cited in textbooks, therefore, one needs to address fundamental issues in science."**



From the book on isotope geology by Gunter Faure, Jyotiranjan came to know about a group of Indian researchers, led by Prof. Devendra Lal, who had initiated and contributed significantly to the research on applications of cosmogonic radiogenic nuclides. This landed, Jyotiranjan at the Physical Research Laboratory (PRL), Ahmedabad in 1992, as a graduate student, where Lal's group was actively pursuing research in isotope geophysics/geochemistry.

Following a year-long rigorous coursework in various subjects related to nuclear physics and chemistry and their applications in earth and planetary sciences, Jyotiranjan joined the Geocosmophysics Division of PRL for a PhD. His PhD supervisor was Dr R. Ramesh, a specialist in paleoclimate studies and stable isotopes. He chose to work on the origin of carbonatites, a subject, however, very different from his supervisor's areas of research. He learnt the fundamentals of stable isotope fractionation and mathematical modelling from Dr Ramesh and used them to understand C-O isotopic variations in carbonatites. He actively collaborated with Dr Kanchan Pande and other scientists of PRL. He was greatly inspired by Prof. S. Krishnaswami

AWARDS

- Shanti Swarup Bhatnagar Prize (2015)
- PRL Award (2014)
- National Geosciences Award (2009)
- MS Krishnan Gold Medal (2009)
- Young Scientist Medal of Indian National Science Academy (2000)

PUBLICATIONS

- 'Carbon isotopes in Kerguelen-plume derived carbonatites: Evidence for recycled inorganic carbon'. *Earth and Planetary Science Letters* (1999).
- 'Rayleigh stable isotopic fractionation from a multicomponent source'. *Geochimica et Cosmochimica Acta* (2000).
- 'U-Pb geochronology and Sr isotope stratigraphy of the Vindhyan Supergroup, India'. *Geology* (2002).
- 'Provenance of the late quaternary sediments in the Andaman Sea: Implications for monsoon variability and ocean circulation'. *Geochemistry Geophysics Geosystems* (2014).
- 'On the existence of a perennial river in the Harappan heartland', *Scientific Reports* (2019).

Clockwise: Receiving the Shanti Swarup Bhatnagar Prize from Union Minister Dr Harsh Vardhan on 26 September 2016

Carrying out geological fieldwork on Barren Island volcano in 2008

On a field expedition to Barren Island volcano with S. Balakrishnan, Hetu C Sheth and Rajneesh Bhutani in 2010

Being felicitated by Chief Minister of Odisha, Naveen Patnaik, 2016

On a field trip to the Barren Island volcano, India's lone active volcano in April 2015

Inset: On a field expedition to Marinoan Diamictite Outcrop in Namibia in 2016

and Prof. Devendra Lal, who taught him how to be innovative in scientific research.

Using multiple geochemical, isotopic and geochronological techniques, and by developing theoretical models in his PhD work, Jyotiranjan contributed significantly to the understanding of fluid-driven deep earth processes and the long-term carbon cycle. Subsequently, he went on to work on the evolution of oceans, sedimentary cover and life on Earth. Dr Ray's approach to research is multidisciplinary and quantitative. He formulates his projects, does fieldwork and collects samples, generates most of his experimental data using indigenous facilities and develops mathematical models to explain the data.

Dr Ray always looks for interesting issues in the earth sciences to work upon and tries to resolve them by using sophisticated geochemical and isotopic techniques. The most exciting part of his research is that he and his team get to visit some of the most inaccessible and spectacular landscapes of India and the world. He also believes in doing all his work within India by developing necessary experimental facilities in the country. He has published more than sixty peer-reviewed research papers and edited a couple of books. His research has been recognized globally and he has been awarded numerous awards by various government and non-government agencies in India.

Dr Ray believes that one should constantly look for new and challenging issues to work on to keep oneself deeply engrossed in research and come up with uncommon approaches. This has led him to work and contribute to many disciplines in geosciences such as igneous petrology, sedimentology, quaternary geology and geoarchaeology.

Dr Ray is currently serving as the Director at the National Centre for Earth Science Studies, Thiruvananthapuram. He is on deputation from the Physical Research Laboratory, Ahmedabad, where he was a Senior Professor. He is fascinated by the rise and fall of ancient civilizations and therefore, he plans to expand his research into archaeology and anthropology. Using principles of geochemistry and isotope geology, he intends to resolve some of the outstanding issues in Indian archaeology and history. Constantly broadening his horizon, Dr Ray likes to read, cook and watch adventure documentaries during his spare time. •

DR JYOTIRMAYEE DASH

Setting an Example

Dr Jyotirmayee Dash's work on artificial ion channels, anticancer drugs could lead to promising applications in drug delivery and development. The exploration of non-canonical nucleic acid structures as therapeutic targets for regulation of gene expression and as building blocks in devising artificial membrane channels are her major areas of research. Targeting nucleic acid secondary structures with small molecules is an emerging area of research in medicinal chemistry. However, a clinically approved drug that acts by stabilizing secondary nucleic acids is still unavailable. In this context, exploring novel chemical tools for selectively targeting a nucleic acid structure would be of high impact in controlling cancer and other associated diseases.

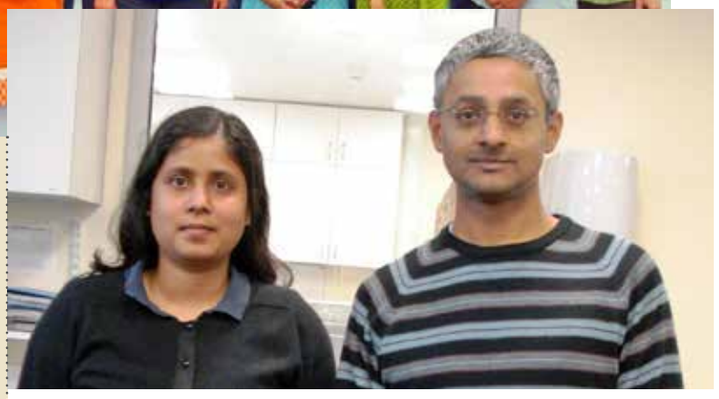
Dr Dash's research group has already made notable contributions to medicinal chemistry and chemical biology research of nucleic acids. Her future direction of research programme would aim at understanding the structure, dynamics of small molecule-nucleic acid interactions and the biological consequences of nucleic acid-targeting small molecule drugs. These studies would address mechanisms that have the potential to inspire novel therapeutic approaches. She aims to carry out extensive research in nucleic acids and develop new paradigms in medicinal chemistry.

Dr Dash's research would enable new platform technologies to support drug discovery science, new and cost-effective molecular therapies and molecular probes. It would provide future scope for translational research and commercialization as well as startups. In the longer term, these findings have the potential to make significant impacts in the healthcare and pharmaceutical sectors.

In this quest, her parents have been a constant aid and source of inspiration. After completing her matriculation from Tarikund High School, she chose science as her higher secondary subject at Swami Vivekananda Memorial College. During school, she liked mathematics but became more passionate about chemistry, choosing it as her major subject for her undergraduate studies; later, she obtained a MSc degree in chemistry with a specialization in organic chemistry from Ravenshaw Government Autonomous College, Cuttack (now a university) in Odisha.

"A strong willed, curious and innovative mind can help overcome the hurdles one faces in life. Hard work and dedication are the constant requirements to achieve one's goal."

Though her family was supportive throughout but they were scared of letting her to move to another city alone. Determined, she pursued her doctoral studies under the supervision of Professor FA Khan at IIT Kanpur, one of the premier institutes of India. She opted for a career in research as it would provide a definite direction to pursue her interest in chemistry and its applications in daily lives. She realized that hard work, discipline and dedication play a pivotal role for a career in research. Subsequently, she was awarded the prestigious Alexander von Humboldt Fellowship to work with well-known German scientist Professor HU Reissig at FU Berlin. Then, she moved to ESPCI Paris as a postdoctoral researcher in the group of Professor Janine Cossy, a renowned French chemist. She was next awarded the highly competitive Marie Curie Fellowship to pursue advanced scientific research in the group of Professor Shankar Balasubramanian, a highly acclaimed scientist at the University of Cambridge, UK, where she garnered expertise in the field of chemical biology of nucleic acids. She always wanted to start her independent research in her own country.



AWARDS

- Shanti Swarup Bhatnagar Prize (2020)
- Selected for CRSI Bronze Medal (2020)
- Swarnajayanti Fellowship (2015)
- Marie Curie Fellowship (2007)
- Alexander von Humboldt Fellowship (2004)

PUBLICATIONS

- 'Target Directed Azide-Alkyne Cycloaddition for Assembling HIV-1 TAR RNA Binding Ligands'. *Angew Chem Int Ed.* (2020).
- 'In situ Formation of Transcriptional Modulators using Non-canonical DNA i- Motifs'. *Chemical Science* (2020).
- 'Ionophore constructed from non-covalent assembly of a G-quadruplex and liponucleoside transports K+-ion across biological membranes'. *Nature Communications* (2020).
- 'Chemical Regulation of DNA i-Motifs for Nanobiotechnology and Therapeutics'. *Angew Chem Int Ed.* (2019).
- 'Target guided synthesis using DNA nano-templates for selectively assembling a G-quadruplex binding c-MYC inhibitor'. *Nature Communications* (2017).

Clockwise: At her convocation at IIT Kanpur, 2003

With her research team. Her work on artificial ion channels, anticancer drugs could lead to promising applications in drug delivery and development

Working in the lab at FU, Berlin after being awarded the prestigious Alexander von Humboldt Fellowship to work with well-known German scientist Professor HU Reissig

With her research group, which has made notable contributions in medicinal chemistry and chemical biology research of nucleic acids

With her mentor Prof. Shankar Balasubramanian, a highly acclaimed scientist at the University of Cambridge, UK

Inset: Receiving the Charusita Chakraborty Memorial Award

Thus, she returned to join first as an assistant professor at IISER Kolkata and then moved to IACS Kolkata, where she is presently a professor. Teaching and research are her primary goals.

After gaining experience in a wide range of synthetic organic chemistry and nucleic acid chemistry in leading research groups, she began integrating synthetic organic chemistry with biological studies for her independent research. Interdisciplinary research in chemistry and biology could provide a new dimension in drug development and therapeutics.

The research in chemical biology intrigued her as these studies may provide novel approaches for the discovery of drugs that may give a new dimension to the field of therapeutics. Prof. Jyotirmayee Dash has developed small molecules for understanding the role of nucleic acid secondary structures in the regulation of gene expression. Her group demonstrated innovative target guided combinatorial strategies for targeting DNA and RNA secondary structures like G-quadruplexes and i-motifs and HIV-1 TAR RNA. Her work also delineates the construction of a nucleic acid-based platform for sensing and ion transportation. These findings significantly contribute to the field of medicinal chemistry and nano-biotechnology.

Selective ligands for a particular nucleic acid structure is crucial for developing drugs suitable for clinical applications as targeting a single structure will reduce the toxicity of the ligand in a cellular system. Most of the reported ligands lack selectivity for a particular nucleic acid target, show poor bioavailability and further, they do not exert desired biological activities. Nucleic acids can also be used to develop intelligent systems for DNA nanotechnology.

Her key questions were: Whether new molecules can regulate gene expression by sequence-specific targeting of nucleic acids? Whether the three dimensional (3D) topology of nucleic acid structures can be used for the construction of artificial molecular systems like nanopores, devices that could find applications in bionanotechnology? Her research work is directly related to the well-being of humankind. By modifying and targeting nucleic acids, ailments like cancer and neurodegenerative disorders can be potentially cured. Antimicrobial agents can be developed by specifically targeting nucleic acids of microbes.

And, outside research, she has a keen interest in Indian classical music and Rabindra Sangeet. She loves spending time with her family, with her husband, a cardiac surgeon by profession, who always motivates and encourages her, and her loving kids. •

PROF. KANISHKA BISWAS

Working for Greater Good

An Associate Professor at Jawaharlal Nehru Centre for Advanced Scientific Research Prof. Kanishka Biswas always wanted to make society's greater good his mission. The alarming and ever-increasing environmental pollution, motivated Prof. Kanishka Biswas to search for alternatives that can ease these critical issues. His search has got the direction with thermoelectric materials, which can independently convert waste heat energy into electricity, and he made it his life-defining purpose to develop efficient thermoelectric materials, which can recuperate the significant amount of lost heat energy into electricity.

Kanishka Biswas was born in Habra in North 24 Parganas of West Bengal. His father, Kalyan Kumar Biswas, was a government officer and his mother, Ratna Biswas, a housewife. He was fascinated with science, especially chemistry, an interest ignited by excellent chemistry teachers at school, hence he decided to study chemistry honours during his graduation from Jadavpur University, Kolkata.

Later, he joined IISc Bangalore (2003-2009) as he was motivated to do research and pursue a career in chemistry. After excelling in MS in chemical sciences, he enrolled for a PhD in solid-state chemistry under Bharat Ratna Prof. CNR Rao. Subsequently, he joined postdoctoral research at Northwestern University, US, with Prof. Mercouri Kanatzidis, a well-known solid-state chemist.

He noticed that one of the determining steps in obtaining high-performance thermoelectric materials is by limiting their thermal conductivity. He hypothesised that phases of a secondary material of various length scales (ranging from nano to mesoscales) if incorporated in a parent compound, a phrase he termed as "all-scale hierarchical architectures", it becomes highly efficient in limiting the thermal flow in a material. Such tuning of transport properties via a wide array of chemical processes like doping, alloying, nano-structuring got him interested and he valiantly pursued it in his quest to understand the fundamental origin for such properties.

> **"Think different, think positive. Have a good chemical intuition, do hard work, be helpful and nice to others."**

The breakthrough came in the form of SrTe alloyed PbTe which showed an unprecedented thermoelectric figure of merit, zT greater than 2, mainly due to the effective realization of the aforementioned hypothesis. This 3rd generation thermoelectric material was extremely important as it meant that the full potential of thermoelectricity as a power-generating tool can be realized in the near future. This finding catalysed him to pursue high performing thermoelectric material. But the major problem lies in the compound PbTe itself, which due to its Pb toxicity limits its commercial applicability. Hence in his independent career (starting from 2012) at JNCASR, he successfully developed several high-performing environmental benign Pb free thermoelectric materials with ultra-high thermoelectric performance.

His research on thermoelectric materials is extremely important as it solves two major global concerns, that is, energy and environment. The ability of materials to independently convert waste heat generated from any relevant sources ranging from household chimneys to industrial boilers makes it essential in solving the energy crisis. It has a wide

Clockwise: With thermal conductivity measurement system in the lab at JNCASR

During his PhD days at IISc with his friends

With his student Dr Subhajit Roychowdhury in front of electrical property measurement system in the lab in JNCASR

With his research group during the initial formative years

Snow-filled winter at the Northwestern University, Chicago, USA, with his wife, Moumita Roy, during his postdoctoral stint

Inset: Beside laboratory fume hoods, a type of ventilation system that primarily functions to provide personnel protection against toxic fumes, vapours and dust

AWARDS

- Fellow, Royal Society of Chemistry (2020)
- ICSC-Materials Science Annual Prize (2020)
- Swarnajayanti Fellowship (2019)
- IUMRS-MRS Singapore Young Researcher Merit Award (2016)
- Young Scientists Medal, Indian National Science Academy (2016)

PUBLICATIONS

- 'Enhanced Atomic Ordering Leads to High Thermoelectric Performance in $AgSbTe_2$'. *Science* (2021).
- 'Intrinsically Ultralow Thermal Conductivity in Ruddlesden-Popper 2D Perovskite Cs 2 PbI 2 Cl 2 : Localized Anharmonic Vibrations and Dynamic Octahedral Distortions'. *J Am Chem Soc.* (2020).
- 'Ferroelectric Instability Induced Ultralow Thermal Conductivity and High Thermoelectric Performance in Rhombohedral p-type GeSe Crystal'. *J Am Chem Soc.* (2020).
- 'Ultralow Thermal Conductivity in Chain Like TlSe due to Inherent Tl + Rattling'. *J Am Chem Soc.* (2019).

range of real-world application to generate electricity ranging from the exhaust of automobiles to industrial and power plant chimneys.

A plethora of Pb free high-performing materials that he successfully synthesized has been well-appreciated by both the scientific community, as well as the scientific and funding agencies. The huge promise that his materials exhibits led to several financial support from the national scientific agencies as well as well-known multinational industries. Importantly, the fundamental breakthroughs in understanding the electrical and thermal transport properties made a significant mark on the global scientific community, which researchers from all over the world regularly employ in their quest to achieve high-performing thermoelectric materials.

In his early independent career, he mostly focused his research on environmentally friendly alternatives to PbTe, like SnTe, GeTe, AgSbTe2 and tailoring their electrical and thermal properties with chemical doping and alloying with foreign elements to successfully achieve high thermoelectric performance. Gradually, he expanded his research attributes into uncharted fields of 2D materials, quantum materials, ferroelectric instability, and Halide Perovskites. and successfully integrated their unique properties into the domain of thermoelectricity to find novel pathways to increase thermoelectric efficiency. The ability to tailor properties by tuning the chemical bonding in inorganic solids is something that encourages him and is one of his favourite aspects of his research.

The career-defining moment of Kanishka Biswas as a scientist is creating the first third-generation (thermoelectric figure of meri >2) bulk materials for thermoelectric energy conversion. Further, he has introduced new concepts like chemical bonding hierarchy and ferroelectric instability to achieve ultra-low thermal conductivity in solid-state inorganic materials.

The short-term future of his research lies in developing the next generation of thermoelectric materials with an efficiency greater than 15%. The subsequent goal will be to fabricate portable thermoelectric modules for power conversion. His long-term goal is to establish thermoelectricity as one of the major energy management applications. He believes that it is not a distant dream to realize the full potential of thermoelectric devices as both energy and thermal management utility.

At the same time, Prof. Biswas is a family man and likes watching movies and series. He follows cricket matches. He likes travelling and trekking to scenic places with his family. •

DR MAMONI DASH

In Service to Humanity

An ambitious girl inclined to serve the society, Dr Mamoni Dash completed her entire education including schooling, graduation and postgraduation from the city of Rourkela at a university affiliated to the Sambalpur University. She is an alumnus of the National Institute of Technology, Rourkela. After her master's in chemistry she went to Italy for a PhD from the University of Pisa.

Mamoni joined the PhD programme at the School of Biomedical Sciences of University of Pisa under the supervision of Prof. Emo Chiellini, a renowned scientist in the area of polymer chemistry. Back in 2007, when Mamoni joined the PhD programme, her particular area of research was more a selection done by the university, which chose her for the programme rather than her own choice. It was during PhD research that she developed interest and passion in the field of polymers and the benefits they can bring to biomedical sciences. Her initial research years were towards developing biodegradable polymers that could finally be used as carriers of drugs, or templates, for tissue regeneration. Mamoni's initial training during her PhD was mainly to employ chemical tools and methodologies to develop such biomaterials. As the field is multidisciplinary, so by the time she finished her PhD thesis, she was trained with techniques to synthesize and modify polymers for making them biomaterials.

The ability to understand polymers led her to acquire other research positions in Europe but each of the positions she held was for different application of polymers. She worked in the northern Europe with industries dealing with telecom to paper industry where she was required to bring in solutions utilizing polymer chemistry. It was a satisfying spell for her in Belgium, when working on an academia-industry collaborative project, the research she was involved in formulating a solution towards developing a polymeric solution that could be made into a self-written waveguide for optical fibres. This offered a solution to the telecom company in the field. Although, this aspect of her research really excited her, she gradually felt that she was moving farther away from biomedical applications. Mamoni wanted to hold on to utility of polymers for biomedical applications.

> **"Persevere, have faith in one's capabilities, dare to dream and be resilient while overcoming the hurdles that one encounters."**

Being in Europe, the interdisciplinary nature of her work was teaching Mamoni a lot. It appeared to her that anybody, be it physicians, or industry, approached universities with a certain problem and as polymer chemists they were able to provide them with solutions. This, in turn, went into immediate applications, which is reflected by the patents she is an author to. Mamoni was really excited about this feature of her research. A decade had passed in Europe gaining experiences and moving ahead with developing different skills in the area of polymer research. She returned to India when she was in the family way. She came back as a young scientist in the Department of Science and Technology. She also secured the Ramalingaswami Fellowship by the Department of Biotechnology.

Since 2018, she is heading a research group at DBT-Institute of Life Sciences.

AWARDS

- Ramalingaswami Fellowship, Department of Biotechnology (2017)
- Best Research Presentation Award (2009)
- Biomaterial Fellowship (2007)

PUBLICATIONS

- 'Polymer–Protein Hybrid Network Involving Mucin: A Mineralized Biomimetic Template for Bone Tissue Engineering'. *Macromol Biosci* (2021).
- 'Cell membrane coated nanocarriers – an efficient biomimetic platform for targeted therapy'. *J Control Release* (2020).
- 'Drug Delivery to the Bone Microenvironment Mediated by Exosomes: An Axiom or Enigma'. *Int J Nanomedicine* (2021).
- 'Ulvan-chitosan polyelectrolyte complexes as matrices for enzyme induced biomimetic mineralization'. *Carbohydrate Polymers* (2018).

Clockwise: Being feliciatated as a Guest of Honour during the National Science Day event organized by KKS Women's College, Balasore, in 2020

Speaking at an event in DBT-ILS

Receiving the best presentation award at the Marie Curie event organised by the 3B's Research group in Mino, Portugal

With Prof. Buddy Ratner of University of Washington

With her research team

With Prof. Federica and Prof. Peter Dubruel during the Advanced Materials for Biomedical Applications Conference, 2015

In front of the Leaning Tower of Pisa during her PhD days in Italy

Inset: With Prof. CristinTanzi of University of Milan in Italy

Her research group now focusses on developing biomaterials for the bone micro-environment. Their model of research is osteosarcoma and the loss of bone due to the tumor. One part of her research group is developing biomimetic nanosystems to deliver a relevant drug to the tumor site to stop tumor growth in a targeted manner while not affecting or harming the normal cells. The other group in her team is looking at developing matrices that will help regenerate the lost bone. Her research team utilizes polymers and employs polymer chemistry to reach their goal. The key factor that excites her about her work is the multidisciplnary approach that needs to have experts from different fields in order to design a material that can be applicable in the real scenario.

After having a trained team in place now, Dr Dash plans to extend her polymer research beyond biomedical applications. She has plans and new grants to use polymers for agricultural and environmental applications. Looking at the use of non-biodegradable plastics in our daily lives, she is currently working on strategies to make them biodegradable in an ecofriendly way. In addition to this, her group is also working towards biodegradable alternatives to existing plastics, such as polyethylene. If successful with her current ongoing research, a greener and eco-friendly environment will be achieved.

As a reasearcher, Dr Dash has published 27 research articles in International journals of repute. She has authored 10 book chapters and has edited a book on biomaterials. She is an author on 4 patents and has delivered many invited lectures and presented her work at several international and national conferences.

Dr Dash feels lucky that her research, her research team, all collaborators are a constant source of motivation and encouragement. The failures in her every day research are the main source of her excitement to keep on trying. The little time left from her work is for her twins, daughter Saanvi and son Shreyansh. •

PROF. MANAS KULKARNI

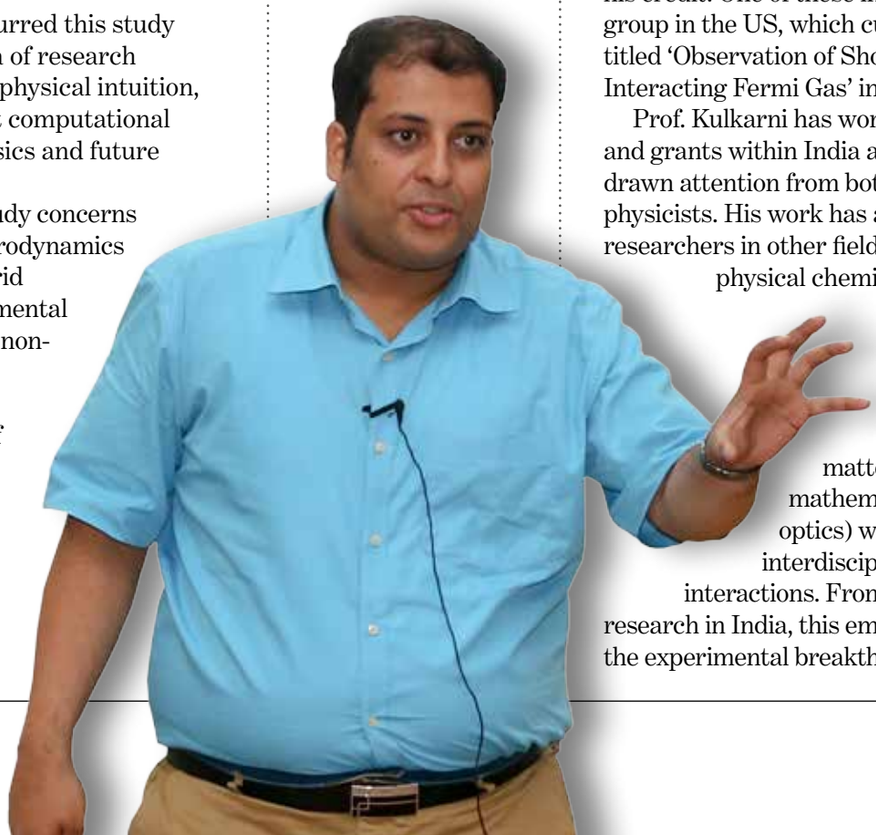
A Defining Role

Prof. Manas Kulkarni, a faculty at the International Centre for Theoretical Sciences of the Tata Institute of Fundamental Research (ICTS-TIFR), Bengaluru, has always been interested in statistical physics and condensed matter physics. He has contributed extensively in the area of non-equilibrium physics and open quantum systems. In particular, he has studied how systems of many-particles behave when they are out-of-equilibrium. When large particles are involved it is often impossible to track every microscopic ingredient and often a collective description is crucial. He has extensively worked in collective theory of many-particle systems. He has made contributions to open quantum systems, which are important both from a fundamental perspective and from the point of view of future technologies. He has also worked extensively towards understanding universal behaviour of low-dimensional systems. His work broadly speaking falls at the interface of statistical physics, condensed matter theory and mathematical physics.

One of the driving forces that spurred this study for Manas Kulkarni is that this area of research involves a beautiful combination of physical intuition, mathematical rigor, state-of-the-art computational tools, bearing on experimental physics and future quantum technologies.

A sample example of one such study concerns quantum-dot circuit-quantum-electrodynamics systems, which is an important hybrid quantum system both from a fundamental perspective (such as understanding non-equilibrium steady state properties, quantum correlations, quantum entanglement) and from the point of view of quantum devices (such as development of lasers in microwave regime also called 'masers', microwave amplifiers, quantum diodes and rectifiers). This kind of work on hybrid quantum systems is key to quantum computation and quantum simulation. In fact, his theoretical work on entanglement in superconducting qubits was a result with an experimental group at the University of California, Berkeley, which culminated in a publication in *Physical Review Letters*. Prof. Kulkarni also works towards understanding collective description of many particle systems and has numerous publications to his credit. One of these involves a direct experimental group in the US, which culminated in a publication titled 'Observation of Shock Waves in a Strongly Interacting Fermi Gas' in *Physical Review Letters*.

> **"A solid academic and research career is impossible without honesty, hard work and lifelong devotion."**



Prof. Kulkarni has won numerous awards, accolades and grants within India and abroad. His work has drawn attention from both theoretical and experimental physicists. His work has also gained attention of researchers in other fields such as mathematics and physical chemistry.

His work has had an impact on basic research efforts in India. He has been involved in working at the interface of core disciplines (condensed matter physics, cold atomic gases, mathematical physics and quantum optics) which constitute the important interdisciplinary field of light-matter interactions. From the perspective of basic research in India, this emerging field, especially given the experimental breakthroughs, has implications

Clockwise: During a discussion pertaining to ICTS programme on Open Quantum Systems

Speaking at a conference organised by the Physics Society of the Philippines where he was invited as a plenary speaker

Being welcomed during an outreach programme promoting science and scientific temper in younger generation

During an ICTS programme on integrable systems in mathematics, condensed matter and statistical physics

Interacting with Ratan Tata and other dignitaries

Inset: In his office at ICTS-TIFR, Bangalore. Prof. Kulkarni hopes to significantly add to the field of future quantum technologies and quantum computation

AWARDS

- Prajawani Young Achiever (leading Kannada daily) Award (2020)
- SERB Early Career Research Award (2019)
- Associate Member, Indian Academy of Sciences (2017)
- Ramanujan Fellowship (2017)

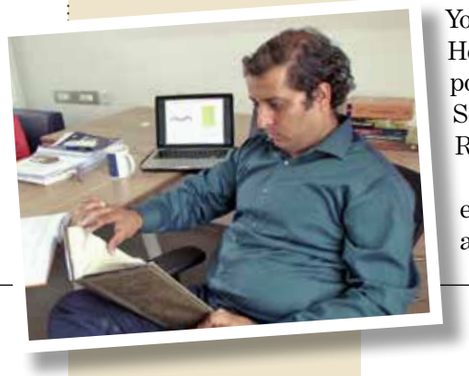
PUBLICATIONS

- 'Transport, correlations, and chaos in a classical disordered anharmonic chain'. *Phys Rev E*. (2020).
- 'Harmonically confined particles with long-range repulsive interactions'. *Phys Rev Lett.* (2019).
- 'Anomalous transport in the Aubry-André-Harper model in isolated and open systems'. *Phys Rev B.* (2018).
- 'Stabilizing entanglement via symmetry-selective bath engineering in superconducting qubits'. *Phys Rev Lett.* (2016).
- 'Cavity-mediated near-critical dissipative dynamics of a driven condensate'. *Phys Rev Lett.* (2013).

for understanding the most fundamental concepts in physics, one the one hand, and on the other, it will be of importance to technologies where quantum control of light-matter interactions play a defining role. He has worked and continues to work on problems which cut across traditional boundaries in theoretical physics and also have a deep connection with recent experimental developments. Prof. Kulkarni has contributed to this new area of research in the Indian context. He has developed close collaborations with researchers in various Indian institutions such as TIFR, Mumbai and IISc, Bangalore.

One of the favourite aspects of Prof. Kulkarni's research is interaction with not only his own group of students, postdocs and visitors but also collaborations/associations with Princeton University (New Jersey, US), École Normale Supérieure (ENS, Paris), New York University (USA), University of Tokyo (Japan), City University of New York (USA), University of Toronto (Canada), Aspen Center for Physics (USA), and Galileo Galilei Institute for Theoretical Physics (Italy) to name a few.

In future, Prof. Kulkarni aims to further explore open problems in quantum statistical mechanics. Some of the planned works may have not only experimental connections, but also are expected to be relevant from the point of view of device applications.



Prof. Kulkarni hopes to significantly add to the field of future quantum technologies and quantum computation.

Born in Hyderabad, his father Professor Shreekanth Kulkarni taught in the Department of Philosophy at the University of Hyderabad and his mother Rajeshwari Kulkarni was the headmistress of the International School, Hyderabad.

After completing graduation in Physics from St. Stephens College, Delhi, Manas moved to New York to pursue his master's and later a PhD in Physics from the State University of New York at Stony Brook, New York (along with a co-advisor at Brookhaven National Laboratory, USA). After completing his PhD, he was a postdoctoral fellow at the University of Toronto, Canada and then a postdoctoral research associate at Princeton University, US. Prof. Kulkarni then took up a faculty position at the City University of New York (CUNY), USA. At CUNY, he won the City University of New York (PSC-CUNY) Research Grant in 2015 and 2016. He moved back to India in 2016 to take up a faculty position at the International Centre for Theoretical Sciences of the Tata Institute of Fundamental Research (ICTS-TIFR), Bengaluru.

He strongly believes that support from family, excellent teachers, encouragement of peers played a pivotal role in shaping his academic career. •

DR MANDAR MADHUKAR DESHMUKH

Pushing Boundaries

Looking towards the future, Dr Mandar Madhukar Deshmukh is excited about three main possibilities. First, research in 2D materials is likely to provide an understanding of the mechanism of high-temperature superconductivity – a long-standing puzzle. High-temperature superconductors' potential to impact human society by reducing energy loss is immense if one can understand and make better materials in a rational process. Second, the possibility of very low dissipation modes of information transport like magnons and valley excitations is promising. Last, the quantum revolution will impact computation, communication, and sensing. Quantum technologies will enable the detection of tiny forces, magnetic fields, and electric fields. And, if we can measure small physical quantities accurately, one can make a sensor. Some of these sensors can have medical applications. Mandar's group is working in these three high-impact areas.

Though Mandar was born in Pune, Maharashtra, his father, Madhukar's job as an officer with the Border Security Force (BSF) required them to stay near the border areas, hence Mandar grew up in BSF cantonments. Mandar moved to Pune with his mother, Mangala, for higher education.

Propelled, Mandar joined the Engineering Physics BTech programme at IIT Bombay. Here his interest slowly shifted towards experimental condensed matter physics. The visiting student's summer research programme at TIFR played a crucial role in firming his interest in experimental physics. At the end of the Engineering Physics Programme, he chose to go to Cornell University. At Cornell, he joined Dr Dan Ralph's group. Mandar participated in setting up the lab and enjoyed taking a semester-long machining class. Mandar's research project involved probing the particle-in-a-box states in metallic single-electron transistors using ferromagnetic materials. He measured the many-body excitations in ferromagnets and used the quantum states to investigate ferromagnets' spin polarization. Towards the end of his PhD, Mandar decided to return to India. He planned to develop experimental ideas and skills that would allow him to establish an internationally competitive research group in India.

> **"Doing something outside your comfort zone is the first step to discovering something new."**

After his PhD, Dr Deshmukh joined the Hongkun Park group at Harvard that had a diverse multi-disciplinary environment. He collaborated with chemists and materials scientists a skill that was very important later in his career while he worked on single-molecule transistors and nanoscale superconductors. At the end of his postdoctoral research at Harvard, he joined the Tata Institute of Fundamental Research (TIFR).

At TIFR, in 2006, Dr Deshmukh set up a new nanoscale physics group. His PhD students joined him in this endeavour. One of the subareas pursued by his research group was transistors and nanomechanical devices using semiconducting nanowires. This line of research's motivation was that these semiconductor nanowires were narrowband semiconductors with high electron mobility. Some predictions suggested InAs nanowires be the basis of next-generation transistors to overcome the challenges of Si devices. One of the exciting discoveries from the young group was that a gate-all-

AWARDS

- OXFORD Instruments Young Nano Scientist India Award (2019)
- Young Career Award in Nano Science & Technology (2018)
- Shanti Swarup Bhatnagar Award (2015)
- Swarnajayanti Fellowship
- BM Birla Prize (2011)

PUBLICATIONS

- 'Observation of standing spin-wave modes in a van der Waals magnetic material'. *Advanced Materials* (2021).
- 'Bulk valley transport and Berry curvature spreading at the edge of flat bands'. *Nature Communications* (2020).
- 'Landau level diagram and the continuous rotational symmetry breaking in trilayer graphene'. *Physical Review Letters* (2018).
- 'Strong electronic interaction and multiple quantum Hall ferromagnetic phases in trilayer graphene'. *Nature Communications* (2017).
- 'Dynamical strong coupling and parametric amplification of mechanical modes of graphene drums'. *Nature Nanotechnology* (2016).

Clockwise: At a science outreach session with students – a believer in science communication and nurturing the young

In his lab working on low temperature measurements. Dr Deshmukh is interested in researching on 2D materials, high-temperature superconductors' potential and quantum technologies

Preparing for a cooldown of a device

Running a marathon in Ladakh

With Prof. Klaus von Klitzing, Nobel Laureate, known for discovery of the integer quantum Hall effect

With Chairman of Tata Sons, Ratan Tata, during his visit to the lab

Inset: On a monsoon trek with his students

around geometry could lead to an excellent field-effect transistor. Their result was highlighted in *Nature* magazine as a 'simple technique that may change the way nanowire-based transistors are made.'

Around this time, a new research area was developing – the research in 2D materials led by the discovery of graphene by Geim and Noveselov. Dr Deshmukh's group also dove into this exciting opportunity. The two sub-areas that were pursued were nanomechanics of graphene and the study of electronic properties.

One of the notable contributions to come out of the research group, using freely suspended nanomechanical devices, was to measure the thermal expansion of graphene that is negative over a large range of temperatures. Following these experiments, measurements were done to study the transfer of energy between different vibrational modes – results from this work were on the cover of the journal Nature Nanotechnology. These devices are analogous to a table, a pair of hand drums, but the drum is of one atom thick graphene, and one measures the vibrations electrically. The motivation for these measurements is to study the mechanical properties of one atom thick membrane. While the mechanics of large objects is well understood – there are unanswered questions about the nature of mechanical properties down to membranes that are one atom thick.

In the recent past, they have also revealed information about the Berry phase in a few layers of graphene – critical information about the system's topology. Ideas about topology are leading to a fundamental change in our understanding of solid-state physics.

His group has also pursued graphene study, where two layers of graphene are twisted relative to each other. The ideas developing out of these studies will help understand the mechanism of superconductivity and magnetism. The older view that superconductivity and magnetism are mutually incompatible is rapidly changing.

Dr Deshmukh derives confidence from his early work in graphene when the group developed expertise in an unfamiliar and rapidly moving field; this confidence allows him to dive into new research areas. For him, it is essential to continually evolve to adapt and tackle new research areas – always push the boundaries of the comfort zone.

In his scientific journey, Dr Deshmukh has published in many of the top journals. His work has received international recognition and many accolades. And, outside his research lab, Dr Deshmukh loves running marathons and indulge in photography, especially birds. •

N-P

DR NARAYAN PRADHAN
PROF. NAVEEN GARG
PROF. NEELESH B MEHTA
PROF. NITIN SAXENA
PROF. NIYAZ AHMED
DR PARTHA SARATHI MUKHERJEE
DR PRADYUT GHOSH
PROF. PRASANTA KUMAR DAS
PROF. PRIYA MAHADEVAN

DR NARAYAN PRADHAN

Staying the Course

By his admission, Dr Narayan Pradhan is so committed to his work that he ends up spending more time in the lab than outside it. He even takes images of the nanomaterials himself and tries to understand their reaction process. And whatever the challenge he surmounts it! For example, when the synthesis process became tedious and one could not run the second reaction before viewing the sample of the first one under the electron microscope, and his group was limited by it, they moved mountains to procure, with the support from DST and IACS, a High-Resolution Transmission Electron Microscope (HRTEM), with which he expects to achieve better outcomes in the future.

One often plans something in research but takes a diversion on the way before reaching the planned destination. This happens frequently in nanomaterials synthesis wherein researchers first get results and then try to understand their chemistry. However, when reactions operate according to a rational design, it indeed gives pleasure. Dr Pradhan has accomplished this in several cases developing the armed structures of light-emitting perovskites with intensified emission by more than 50-fold.

However, radically new results are not always readily accepted in the researcher community. Dr Pradhan had to spend more than three years on a rejected work on perovskite nanocrystals which questioned why perovskite forms six-faceted cubes. Finally, his group succeeded in creating multiple facets and arm growth. This also led to substantial changes in their light emission properties. This work has been the turning point for him.

Dr Narayan Pradhan is a synthetic chemist engaged in designing nanomaterials. His research is focused on understanding the chemistry and physics of different inorganic semiconducting nanocrystals. He is well known for his work in doped semiconductor nanocrystals with tunable optical properties. For example, doping Mn(II) ions in ZnS, ZnSe and perovskite host nanocrystals tuned their blue light emission to a bright orange colour. The major fraction of his publications is on understanding foreign ion incorporation and the resultant change in optical properties. These optical materials with above 70% photoluminescence quantum yield have tremendous scope for applications in solid-state lighting as they show minimal self-absorption. Moreover, he has developed a strategy that can lead to doping more ions in more host nanocrystals to explore several hidden properties. The concept of such doping is related to the nanocrystal engineering process.

> **“Learning the core science fundamentals would take someone as high as their dreams. One should not be crazy, but one should not leave the ground unless the problem is solved.”**

Watching atoms joining and forming a nanocrystal, and facet directive joining to tune the shape of the nanocrystal is quite exciting and has the added fun of learning chemistry at the nanoscale. Further, the beauty lies in their properties, some of which appear new and quite different from their bulk forms. One of their most important results is the near-unity photoluminescence quantum yields of perovskite nanocrystals in blue, green and red colours. Under the microscope, these crystals look beautiful, and so are their exciting and useful luminescence properties. Apart from this, Dr Pradhan and his research team have published

Clockwise: Receiving the Oxford Nanoscientist award from Prof. CNR Rao at JNCASR, Bangalore

Preparing a sample for Electron Microscope Imaging

In front of an electron microscope funded by Department of Science & Technology

During the inauguration of SJF-DST sponsored TEM among with office and project staff members at IACS, 2015

Listening to the presentation by a young scientist from RN Jew High School, Balasore, in 2008

Inset: Illuminated nanocrystals under UV light irradiation. Dr Pradhan is showing green emission from Cu doped ZnSe nanocrystals

AWARDS

- Swarnajayanti Fellow (2011)
- LNJ Bhilwara Research Fellowship Award (2007)
- Young Carrier Award, DST Nano-Mission (2015)
- Oxford Instrument Young Nanoscientist Award (2017)
- Fellow, Indian Academy of Sciences, Bangalore (2019)

PUBLICATIONS

- 'Alkylammonium Halides for Facet Reconstructions and Shape Modulations in Lead Halide Perovskite Nanocrystals'. *Acc Chem Res.* (2021).
- 'α-Halo Ketone for Polyhedral Perovskite Nanocrystals: Evolutions, Shape Conversions, Ligand Chemistry and Self-assembly'. *J Am Chem Soc.* (2020).
- 'Facets Directed Connecting Perovskite Nanocrystals'. *J Am Chem Soc.* (2020).
- 'Tips and Twists in Making High Photoluminescence Quantum Yield Perovskite Nanocrystals'. *ACS Energy Letters* (2019).

significant fundamental research on perovskite nanocrystals. The motivation of this research was to achieve intense emission, for example, by adding just a pinch of halide salts, their emission intensity enhanced even more than 50-fold. Moreover, the bigger question he addressed was about the crystal shape since almost all earlier reports showed six-faceted hexahedrons of perovskites. Being a synthetic chemist, this question indeed puzzled him and he continued his research in generating perovskite nanocrystals with new facets. Finally, his group succeeded in obtaining novel-shaped nanocrystals. The entire adsorption phenomenon changes with crystal facet alteration and so do their catalytic activities. Dr Pradhan says that this is a big opportunity for these materials, which would drive their applications in fields other than only in light-emitting nanocrystals or photovoltaics.

The aim of his life continued to evolve until he enrolled for a PhD. And, his academic life was shaped mostly during his PhD when he used all his energy and talent to establish himself as a synthetic chemist in materials science.

The person Dr Pradhan, feels he owes his success the most to his mathematics teacher Sri Rabindra Nath Dey, who was extremely talented and helped him in building his life in academics.

Another diversion that had changed the course of his career was during his BSc. He was interested in studying physics, but he joined chemistry honours, similarly for his PhD, he wanted to work in organic chemistry, but got to work in materials chemistry. But whatever happened, happened for a reason. After a PhD from IIT-Kharagpur, Dr Pradhan continued further research on nanomaterials as a post-doc in Israel and the USA and joined as a researcher at the Indian Association for the Cultivation of Science, Kolkata in 2007. His future aim is to learn how to grow nanocrystals to cater to a chemist's wish and to tune their properties.

In his 14 years of independent research, Dr Pradhan has published 35 publications in *The Journal of Physical Chemistry Letters*, each with close to ~50 average citations. This is a very prestigious journal in physical chemistry and he thinks that crystal growth of nanocrystals is primarily governed by understanding the fundamentals of physical chemistry.

Keen to share his knowledge, Dr Pradhan is engaged in several social activities in his village and nearby areas, helping students from economically weaker backgrounds. •

PROF. NAVEEN GARG

Having the Courage of One's Convictions

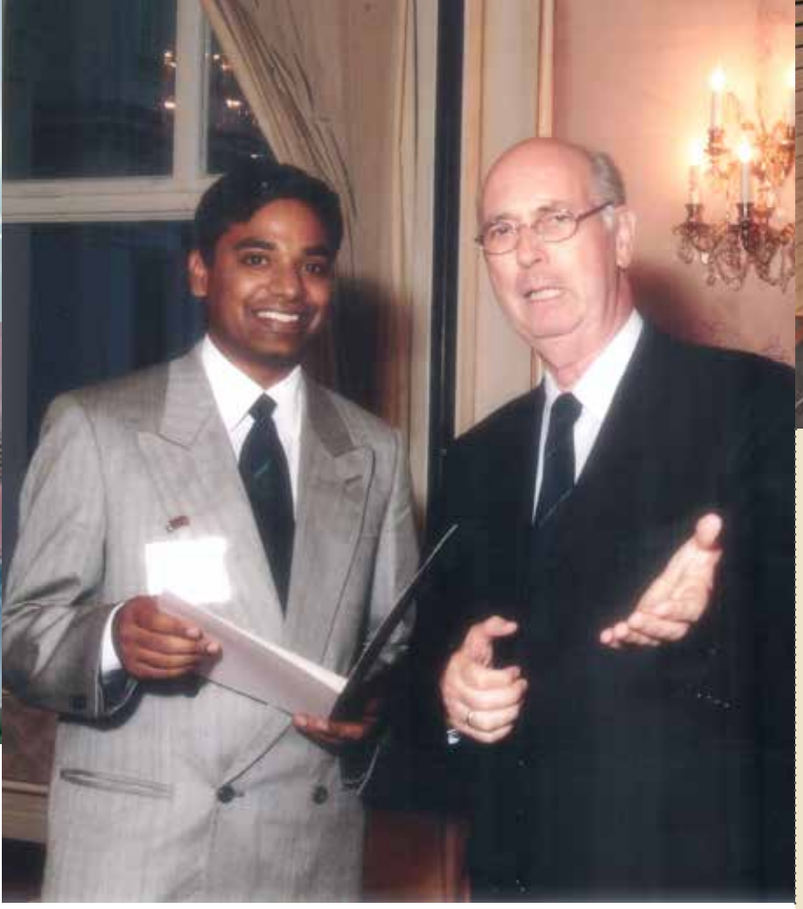
Algorithms – best described as a sequence of steps one needs to follow to solve a problem – are central to computer science. Equally key is the idea of polynomial time as a benchmark for algorithmic efficiency. The celebrated *P? NP* question is whether every problem with efficiently checkable solutions also has efficient algorithms for computing these solutions. Since it is widely believed that the answer to this is a 'no', algorithm designers are interested in finding efficient algorithms for NP-hard problems, perhaps at the cost of sacrificing optimality. Approximation algorithms provide provable guarantees on the quality of the solution returned and this area, which was still in its infancy in the early nineties, is what Prof. Naveen Garg began exploring during his graduate studies. Leighton-Rao's results relating multi-commodity flows to sparsest cuts in graphs and the Primal-dual algorithm for Steiner forests by Agrawal-Klein-Ravi and Goemans-Williamson had established the key role that combinatorial and mathematical optimization techniques were to play in designing such algorithms. It was the beauty of the concepts and their sophisticated application together with the numerous problems in need of efficient approximation algorithms that led Prof. Garg to dive headlong into this area of research.

As an illustration, consider a city government that plans to set up 100 ration shops. The addresses of all beneficiaries and possible locations for setting these shops are known. We would like to identify the locations at which to open the shops such that the total distance travelled by the beneficiaries to their nearest ration shop is minimized. This is a classical clustering problem, referred to as the k-median problem in the facility location literature. A simple and intuitive algorithm is to initially open the 100 shops at arbitrary locations and improve the solution with swaps – if shifting a shop from one location to another reduces the total distance travelled, then we make the switch. The algorithm halts when no further improvement is possible. How good is the solution obtained? Prof. Garg and his co-authors proved that the solution is never more than 5 times the optimum and that this bound is best possible.

> **"It takes hard work and perseverance to unravel the beauty of algorithms."**

Many approximation algorithms are simply stated but often their analysis tends to be tricky and requires sophisticated arguments and mathematical techniques. For k-median, a tight analysis of the above local search had remained an open problem for over 40 years. The joy of designing simple and elegant algorithms, of unravelling hidden structures in the problem and of crafting clever arguments to analyse these algorithms is what keeps Prof. Garg hooked to this area of research. Research in theoretical CS can often be very frustrating with long periods when all-brilliant ideas seem to hit a wall. But perseverance pays and brings with it those inspired moments when the arguments finally fall into place and fit together like a jigsaw puzzle. It is the high provided by these Eureka moments that keeps researchers like Prof. Garg going.

The problems Prof. Garg considers in his research are mathematical abstractions of real-world problems arising in the design of communication and road networks, routing data and traffic, scheduling jobs on machines and processors, VLSI design, and facility location. The real problem would typically have additional constraints that are ignored in the abstraction but quite often the algorithms designed can be adapted



Clockwise: Receiving the BTech degree from Director IIT Delhi, August 1991

At work at IIT Delhi, 2021. Many challenging problems in Approximation algorithms continue to defy solutions and Prof. Garg plans to work on them

Receiving the Friedrich-Wilhelm-Bessel Bessel Prize from the President of the Humboldt Foundation, Opernpalais Berlin, June 2002

At a farewell dinner with his students, New Delhi, April 2005. Prof. Garg thoroughly enjoys teaching and works very closely with his students

With his postdoctoral mentor, Prof. Kurt Mehlhorn, Saarbruecken, Germany, in 2009

Inset: Delivering a lecture on living science in New Delhi in September 2017

AWARDS

- Shanti Swarup Bhatnagar Award (2016)
- ACM Distinguished Speaker Association for Computing Machinery (2014)
- Teaching Excellence Award (2012)
- Chosen as a partner group on 'Approximation Algorithms' at IIT Delhi (2005)
- Friedrich Wilhelm Bessel Research Award (2002)

PUBLICATIONS

- 'Faster and Simpler Algorithms for Multicommodity Flow and Other Fractional Packing Problems'. *SIAM Journal on Computing* (2007).
- 'Local Search Heuristics for k-median and facility location problems'. *SIAM Journal on Computing* (2004).
- 'Primal-dual approximation algorithms for integral flow and multicut in trees, with applications to matching and set cover'. *Algorithmica* (1997).
- 'Constant Factor Approximation Algorithm for Weighted Flow Time on a Single Machine in Pseudo-polynomial time'. *59th Annual IEEE Symposium on Foundations of Computer Science* (2018).

or extended to handle these constraints and give valuable solutions that improve efficiency and performance of the systems built using them. Naveen's major contributions include extending the celebrated Max-flow min-cut theorem of Ford and Fulkerson to an approximate max-flow min-multicut theorem for multicommodity flows, developing the primal dual framework to obtain fast approximate solutions for packing and covering linear programmes, improving the analysis of the local search method for k-median and capacitated facility location and applying techniques from linear programming and duality to problems involving scheduling jobs to minimize their average flow time.

While growing up, Naveen was curious about how things worked and would voraciously read the encyclopedias that his father brought for him. A career in engineering seemed an obvious choice and like many other boys his age he began preparing for JEE. Naveen surprised himself and his extended family with the JEE results and set off to IIT Delhi to study computer science.

At IITD, the turning point was the course on Theory of Computation which introduced Naveen to models, tools and techniques to reason about computation and its limits. This, and the course on Algorithms, convinced him to take up research in theoretical computer science. Naveen was accepted to and offered a UC Regents fellowship to pursue graduate studies at University of California, Berkeley. However, he opted out of UCB and joined IITD for a PhD with Prof. Vijay Vazirani. This was not an easy decision and required a lot of conviction and confidence; it was a decision that changed the course of his life if not his career.

After completing his PhD and a postdoc from the Max-Planck-Institut fur Informatik, Saarbruecken, Germany, as part of the Algorithms and Complexity group of Kurt Mehlhorn, Prof. Garg joined his alma mater as an Assistant Professor in December 1997 and soon found an excellent set of students to work with. He continued to maintain close ties with MPI-Informatik and in 2005 was chosen by the Max-Planck-Society to head a partner group on 'Approximation Algorithms' at IIT Delhi. This eventually led to the formation of the 'Indo-German Center for Excellence in Computer Science' – a virtual centre for collaborative research between Indian and German scientists which was funded by DST, Max-Planck-Gesselschaft and the German Federal Ministry for Science and Research.

Prof. Garg thoroughly enjoys teaching and works very closely with his students. His video lectures on 'Data Structures and Algorithms' recorded as part of NPTEL are quite popular. In 2012, he was awarded the 'Teaching Excellence Award' by IIT Delhi. •

PROF. NEELESH B MEHTA

Wired for Success

Prof. Neelesh B Mehta, envisages a future where wireless communications will become an integral and indispensable part of everyone's lives. It will impact and transform a wide swath of industries. While 5G cellular systems are seeing rapid deployment worldwide, research work has already commenced on 6G. He, along with several researchers globally, is working on a variety of cutting-edge technologies. These technologies include spectrum sharing, in which different wireless systems or providers co-exist and efficiently share the scarce wireless spectrum. Another futuristic technology is full-duplex communications, in which a device can transmit and receive on the same frequency band at the same time. This capability is not available in the current generation of devices, which can transmit and receive at the same time but at different frequencies. Consequently, full-duplex communication promises to double the data rates of wireless systems without taking up any additional bandwidth. The research challenge lies in controlling the interference between simultaneous transmissions and developing communication protocols that fully exploit the full-duplex capability. The third technology is green and energy-efficient communication. The research challenge lies in ensuring that communication systems meet the ever-increasing demand for higher data rates while still being energy efficient. Energy efficiency is essential to control the bourgeoning carbon footprint of the telecommunication industry and to ensure a long duration of operation before a device's battery has to be recharged or replaced.

The techniques Prof. Mehta has exploit the wireless medium's time, frequency, and space dimensions. They include: multi-antenna techniques, in which information is transmitted from different antennas; cooperative relaying, in which helper relay nodes forward information of other nodes to improve the rate and reliability of communication; energy harvesting, in which the nodes harvest green renewable energy to power their operation and to communicate; and spectrum sharing, in which different wireless systems efficiently and amicably share the same scarce spectrum. His work finds applications in cellular radio systems, wireless local area networks (WiFi), and wireless sensor networks. He has published 75+ papers in IEEE journals, 90+ conference papers, and 3 book chapters, and is a co-inventor of 25+ issued US patents.

> **"Focus on the basics and do not take any assumption or model for granted. Learn from the right mentors and work with enthusiastic and bright students."**

Prof. Mehta has developed a highly innovative suite of selection algorithms that determine – in a distributed and scalable manner – the best relay to forward the information reliably to a destination. Identifying the best relay among the many available relays is challenging in practice because the relays are geographically separated and cannot communicate freely with each other. No relay, based on its limited local information, knows upfront who the best relay is. While the time required by conventional algorithms to select the best relay increases as the number of nodes increases, it saturates to a remarkably small constant for the algorithms he has developed. This translates to markedly higher spectrum utilization and energy-efficiency in wireless systems that employ these algorithms.

Another topic that Prof. Mehta has worked extensively on since he joined IISc is energy harvesting wireless networks. His work showed that energy harvesting could increase the energy-efficiency and lifetime of wireless networks manifold. It addresses the fundamental new challenges that arise

Clockwise: Receiving the Shanti Swarup Bhatnagar Award from Prime Minister Narendra Modi in 2019

At work in his office at IISc. He envisages a future where wireless communications will become an integral and indispensable part of everyone's lives

Being inducted as a Fellow of the Indian National Science Academy in 2019

With the Next Generation Wireless Systems group, ECE department, IISc

Being felicitated for IEEE fellowship at the IEEE Global Communications Conference 2019

Inset: Being inducted as a Fellow of the Indian National Academy of Engineering in 2016

AWARDS

- Khosla National Award in Engineering, IIT Roorkee (2019)
- Shanti Swarup Bhatnagar Award (2017)
- Hari Om Ashram Prerit Vikram Sarabhai Research Award (2016)
- Swarnajayanti Fellowship (2016)
- Fellow of IEEE (2019), INAE (2015), INSA (2020), NASI (2013)

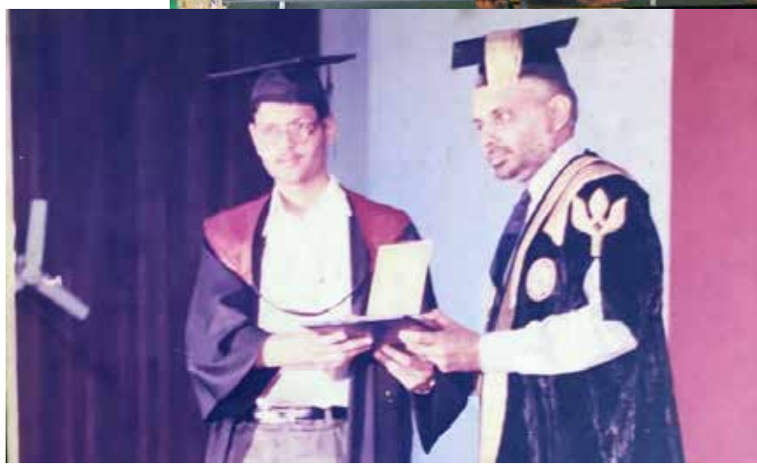
PUBLICATIONS

- 'Modeling and Analysis of Differential CQI Feedback in 4G/5G OFDM Cellular Systems'. *IEEE Trans. on Wireless Communications* (2019).
- 'Transmit Antenna Selection for Interference-Outage Constrained Underlay CR'. *IEEE Trans. on Communications* (2018).
- 'Voluntary Energy Harvesting Relays and Selection in Cooperative Wireless Networks'. *IEEE Trans. on Wireless Communications* (2010).
- 'Optimal Timer Based Selection Schemes', *IEEE Trans. on Wireless Communications* (2010).
- 'Approximating a Sum of Random Variables with a Lognormal'. *IEEE Trans. on Wireless Communications* (2007).

due to the randomness in the energy harvested, and has led to new principles for redesigning protocols for energy harvesting wireless systems.

He has also played a significant role in ensuring the adoption of the transmit antenna selection technique in the 4G cellular standard and in characterizing its performance. By opportunistically selecting one or more antennas from among the available antennas to transmit or receive, antenna selection harnesses the benefits of multiple antennas, but with much lower hardware complexity and cost. His subsequent work on exploiting antenna selection in emerging spectrum sharing systems has achieved a ten-fold to a hundred-fold reduction in the error rates of communication compared to the ad hoc approaches. His works show how spectrum sharing can provide highly reliable communication and address the severe spectrum shortage that wireless systems face today.

An equally important factor that has contributed to the rapid advance of wireless systems is new tools for modelling and analysing them. Here, Prof. Mehta's research has had a visible impact. His novel technique for characterizing the statistics of the aggregate interference from multiple transmitters is now a de facto approach for analysing and optimising wireless systems. Surprisingly, his method has also found applications in diverse areas such as bioinformatics and financial modelling. He has also developed a new statistical model for characterizing the reliability of communicating data over the large bandwidths that are typical of 4G and beyond systems. His work has led to new analytical approaches for characterising the performance of wideband resource allocation and feedback. The feedback provides the base station with essential millisecond-level information about the wireless medium it is transmitting over. It enables the base station to dynamically adapt its data rate and transmit power, and determine the users it will serve. Neelesh B Mehta is a Professor in the Department of Electrical Communication Engineering at the Indian Institute of Science (IISc), Bangalore. He received his BTech degree in Electronics and Communications Engineering from the Indian Institute of Technology (IIT) Madras and his master's and PhD degrees from the California Institute of Technology, Pasadena, USA. From 2001 to 2007, he worked at the AT&T Research Labs, Broadcom Corp. and Mitsubishi Electric Research Labs in USA. He has been at the Indian Institute of Science (IISc), Bangalore, since 2007, where he leads the Next Generation Wireless Systems group in the Electrical Communication Engineering department at IISc. •



PROF. NITIN SAXENA

Ahead of His Times

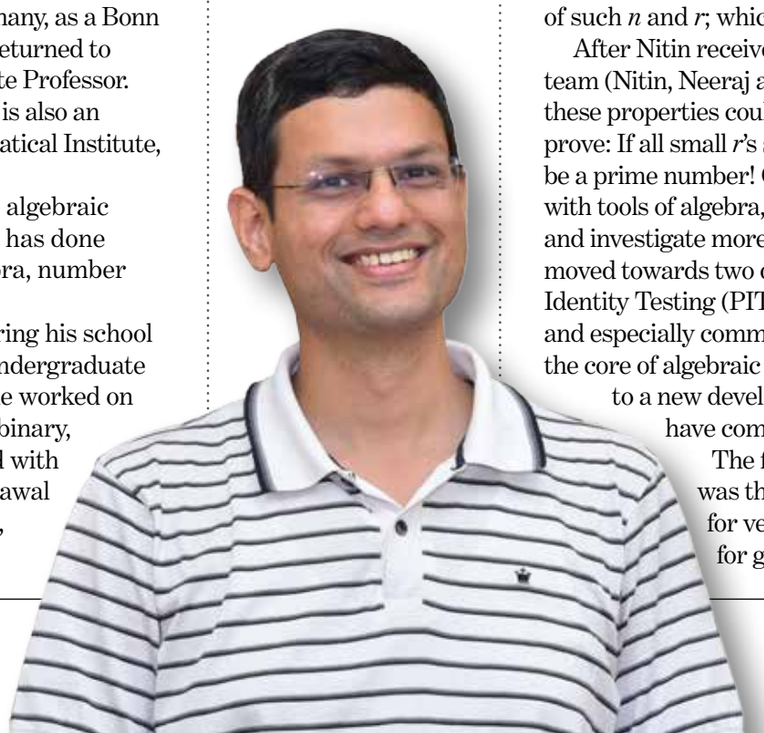
Prof. Nitin Saxena, a highly acclaimed computer scientist and a professor at IIT Kanpur, was born in Prayagraj, Uttar Pradesh. Nitin had little interest in mathematics, or in any other subject, till class 7, however, when he was introduced to higher mathematical concepts in the biographies of scientists from ancient India and Europe, it inspired him to learn the subject.

Always highly passionate and perseverant, his interest in math allowed him to understand subjects like computers, physics and chemistry better and also helped him succeed in maintaining a good rank in his class. The math camps (BARC Mumbai) that he attended, followed by his BTech studies from IIT Kanpur made sure that his math and engineering education was top-notch. He pursued his PhD under Prof. Manindra Agrawal at the Department of Computer Science and Engineering, IITK. During his doctoral studies, he was a Visiting Student Research Collaborator at Princeton University (2003-04) and a Visiting Scholar at the National University of Singapore (2004-05). In September 2006, he started his postdoctoral work at the Centrum Wiskunde & Informatica (CWI), Amsterdam, Netherlands, and continued till 2008. He then joined the Hausdorff Center for Mathematics, University of Bonn, Germany, as a Bonn Junior Fellow (W2 Professor). In 2013, he returned to India and joined IIT Kanpur as an Associate Professor. He was promoted to Professor in 2018 and is also an Adjunct Professor at the Chennai Mathematical Institute, Tamil Nadu (2018-21).

Prof. Saxena's primary area of work is algebraic complexity theory. Other areas where he has done significant work are computational algebra, number theory, and algebraic combinatorics.

His interest in algebra, which arose during his school days, got formalized in the course of his undergraduate studies. The first research problem that he worked on is primality testing: Given a number n, in binary, test whether it is a prime. He collaborated with batchmate, Neeraj Kayal, under Prof. Agrawal as the BTech Project (BTP) advisor. Nitin, worked with Neeraj and Prof. Agarwal, to solve primality in one year (2001-02). This was a breakthrough in science and made India proud. Since it lies at the intersection of basic math, computer science, and security, the accomplishment was covered widely by the global press and media.

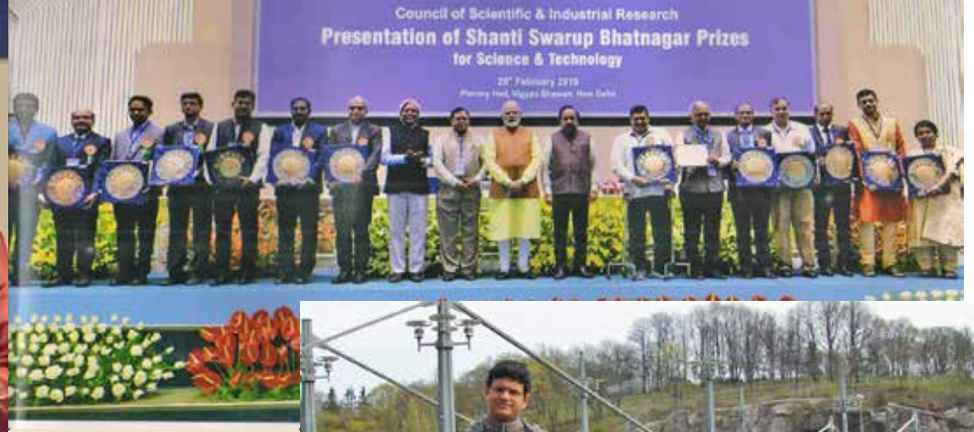
> **"Enjoy doing the work one chooses to do and set ambitious goals. It is important that one keeps making progress towards a big goal even if the goal looks distant."**



The basic idea that started their work is a ring identity that Prof. Agarwal had identified as useful many years ago: *(x+1)^n = (x^n + 1) mod <n, x^r -1>*. This is satisfied by all prime numbers n but fails for composite n for many r's. The outstanding question was which special r's satisfy this congruence when n is composite? They discovered a large number of intriguing properties of such n and r; which is included in their BTP report.

After Nitin received his BTech degree, in 2002, the team (Nitin, Neeraj and Prof. Agarwal) realized that these properties could be combined in a magical way to prove: If all small r's satisfy the congruence, then n has to be a prime number! Consequent to this dizzying success with tools of algebra, Prof. Saxena decided to learn, and investigate more problems in this area. Broadly, he moved towards two directions: studying other Polynomial Identity Testing (PIT) problems and studying other rings and especially commutative algebra. PIT problem is at the core of algebraic complexity theory. Its study leads to a new development in algebra; which would not have come to light otherwise.

The first such concept, he focused on, was that of bootstrapping — solving PIT for very special models implies solving it for general circuit models. Prof. Saxena



AWARDS

- Fulkerson Prize (2006)
- Gödel Prize (2006)
- Swarnajayanti Fellowship (2013)
- Shanti Swarup Bhatnagar Prize (2018)
- Fellowship of Indian Academy of Sciences (2021)

PUBLICATIONS

- 'PRIMES is in P'. *Annals of Mathematics* (2004).
- 'Polynomial Identity Testing for Depth 3 Circuits'. *Journal Computational Complexity* (2007).
- 'From Sylvester-Gallai Configurations to Rank Bounds: Improved Black-box Identity Test for Depth-3 Circuits'. *Journal of the ACM* (2013).
- 'Algebraic Independence and Blackbox Identity Testing'. *Journal Information & Computation* (2013).
- 'Bootstrapping variables in algebraic circuits'. *Proceedings of the National Academy of Sciences of the USA, PNAS* (2019).

Clockwise: Receiving his BTech degree in 2002

Giving a lecture in Turku, Finland, 2007. Prof. Saxena's primary area of work is algebraic complexity theory

Receiving the Shanti Swarup Bhatnagar 2018 Prize from Prime Minister Narendra Modi

With Prime Minister Modi and other recipients of the Shanti Swarup Bhatnagar Prize

In Turku in Finland, 2007

Inset: With Neeraj Kayal, his batchmate, and Prof. Manindra Agarwal in 2002. Together, they had solved the issue of primality in one year, which was a breakthrough in science and made India proud

optimized bootstrapping to the level of sum-of-squares representation. He showed that proving a weak, explicit, lower bound in this representation is enough to solve the core problem in algebraic complexity! The latter is called the 'algebraic version' of the P\=NP question; P\=NP is one of the highly-recognized 'Clay Mathematics Institute's Millennium Problems' and lies at the intersection of mathematics and computing. With this historic motivation, Prof. Saxena has investigated the algebraic model of computation. The second concept was that of algebraic dependence — polynomials that satisfy an algebraic equation (called an annihilator), tend to have a better structure to study. Prof. Saxena mined a classical invariant, called Jacobian, to solve PIT for various circuit models. Jacobian is known to fail over finite fields. He discovered new ways to test algebraic dependence in those cases; giving evidence for the first time that this computational problem is likely, not hard!

The third concept that Prof. Saxena tackled was that of approximative complexity, he designed an algorithm that could find approximative roots of polynomial systems in time, and space, exponentially better than what was known before. As a byproduct, he also proved new results about the classical Hilbert's Nullstellensatz, that is, finding exact roots of polynomial systems. Other concepts were—rank-concentration and Sylvester-Gallai configurations. Using these Prof. Saxena solved PIT for many interesting models.

The structure of commutative rings manifests a lot in computational algebra questions; some of which have deep applications in communications, error-correcting codes, cryptosystems, data storage and retrieval. He proved better results about factors of univariate polynomials, that of multivariate circuits, ABPs, and formulas. Each of these results was taken up by many researchers, and further optimized.

In the root-finding mod prime-powers regime not much was understood since a polynomial does not have unique factorization over such rings. Prof. Saxena revolutionized this area by obtaining a large number of structural and algorithmic results. He could find roots, factor univariate polynomials, and even compute Igusa's local-zeta function.

Prof. Saxena's investigations continue in the above areas and he expects them to take even more diverse directions. His goal is to keep improving the state of the open problems and to invent new machinery. The final destination of this journey is to solve the algebraic version of the P\=NP question and find the general PIT algorithm.

And, the little time that remains, beyond his profession, Prof. Saxena spends it with his family travelling, binge-watching films, and reading non-fiction. He also likes music, especially western classical, and plays the piano regularly. •

PROF. NIYAZ AHMED

Perseverance Pays

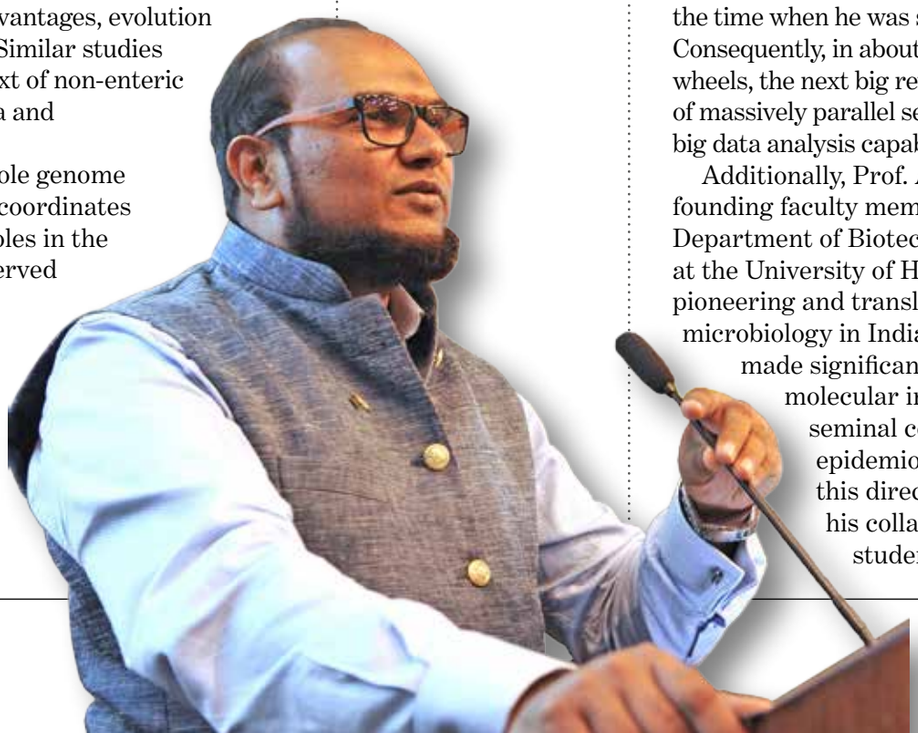
From his early days, Prof. Niyaz Ahmed, a Professor in the School of Life Sciences at the University of Hyderabad, had a penchant for research and, motivated by the struggle and suffering of the rural people, he desperately wanted to work in the public health domain, especially as the Indian subcontinent is a major hub of bacterial infections.

Prof. Ahmed's expertise in microbial genomics, coupled with cell signalling studies uniquely unravelled the extent and significance of chromosomal and functional plasticity of bacteria and their relevance to survival and adaptation mechanisms underlying the emergence, transmission, carriage and/or maintenance of the pathogens in a community setting, habitats and ecosystems of relevance to human and veterinary health.

With the help of high-resolution genomics, Prof. Ahmed and his team successfully unravelled the population genetic structure of important bacterial pathogens, namely, Helicobacter pylori, E. coli, Salmonella typhi and other enteric pathogens in India and globally; this gave impetus to the development of novel molecular epidemiology studies of the pathogens to understand their survival in the host and the environment, their fitness advantages, evolution and transmission dynamics. Similar studies were carried out in the context of non-enteric pathogens such as Leptospira and M. tuberculosis.

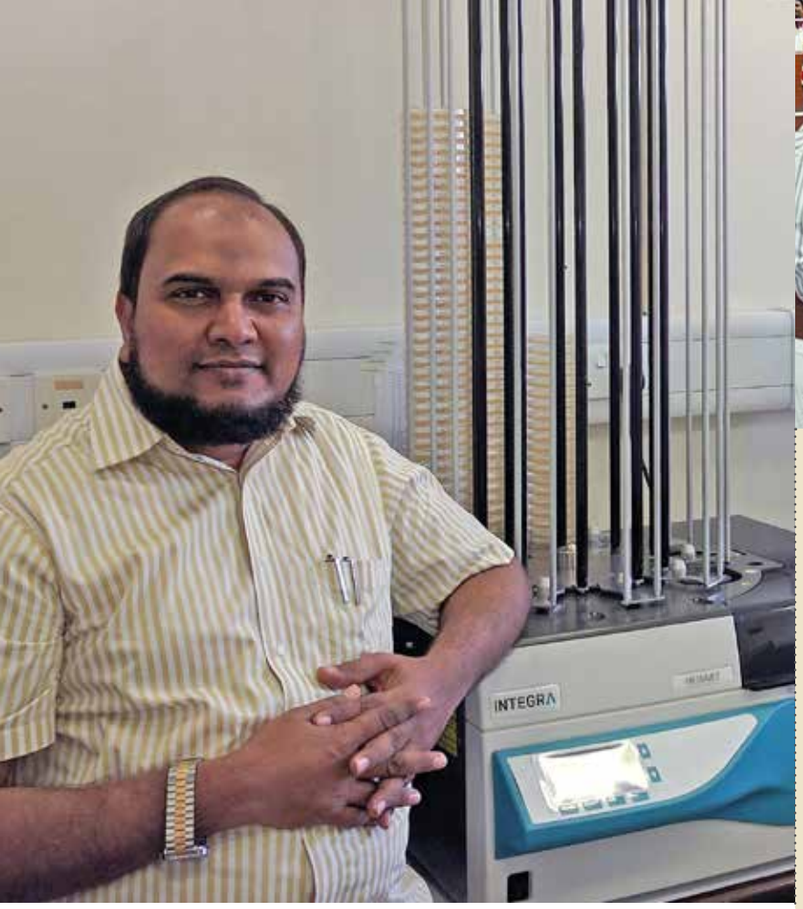
Based on comparative whole genome analyses, important genetic coordinates with putative or predicted roles in the disease process, either conserved or variable, were identified and subjected to functional characterization to prove the predicted virulence functions that helped the pathogens survive and multiply against the host immune defences. Many such virulence factors, namely, the TieA, ctkA, cholesteryl-α-Glucoside Transferase from H. pylori and DATIN (dormancy associated translational inhibitor) from M. tuberculosis were successfully characterized with respect to their multipronged virulence functions and regulatory acumens that provided novel and previously unknown insights into the pathogenesis of bacterial infectious diseases.

> **"The mantra for success is a combination of single-mindedness and honest hard work."**



The defining moments in Prof. Ahmed's work came with the advent of whole genome sequencing right at the time when he was starting his research career. Consequently, in about a decade, when his work took wheels, the next big revolution through the development of massively parallel sequencing and the development of big data analysis capabilities took place.

Additionally, Prof. Ahmed was among the founding faculty members of the newly created Department of Biotechnology & Bioinformatics at the University of Hyderabad. Through his pioneering and translational work in public health microbiology in India and South Asia, Prof. Ahmed made significant effort in the development of molecular infection epidemiology and made seminal contributions to host-pathogen epidemiology of bacterial pathogens. In this direction, he successfully leveraged his collaborative linkages for research student exchange/joint-supervision at



AWARDS

- Shanti Swarup Bhatnagar Prize (2016)
- University of Hyderabad Chancellor's Award (2015)
- National Bioscience Award (2011)
- Fellow, American Academy of Microbiology (2018)
- Fellow, Royal Society of Chemistry (2015)

PUBLICATIONS

- 'Comparative genomic analysis of Helicobacter pylori from Malaysia identifies three distinct lineages suggestive of differential evolution'. *Nucleic Acids Res*. (2015).
- 'Multipronged regulatory functions of a novel endonuclease (TieA) from Helicobacter pylori'. *Nucleic Acids Res*. (2016).
- 'Genome Dynamics of Vibrio cholerae Isolates Linked to Seasonal Outbreaks of Cholera in Dhaka, Bangladesh'. *mBio*. (2020).
- 'Evolutionary Dynamics Based on Comparative Genomics of Pathogenic Escherichia coli Lineages Harboring Polyketide Synthase pks Island'. *mBio*. (2021).

Clockwise: Receiving the Shanti Swarup Bhatnagar Prize (2016) from Prime Minister Narendra Modi

Prof. Ahmed at work

Prof. Ahmed has made significant contribution to the development of molecular infection epidemiology and host-pathogen epidemiology of bacterial pathogens

In discussion with Dr APJ Abdul Kalam, former President of India

Receiving the National Bioscience Award from Union Minister S Jaipal Reddy, and Prof. K Vijayraghavan

Interacting with Penny Mordaunt, former Defence Secretary, UK

Inset: At a University of Hyderabad convocation ceremony

the university through international bilateral science cooperation instruments such as the Indo-German Internationales Graduiertenkolleg – GRK1673 of which Prof. Ahmed has been the co-ordinator/ spokesperson from the Indian side.

He has also served as the Senior Director at the International Centre for Diarrheal Disease Research, Bangladesh (icddr,b) in an international leadership position from 2016 to 2020. As a part of his leadership and vision, Prof. Ahmed developed state-of-the-art containment labs, biorepositories, bioinformatics platforms and a modern animal house. Prof. Ahmed also oversaw benchmarking of 500 plus diagnostic tests and parameters according to ISO 15189 and ISO15190 accreditation regimes. Prof. Ahmed carried out pioneering research on the genomic basis of the seasonality of cholera in Bangladesh and worked extensively on the problem of antimicrobial resistance in municipal and refugee settings.

Prof. Ahmed's research work, as evidenced from his publications trajectory spread over 160 plus research papers highlights his remarkable intellectual contribution to functional molecular epidemiology of bacterial pathogens that have provided a significant impetus to the field of Public Health Microbiology (cellular microbiology/ pathogenesis in particular).

He feels, the discovery of new antimicrobial drugs would require a lot of epidemiological studies in its base and that is where the need for population-level studies of pathogen-host interaction dynamics would be extremely vital. As perseverance always pays, Prof. Niyaz Ahmed who hails from Maharashtra, from a family of farmers, though could not succeed in pursuing medicine, but proceeded to study veterinary medicine from the Veterinary College, Nagpur followed by a master's degree in animal biotechnology from the National Dairy Research Institute, Karnal.

Later he completed his PhD in the area of infectious diseases from CDFD, Hyderabad (Manipal University, Manipal) under the supervision of Prof. Seyed E Hasnain. In 1998, at an early age of 26 years, Prof. Ahmed was recruited as a scientist to work in Prof. Lalji Singh's group at the Centre for DNA Fingerprinting and Diagnostics in Hyderabad. Prof. Ahmed, bolstered by this opportunity and the mentoring of veterans such as Prof. Singh and Prof. Seyed Hasnain embarked upon his research journey to unravel bacterial fingerprints with special reference to their survival, fitness and transmission dynamics. •

DR PARTHA SARATHI MUKHERJEE

Propelled by Reason

Mumbai terror attacks in 2008 startled Dr Partha Sarathi Mukherjee and he realized the country's requirement for efficient sensors for explosive detection. He also felt that the molecular sensors would be more effective than metal-based ones. Dr Mukherjee's group has reported several discrete and supramolecular sensors for efficient sensing of explosives in both vapour and solutions phases. His research has shown the role of H-bonding in enhancement of sensitivity of supramolecular sensors for sensing explosive nitroaromatics. His contribution in this area has been well-cited by the scientific community.

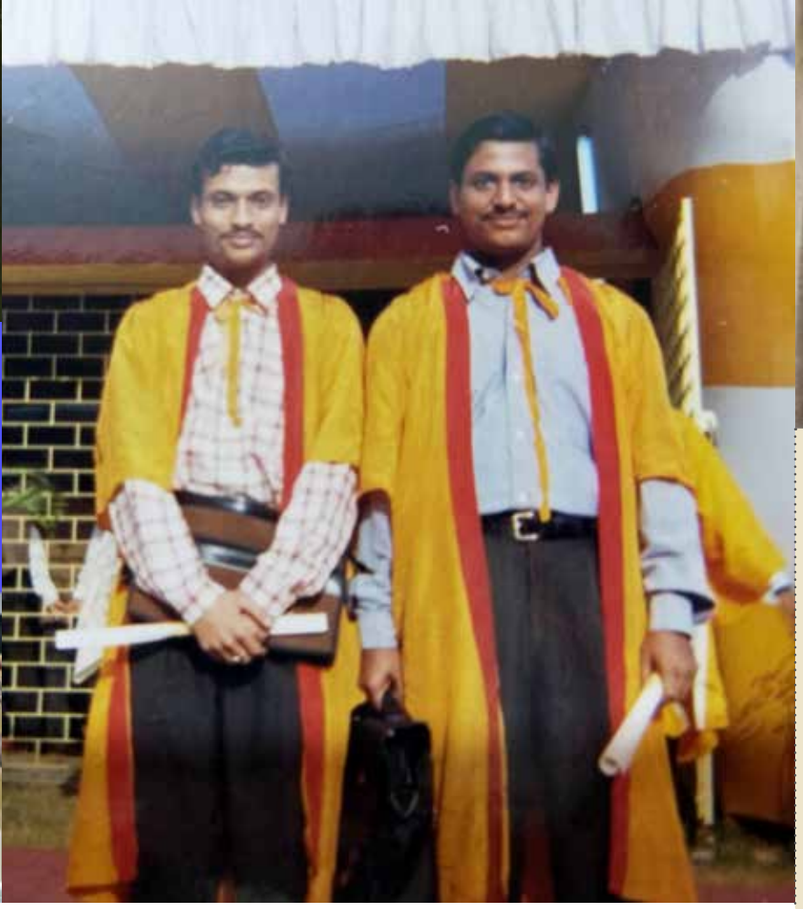
Dr Mukherjee benefitted immensely from experience in diverse research areas like magnetochemistry, supramolecular chemistry and main-group chemistry during his PhD and postdoctoral trainings. The training he received at the University of Utah on engineering molecules of defined shapes and sizes motivated him the most. He started his independent career at IISc (Indian Institute of Science) to address a few important issues on designing new generation supramolecular sensors for explosives and molecular vessels for catalysis. In the initial stage of his career at IISc, Dr Mukherjee made major and outstanding contributions to coordination-driven self-assembly. His group was the first to observe self-sorting phenomenon in organic cage formation. This unique observation has opened new avenues for selective formation of desired organic self-assembled large molecules from complex reaction mixtures. Such self-sorting was further utilized successfully for cage-to-cage transformation in a facile manner.

Selectivity of nature's enzymatic reactions in the confined pocket of enzymes encouraged Dr Mukherjee to design appropriate molecular vessels that can mimic enzymes' function. Dr Mukherjee's group is well known to the international community for his significant contributions to water-soluble metal-based molecular barrels and their use as molecular vessels for performing catalytic organic transformations and storing reactive intermediate/s. Use of such molecular barrels for multiple purposes is the most important aspect of Dr Mukherjee's research. His group has developed a series of water soluble Pd(II)/Pt(II) molecular barrels with diverse functionality for catalysis, unusual photochromism of photochromic molecules, and for delivery of water insoluble drugs.

> **"Punctuality, hard-working nature and ability to get research work done efficiently, in time and without stress are the keys to success."**

Moreover, his group has recently developed a new strategy for decorating the confined space of discrete molecular barrels/cages with proper functional groups for activating substrates for specific organic transformations in confined spaces in aqueous medium in heterogeneous fashion. Such kind of interior decoration of nanocages also allowed nucleation of very tiny Pd/Au-nanoparticles in confined space of organic cages for efficient organic transformations. Recently, his group, in collaboration with Dr Mrinmoy De of Organic Chemistry Department at IISc, has reported the first example of water-soluble molecular cage-based nanozyme for killing bacteria in water.

Achiral building units generally yield achiral assemblies or racemic mixture of enantiomers. Thus, separation of enantiomers in such a process is essential. Dr Mukherjee's group has



Clockwise: Receiving the Shanti Swarup Bhatnagar Prize from Prime Minister Narendra Modi at Vigyan Bhavan (Delhi)

Presenting a poster at the MTIC conference in Kolkata in 2001

During the MSc convocation ceremony at Jadavpur University (on the left)

With Prof. Qing-Fu Sun of the Fujian Institute in China

Receiving The World Academy of Sciences (TWAS)-Affiliateship from the President of TWAS in Trieste (Italy) in 2011

Inset: Receiving the INSA Medal from the President of INSA in 2009 in Delhi

AWARDS

- Shanti Swarup Bhatnagar Prize (2016)
- Swarnajayanti Fellowship (2012)
- NASI-SCOPUS Young Scientist Award (2012)
- Young Affiliateship of TWAS (2011)
- INSA Medal for Young Scientists (2008)

PUBLICATIONS

- 'Molecular Cage Imgregnated Pd Nanoparticles: Efficient Additive-Free Heterogeneous Catalysts for Cyanation of Aryl Halides'. *J Am Chem Soc.* (2016).
- 'Urea functionalized self-assembled molecular prism for heterogeneous catalysis in water'. *J Am Chem Soc.* (2016).
- 'Self-Assembled Molecular Barrels as Containers for Transient Merocyanine and Reverse Photochromism'. *J Am Chem Soc.* (2018).
- 'Guest-Induced Enantioselective Self-Assembly of a Pd6 Homochiral Octahedral Cage with a C3-Symmetric Pyridyl Donor'. *J Am Chem Soc.* (2020).

recently unlocked a new paradigm in the design of enantiopure self-assembled architectures from achiral building units using a chiral guest. This novel strategy of designing enantiopure assemblies from achiral building blocks without chiral resolution (separation) may allow chemists to develop enantiopure assemblies using chiral organic/inorganic catalysts as guests for chiral catalysis in confined space and for other applications. One-step self-assembly approach of designing molecules of diverse shapes and sizes with desired function/s is the coolest part of his research.

However, Dr Partha Sarathi Mukherjee, born in West Bengal, was more focused on cricket and football than on his study till his tutor, Jnaneswar Vajpayee, had not aroused his interest in science in class 10. Set on course, Partha after his schooling and graduation, took admission in Jadavpur University (Kolkata) for MSc and then joined the Indian Association for the Cultivation of Science in Kolkata as a research scholar to work under Prof. N Ray Chaudhuri for his PhD on Cu(II) coordination polymers and their magnetic properties. In the beginning of 2003, he moved to the University of Utah (USA) to work as a postdoctoral fellow under the supervision of Prof. Peter J. Stang on molecular self-assembly. After completion of his tenure in Utah, he moved to Göttingen University (Germany) as an Alexander von Humboldt postdoctoral fellow to work with Prof. Herbert W. Roesky, prior to joining the Indian Institute of Science (IISc) in July 2005 as an assistant professor in the Inorganic and Physical Chemistry Department where he is currently a professor.

In addition to his research and teaching at IISc, he is currently serving as an associate editor for the journal *Inorganic Chemistry* (American Chemical Society's journal). His 188 publications have received over 11,000 citations with a high H-index of 59!. Dr Mukherjee has delivered over 200 invited/ keynote/ plenary lectures in India and abroad.

Dr Mukherjee's main ambition is to develop water soluble metal-free organic molecular vessels that would be potential for enantioselective organic transformations and for other stereoselective organic transformations. He also wants to explore such molecular vessels as drug delivery vehicles for delivery of water insoluble drugs.

Dr Mukherjee, prefers listening to Rabindra Sangeet and old movie songs in his free time. Being a synthetic chemist, he loves to explore cooking different dishes in the kitchen by tuning the ingredients. •

DR PRADYUT GHOSH

On the Path Less Travelled

His research exposure spans over inorganic, supramolecular and material chemistry during his PhD and post-doc tenures, which helped him to start an interdisciplinary chemistry research in his independent career. Today, Dr Pradyut Ghosh is an internationally reputed name in the area of anion coordination chemistry, a field that is more than 75 years younger than the transition metal ion coordination chemistry. His significant contributions also include chemical sensing of ions and synthetic small molecular machines. His research in the area of anion recognition chemistry concerns some of the fundamental problems associated with anion recognition chemistry such as development of selective receptors for various anions, recognition of anions in aqueous medium, extraction of anions and salts from water, fixation of aerial carbon dioxide, and anion assisted capsular assembly and disassembly processes. Dr Pradyut Ghosh's research group has been actively working on the development of synthetic receptors on appropriate platforms that can form distinct clefts or cavities with suitable binding sites. These receptors selectively recognize anion from bulk solvent media or can accommodate hydrated-anions, which are otherwise energetically unfavourable. A few of his important works include the recognition of hydrated fluoride, cyanide and arsenate, fixation of aerial carbon dioxide, and extraction of sulfate, fluoride, and potassium fluoride/chloride from water. An example of his work is the *Chem. Sci.* 2012, 3, 1522 paper, an exemplary piece on the encapsulation of oxyanions in capsules held by large number of hydrogen bonds, where the sulfate anion is bound very strongly, allowing the extraction of this anion right from water (99% from extracted pure mass). He has also developed a bench scale production method for a cyanide-capturing compound, which has been implemented by a steel industry in the study of pilot scale treatment of steel manufacturing wastewater containing ppm level of free cyanide.

"To succeed one needs to be determined to pursue one's passion, for success only comes to those who are dedicated and work hard."

Non-covalent synthesis of supramolecular structures with an internal cavity to accommodate guest molecules has attracted much attention because these aggregates are important in molecular recognition, selective guest-inclusion and the catalysis of specific reactions. Further, the synthesis of such artificial architectures with internal voids to mimic viruses is one of the current concepts for drug delivery applications. Though numerous nanoscale synthetic molecular capsules have been achieved, the challenge to control the assembly and disassembly processes still exists when a guest acts as a template. Therefore, such systems are very important to develop effective delivery systems. Thus, the recognition and binding of anions in molecular capsules is definitely a field, which can expand considerably and witness immense advances over the next few years. Research is ongoing in these areas, and technological applications based upon the remarkable anion binding molecular capsules appear to be forthcoming.

The presence of fluoride, nitrate, and arsenate in water is one of the major concerns because of their implication on human health. Dental and skeletal fluorosis has been reported in various countries

Clockwise: Receiving the Shanti Swarup Bhatnagar Prize from Union Minister for Science & Technology and Earth Sciences, Dr Harsh Vardhan, in New Delhi in 2015

Working at the Kekulé Institute Lab, Bonn, Germany in 2001

Working in the Laboratory at IACS with the PhD Students

With the Prime Minister and other dignitaries during SSB Prize 2015

With Nobel Laureate Prof. Ben L. Feringa during His Visit to IACS

Inset: Receiving the CSIR Young Scientists Award from former Minister for Science & Technology, Kapil Sibal, at the Council of Scientific and Industrial Research (CSIR) Foundation Day Celebrations, in New Delhi on 26 September 2004

AWARDS

- Fellow, Indian National Science Academy (2021)
- Fellow, Indian Academy of Sciences (2016)
- Shanti Swarup Bhatnagar Prize (2015)
- Swarnajayanti Fellowship (2009)
- BM Birla Science Award (2009)

PUBLICATIONS

- 'Selective Sensing of Phosphates by a New Bis-HeterolepticRu(II) Complex via Halogen Bonding: A Superior Sensor Over Its Hydrogen Bonding Analogue'. *Chem Eur J.* (2016).
- 'Halogen Bonding Assisted Selective Removal of Bromide'. *Chem Commun*. (2015).
- 'Acid/base controlled size modulation of capsular phosphates, hydroxide encapsulation, quantitative and clean extraction of sulfate with carbonate capsules of a tripodal urea receptor'. *Chem Sci.* (2012).
- 'Formation of Hybrid Water-Chloride Structure with Discrete Undecameric Water Self-Assembly in a Heptaprotonated Octaamino Cryptand'. *Angew Chem Int Ed.* (2006).

around the world associated with high level of fluoride in drinking water. Recently, fluoride has been accused of causing osteosarcoma, and many other health hazards. It is estimated that more than 100 million people are drinking water which contain fluoride concentrations over the limit suggested by the World Health Organization guidelines. High concentration of nitrate in drinking water has been found to cause methaemoglobinaemia in infants, a fatal disease characterized by cyanosis in which blood pigment losses oxygen required by human tissues. Thus the problem of high nitrate concentration in ground water is receiving increasing attention. Similarly, presence of highly toxic arsenate in ground water is a serious warning to more than ~ 43 million people worldwide. Further, sulfate removal from nuclear wastes is regarded as one of the major barriers in retrieving or converting nuclear wastes, stored in underground tanks worldwide. On the other hand, carbon dioxide concentration in the atmosphere is constantly increasing due to industry and transport and that contributes to global climate change. The work on efficient fixation of aerial carbon dioxide in capsular assembly and the development of systems for converting aerial carbon dioxide to other value added products are of potential to address this problem.

Dr Ghosh's research works on the design and isolation of Interlocked Molecular Systems based on late transition metal ions template have also received considerable attention in the international community because of its implications for molecular machines. Furthermore, his works on macrobicyclic cages for stabilization of water clusters and sensing of ions are noteworthy.

The seeds of his interest in science were sown very early on by his physics teacher, Arup K Biswas, who had staged a drama for the students of class IX on 'The Nature of Light', which dealt with the evolution of wave-particle duality of light by the works of great scientists, where he played the role of Galileo. This had a profound impact on him as a child, which played a major role in choosing a career in scientific research in later years. After completion of his school, he graduated in chemistry from City College, Calcutta University, followed by a master's degree from the Rajabazar Science College, Calcutta University and, subsequently, a PhD and a postdoc.

When Dr Ghosh is not working on his research, he refreshes himself by pursuing photography, and reading biographies. Occasionally, he watches football and cricket. •

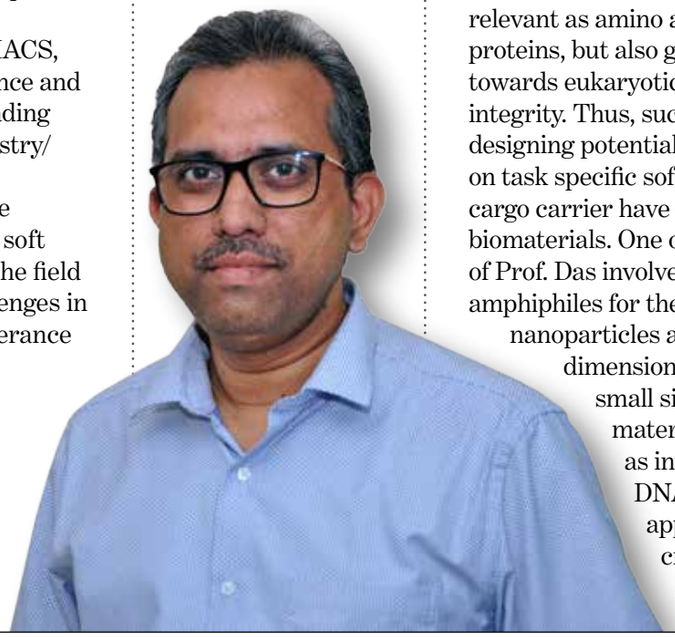
PROF. PRASANTA KUMAR DAS

Against All Odds

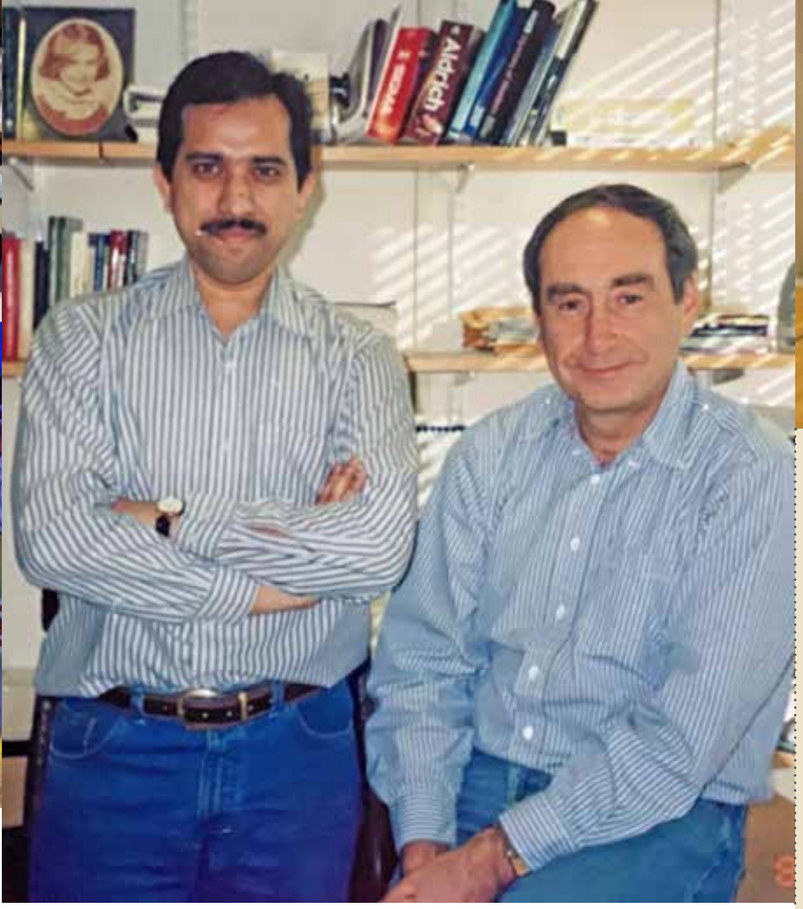
Prof. Prasanta Kumar Das, the youngest son of Sailendra Nath Das, a labourer and Sabita Das, a homemaker, despite difficult circumstances as a child, showed exceptional excitement and interest in asking questions about events in nature. Being a bright student with many distinctions, his inquisitiveness towards science grew in his school years. This led him to pursue a career in science with an inclination towards fundamental and cross-disciplinary sciences of chemistry and biology. To pursue undergraduate study, he joined Jadavpur University, Kolkata, one of the premier universities of India. After receiving his master's degree from the same university in 1994, Prasanta began the journey towards the world of scientific research in the interdisciplinary field of bio-organic chemistry by joining the Indian Institute of Chemical Technology (IICT), Hyderabad in Dr Arabinda Chaudhuri's group. After finishing his doctoral studies with noteworthy contributions in colloidal sciences, liposomal agents and micellar enzymology, Dr Das embarked on the post-doc stint at the Massachusetts Institute of Technology, USA in the field of non-aqueous enzymology. The couple of years of stay at MIT equipped him to start an independent career at IACS, Kolkata, in 2002. His contagious passion for science and subsequent training shaped him as one of the leading researchers in the field of supramolecular chemistry/ self-assemblies in India.

During his graduation and postgraduation, he acquired an avid interest in the development of soft nanomaterials, which can have applications in the field of biomedicine and drug delivery. The key challenges in the field, which involve biocompatibility and tolerance towards the living cells worked as stimuli to his growing interest in the particular field. He felt that organic molecules capable of undergoing self-assembly can disperse nanomaterials in water, making the materials stable and also biocompatible towards cells. He was fascinated about the synthesis and development of membrane spanning compounds with the bigger objective to make his contribution in the ever-growing field of drug design and delivery.

> **"You need to have indomitable passion for science with a mix of honest and sincere hard work; while patience is a virtue in scientific research."**



He has made significant contributions towards fabrication of molecules based on amino acid scaffolds. These molecules have an adequate balance of hydrophobicity and hydrophilicity, can spontaneously form aggregates and can further be applied for diverse applications, such as the stabilisation of materials which are otherwise unstable. The fact that the molecules are based on amino acids not only make them biologically relevant as amino acids are the building blocks of proteins, but also guarantee better compatibility towards eukaryotic cells and help to retain their integrity. Thus, such molecules are better suited for designing potential drug delivery agents. His discoveries on task specific soft-nanocomposite as targeted cargo carrier have enriched the existing arsenals of biomaterials. One of the leading research activities of Prof. Das involves rational designing of functional amphiphiles for the development of fluorescent organic nanoparticles and efficient dispersion of nano-dimensional allotropes of carbon. These ultra small sized organic particles or carbon materials based self-assemblies are used as intracellular cargo carriers for drug/ DNA/protein, as well as for theranostic applications. He has also shown his credentials in developing simple bio-imaging and strategies of selective



Clockwise: Being felicitated for his academic prowess in 2017

Gathering hands-on experience at the Massachusetts Institute of Technology Laboratory in USA

At the Massachusetts Institute of Technology with his post-doc supervisor Prof. Alexander M Klibanov in 2001

During the Indo-Korean Joint Workshop Seoul-South Korea with a group of Indian scientists and his Korean host, 2012

With Nobel Laureate BL Feringa at the Consulate General of Netherlands in Kolkata in 2019

Inset: In his office at the Indian Association for Cultivation of Science, Kolkata

AWARDS

- Fellow, Indian Academy of Sciences (2017)
- Materials Research Society of India Medal (2017)
- CRSI Bronze Medal (2011)
- Ramanna Fellowship Award (2006)
- BM Birla Science Prize (2006)

PUBLICATIONS

- 'Glucose Oxidase Mediated Targeted Cancer-Starving Therapy by Biotinylated Self-Assembled Vesicle'. *Chem Commun*. (2018).
- 'Hydrophobic End Modulated Amino Acid Based Neutral Hydrogelators: Structure Specific Inclusion of Carbon Nanomaterials'. *Chem Eur J*. (2016).
- 'Single-Walled Nanotube/Amphiphile Hybrids for Efficacious Protein Delivery: Rational Modification of Dispersing Agents'. *Angew Chem Int Ed*. (2011).

sensing of biomolecules by exploiting the tuned emitting ability of both fluorescent organic particles and surface functionalized carbon dots.

He has also developed supramolecular gels, that is, self-assembled networks of amphiphilic molecules capable of holding solvent and other small molecular guests. These gels can be exploited to trap drug molecules and for the sustained release of these drugs. Noticeably, the amphiphilic hydrogelators exhibited a broad spectrum of antimicrobial activity against several gram-positive and gram-negative bacteria and fungi while being befittingly biocompatible to different mammalian cells. Design and development of natural precursors based soft nanocomposites with tunable mechanical rigidity, antimicrobial property and biocompatibility make them excellent competitor as therapeutic agents and tissue engineering scaffolds. Injectable low molecular weight sweet hydrogels are potentially applicable for glucose stimulated insulin release and diabetes treatment.

Apart from drug design and delivery, his work also involves development of supramolecules, which are capable of mimicking cellular membranes in terms of structure and encapsulating enzymes or proteins, leading to superior catalytic prowess of the biomolecules.

His pioneering work on 'biocatalysis within organized assemblies' is a benchmark contribution, which offers the most promising opportunity in the field of enzyme biotechnology where increasing the stability and reactivity of enzymes are a primary concern. He demonstrated for the first time the importance of 'space' for modulating enzyme activity in membrane-mimetic systems.

His research works have been highly appreciated and he has published more than hundred original works in his career so far, with some of them getting the deserved recognition in the form of being selected as 'hot paper' in distinguished journals. He also has 5 US patents and 2 Indian patents to his credit. Many of his PhD scholars are in academic positions in the premier institutes of India.

The burning desire to do independent research, to undertake frontline scientific problems, and to realize new chemistry has long been the reason for Prof. Das's ambition and motivation. One of the things, Prof. Das enjoys most is to take part in scientific discourses, his mentors, collaborators, research group, and colleagues have all have played crucial roles in influencing his approach towards science and supported him to try out his out-of-the-box ideas. •

PROF. PRIYA MAHADEVAN

Keeping an Eye on the Ball

A senior professor, in the Department of Condensed Matter Physics and Material Science, SN Bose National Centre for Basic Sciences, Kolkata, Prof. Priya Mahadevan's research is on the electronic structure of materials using a combination of ab-initio and model Hamiltonian approaches with an emphasis on understanding the mechanism of magnetism in unusual systems. She is credited for providing the microscopic origin of the counter-intuitive observation of higher magnetic ordering temperatures in 4d and 5d transition metal oxides compared to the 3d analogues in terms of a low Coulomb interaction strength coupled with a large bandwidth – ideas that are contrary to the conventional understanding of magnetism. She has gone on to show how doping carriers into these 4d and 5d oxides could provide a route to realizing antiferromagnetic metals.

Her search for materials exhibiting magnetism without the presence of the traditional magnetic elements led her to a class of stoichiometric alkali metal oxides. An orbital ordering was found in these p-band systems, which precluded any possibility of magnetism.

Over the years, a key interest of Prof. Mahadevan's research group has been to study magnetic materials, primarily with the aim to understand the mechanism that leads to the observed magnetic ordering. The group, in the course of its research, identified several ferromagnetic insulators.

These have been found among doped transition metal oxides, and the group finds that the doped carriers are localized on some of the transition metal sites. This leads to hopping pathways between sites, which have the doped electron localized and those which do not, leading to a ferromagnetic insulating state. Analyzing the contributions from different pathways has helped identify their role in the observed magnetic ground state, in addition to discussing the doping regime where one can observe this unusual ground state.

> **"Never be intimidated by a problem, especially when trying to bring a new perspective on something that has been accepted by the community for some time."**

The other contrarian example that the group has examined is the antiferromagnetic metallic solution. Doping an antiferromagnetic insulator was explored as a route to

Clockwise: With project partners during the Indo-US project

Receiving the NASI-Scopus Award from former DST Secretary T Ramaswami

With her mother, who has always encouraged her to follow her passion

During an Indo-Japan meeting at Tokyo University in 2019

With TWOWS awardees and the Chinese Vice President, 2010

With Prof. Terakura and Mrs Terakura at the Indo-Japan Meeting, 2019

During the Indo-German meeting in in Dresden, 2019

Inset: During a seminar at the Indian Institute of Science, Bangalore, in 2019

AWARDS

- SERB Power Fellowship (2021)
- MRSI Medal (2014)
- DAE Raja Ramanna Prize Lecture in Physics (2013)
- TWOWS Prize for Young Woman Scientist in Physics/ Mathematics (2010)
- NASI-SCOPUS Young Scientist Award in Physics (2010)

PUBLICATIONS

- 'Evolution of the Electronic structure of twisted bilayer $MoSe_2$'. *Phys Rev B*. (2020).
- 'Ferroelectric distortions in doped ferroelectrics: $BaTiO_3$: M (M=V-Fe)'. *Phys Rev B*. (2013).
- 'Route to high Neel temperatures in 4d and 5d oxides'. *Phys Rev B*. (2012).
- 'KO_2 : Realization of orbital ordering in a p-orbital system'. *Phys Rev Lett*. (2010).
- 'Charge ordering induced ferromagnetic insulator: $K_2 Cr_8 O_{16}$'. *Phys Rev Lett*. (2010).

antiferromagnetic metals based on numerical studies that existed on the Hubbard model away from half-filling. However, this regime was absent in the phase diagram of the 3d transition metal oxides because of the strong electron phonon interactions operative in them, which leads to a localization of the charge carriers. However, moving to the transition metal oxides involving 4d and 5d atoms, the group showed that a wider parameter window existed to stabilize this unusual phase.

This work followed an earlier work that examined 4d and 5d transition metal oxides and explored the possibility of magnetism among them. Usually, one does not expect high magnetic ordering temperatures among these oxides as they have wider bandwidths associated with them, in addition to a much weaker intra-atomic exchange interaction strength as compared with the 3d transition metal oxides. But contrary to the expectations, the group identified an entire family of oxides with a half filling of the crystal-field split d-band, which were magnetic. They found that the limit that they belonged to led to ordering temperatures far higher than the 3d transition metal counterparts. This aspect was not appreciated earlier and led to entire families being identified among the 4d-5d oxides.

Born in Bangalore, Prof. Mahadevan enjoyed the simple science demonstrations at school. Her preference for the sciences, therefore, was inevitable. She received a PhD in Physics from the Indian Institute of Science, Bengaluru, for which she received the Best Thesis award. Her parents, Malathy and Sundaresa Mahadevan, encouraged her to follow her passion and do a PhD, when she had to choose among several options. •

R

DR R MAHALAKSHMI
DR RADHIKA NAIR
DR RAJAT SUBHRA HAZRA
PROF. RAJEEV VARSHNEY
DR RAJESH GANAPATHY
DR RITABRATA MUNSHI
DR RITESH AGARWAL
DR RITU TRIVEDI
PROF. ROHIT SRIVASTAVA
DR RV NAIR

DR R MAHALAKSHMI

On a Mission

Dr R Mahalakshmi's family, her parents, Mrs Meena and Mr Radhakrishnan, valued education and academic excellence, which is a trait they instilled in her since her childhood. In school, her favourite subjects were mathematics and physics, and she developed interest in biology during high school. During her bachelor's, she read an article on ammonia transporters, which piqued her interest and set the path for her future work on membrane proteins.

Recognizing her outstanding academic excellence and passion for research, Mahalakshmi was selected for the prestigious integrated PhD programme at the Indian Institute of Science, Bangalore, in 2000, where she learnt from stalwarts in the field. In January 2002, she got the opportunity to work with Prof. P Balaram for her MS research, where she learnt about peptide chemistry. This research on mapping molecular interactions at the atomic level intrigued her so much that she continued theresearch for her PhD thesis, under Prof. Balaram's guidance. The training played a major role in shaping her approach to science. After graduating in 2006, she carried out two short postdoctoral stints in San Diego, California, working on membrane protein NMR and crystallography.

Dr Mahalakshmi first developed an interest in voltage-dependent anion channels, or VDACs, in 2006, while she was searching for a functionally indispensable yet uncharacterized membrane protein system that was 'structurally different' from ion channels, but behaved 'functionally' like one. Unlike most channels, VDACs were predicted to be transmembrane β-barrels and were incredibly challenging to characterize. When the prospect of leading her research group presented itself in 2009, Dr Mahalakshmi immediately realized that the opportune moment for her to initiate work on VDACs had arrived.

Identified in 1976, VDACs are metabolite transporters ubiquitous in the outer mitochondrial membrane, and are indispensable for cell survival. Yet, very little was known about VDACs.

> **"Hard work, dedication, and, above all, honesty are the pathways to success."**

Dr Mahalakshmi overcame intrinsic challenges in VDAC biology using an interdisciplinary approach that combined protein biophysics, molecular spectroscopy, and single molecule electrophysiology. Over the last ~12 years, she has been the first to identify vital features of VDAC isoforms essential for mitochondrial biogenesis and bioenergetics. Her ongoing research is to develop peptidomimetics that selectively target VDACs towards finding cures for cancer. Her research also encompasses the study membrane proteins of Gram negative bacteria including *Salmonella typhimurium* and *Yersinia pestis* towards developing tailored drugs that target these pathogens. Most recently, Mahalakshmi's studies are focused on understanding the folding, function, and regulation of other essential human mitochondrial membrane proteins, to identify viable cures for neurodegeneration.

Dr Mahalakshmi's work and contributions have been recognized internationally, with a multitude of awards and accolades. Her multifaceted approach to studying membrane protein biophysics is the first-of-its-kind in India. She has published >70 peer-reviewed international publications with ~1200 citations. She has been felicitated with the prestigious Intermediate Fellowship, Exceptional Fellows Fund, and Senior Fellowship from the Wellcome Trust, UK-DBT India Alliance. Additionally, she is the recipient of the Swarnajayanti Fellowship, Young Researcher Award (Tata Trust), Young Scientist

AWARDS

- Innovative Young Biotechnologist Award (2009)
- Intermediate Fellowship (2015)
- Women Excellence Award (2017)
- Young Researcher Award (2020)
- Senior Fellowship, DBT (2020)

PUBLICATIONS

- 'Direct Structural Annotation of Membrane Protein Aggregation Loci using Peptide-Based Reverse-Mapping'. *J Phys Chem Lett.* (2018).
- 'Helix–strand interaction regulates stability and aggregation of the human mitochondrial membrane protein channel VDAC3'. *J Gen Physiol.* (2019).
- 'Single-residue physicochemical characteristics kinetically partition membrane protein self-assembly and aggregation'. *J Biol Chem.* (2020).
- 'Evolutionary selection of a 19-stranded mitochondrial β-barrel scaffold bears structural and functional significance'. *J Biol Chem.* (2020).

Clockwise: Receiving her MS degree in biological sciences from IISc in 2003

During school years

With her PhD student Ulfat Mohammad Sayyed Hanif

With her husband Dr Vikas Jain, an Associate Professor, at IISER Bhopal

With her PhD student Shashank Srivastava

On the IISER campus

With Dr Juan Del Valle, postdoctoral advisor of her PhD student Dr Kamlesh Makwana at the American Peptide Symposium held in Monterey, CA

Inset: With Deepti Chaturvedi her PhD student

Award (Indian Peptide Society), SERB Women Excellence Award, NASI Young Scientist Platinum Jubilee Award INSA Medal for Young Scientists, Associateship of the Indian Academy of Sciences, Innovative Young Biotechnologist Award, and Ramalingaswami Fellowship. She is on the editorial board of *Scientific Reports*, *Peptide Science*, member of Biophysical Society–IOP Advisory Board, Guest Editor for *Frontiers in Physiology* and *BBA*, and an advisory member of the Wellcome/DBT Gateway. She has been featured in *Future of Biochemistry: The Asia-Pacific Issue*. Additionally, Dr Mahalakshmi has been invited to present her work at several Gordon Research Conferences (GRC), and the American Peptide Society. She has been the Session Chair for multiple GRCs on Membrane Protein Folding.

Dr Mahalakshmi's work belongs, quite appropriately, at the interfaces between biology, physics, and chemistry. Carrying out research at the interface sets her in the advantageous position of utilizing the state-of-the-art equipment available to all three streams of basic science. In addition to her proficiency in biophysical methods, which she has meticulously acquired over the years, she has conceived new ideas and proposed new questions in the area of membrane protein biophysics, and designed and developed novel approaches to addressing them. She additionally enjoys teaching both undergraduate and graduate students.

Dr Mahalakshmi's family has taught her to always act in a conscionable manner and with tenacity in even the most difficult of times, and she values these lessons the most. She also constantly draws inspiration from her PhD mentor Prof. Balaram, whose unending curiosity for science continues to inspire and motivate her. His enthusiasm for all research problems and his in-depth knowledge of every aspect of science has served as a motivation throughout her work. She is also motivated by her professors R Varadarajan and D Chatterji of the Molecular Biophysics Unit of IISc. Her approach to her research is molded largely by what she has learnt from these stalwarts, as well as her colleague, friend, and husband Dr Vikas Jain. As a human being, she has always been honest to a fault, and she strongly believes that all her successes are a result of this one characteristic. Her dedication for her research is deeply founded in her unwavering interest in science, her commitment to hard work, and her passion for solving fascinating biological problems that also benefit humankind. •

DR RADHIKA NAIR

Breaking New Ground

With a nuclear submariner in the Indian Navy as a father, it was but natural for Dr Radhika Nair to opt for science and dream of being an astrophysicist initially. Born in Thiruvananthapuram, she studied in Mumbai and Delhi. She was fortunate to have inspiring teachers like Mrs Srinivasan and Mrs George who she still remembers fondly.

During her undergraduate studies at St Xavier's college in Mumbai, she was part of a small, but a dynamic group in the microbiology department. At this juncture, Radhika was fortunate to have Mrs Amonkar as a mentor, who thought she had potential. While doing project on AIDS for the Honours programme, she realised, that the practical aspect of science held a certain fascination for her.

Her desire to actively pursue research as a career came true during her stint with Prof. Shobhona Sharma at TIFR when she was selected for the visiting research scholars' programme. Radhika continued to work there, while completing her master's at the Institute of Science in biochemistry. She was part of the first trials for the putative malarial vaccine and was hooked!

She pursued her PhD at the National Institute of Immunology under Dr Chandrima Shaha. Her work on the apoptotic pathways in germ cells, she feels, was preparing her for the research topic she would ultimately choose in the future – for in some ways cancer is the opposite side of the coin of apoptosis. In 2005, she was awarded the Career Development Fellowship by the Medical Research Council at Cambridge and spent the two most amazing years of her career there surrounded by the most brilliant minds. She was particular that she wanted to widen her horizons during her post-doctoral training by learning molecular biology, which she felt was key to understanding cancer if she decided to pursue this line. Her work involved understanding a bacterial toxin antitoxin pair, which was found to play a key role in homeostasis in the mammalian system. At this point, her family moved to Australia and she was fortunate to meet Prof. Alexander Swarbrick who turned out not only to be her mentor but a wonderful colleague and friend. They shared students and the lab for seven of the most productive years of her life. It was at this stage of her career that she focused on what would ultimately be the question she wanted to ask. Passing away of her friend Nidhi Kadir, a neurosurgeon, at the young age of 30 due to breast cancer, was the last deciding factor in pursuance of cancer as a subject.

"Be passionate about what you do, aim for the best, work with the best and you will be constantly inspired."

During the course of her years at the Garvan Institute of Medical Research in Sydney (where she was also affiliated with the Kinghorn Cancer Center and Faculty of Medicine, UNSW Sydney), she was fortunate to have worked on multiple cutting-edge projects, multi-institutional international collaborative efforts like Promis an effort to understand Prostate cancer metastasis to the bone. She started crystallizing her objective to work in the field of metastasis as the spread of cancer is still unfortunately a death sentence for the patients.

Around this time for personal and professional reasons, the family decided to move back to India. Dr Nair was

AWARDS

- Junior Research Fellowship (1998)
- Senior Research Fellowship (2000)
- Career Development Fellowship (2005)
- Ramanujan Fellowship (2015)

PUBLICATIONS

- 'Lineage Plasticity in Cancer: The Tale of a Skin-walker'. *Cancers* (2021).
- 'Cancer Stem Cell plasticity: A deadly deal'. *Front Mol Biosci.* (2020).
- 'Targeting the Id1-Kif11 Axis in Triple-Negative Breast Cancer Using Combination Therapy'. *Biomolecules* (2020).
- 'Id proteins promote a cancer stem cell phenotype in mouse models of triple negative breast cancer via Robo1-dependent c-Myc activation'. *Front Cell Dev Biol.* (2020).
- 'Toxin Kid uncouples DNA replication and cell division to enforce retention of plasmid R1 in E.coli cells'. *ProcNatlAcadSci USA*. (2014).

Clockwise: Gathering hands-on experience with the microscope at the MRC Hutchison, CCU Cambridge

During an event at the Garvan Lab in Australia

With her family

During an alumni meeting at the National Institute of Immunology, New Delhi

During her lab days in Cambridge, UK

Mixing work and pleasure

Inset: At the Cancer Tumor Progression Lab in Australia, Dr Nair hopes to one day make a difference to the women who currently live with the fear of cancer relapse and give them a better quality of life

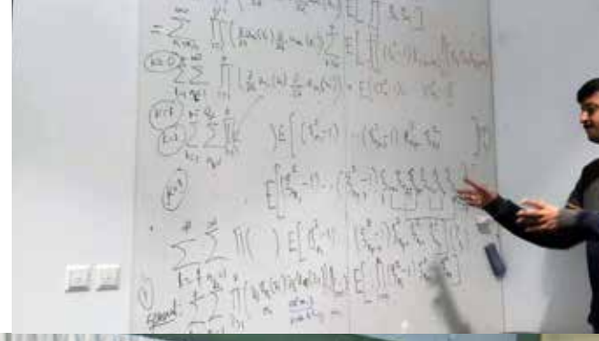
awarded the Ramanujan Fellowship by the Government of India and joined the Rajiv Gandhi Centre for Biotechnology to set up her laboratory in 2015 with Prof Pillai's, the director, support. While there were challenges in setting up the lab, she preferred to focus on her fantastic team. Their work came together in the fourth year as animal modeling and complex *in vivo* and *in vitro* model systems don't always stick to timelines! This resulted in a wave of publications in 2020 and 2021. They pursue the fundamental question of how cancer cells move to different organs from the primary tumor, which ultimately is the cause of mortality for patients. They have found a cell intrinsic programme that predisposes cells to metastasize to the lungs and are exploring the effect of the microenvironment using novel *ex vivo* systems. They leveraged the molecular findings from this work to identify a novel way to more effectively target breast cancer using small molecule inhibitor drugs in combination with conventional chemotherapy. Going forward, Dr Nair hopes to be able to move into clinical studies, which will be the ultimate proof of principle discoveries made in the lab in a translational manner. She does hope to one day make a difference to the women who currently live with the fear of relapse of the disease and give them a better quality of life.

Another aspect of her professional life that she thoroughly enjoys is teaching graduate and PhD students. She also nurtures another passion: to retain women in the STEM fields. In addition, Dr Nair has contributed articles to the mainstream media demystifying science for the laypersons. She has disseminated her research findings at multiple national and international conferences and believes a collaborative atmosphere in science is essential in this post pandemic era.

Besides research, Dr Nair is an avid reader and movie buff and loves to travel to indulge her taste buds. •

DR RAJAT SUBHRA HAZRA

A Fair Coin



Dr Rajat Subhra Hazra's work is related to probability theory, where the probability of an event is a number indicating how likely that event will occur. The main problems in probability arose from physical models but at the Indian Statistical Institute, where he was a PhD student, the problems emerged from statistical issues. It was this beautiful relationship and tradition of statistics and probability going hand in hand drew him to study the subject.. Before Dr Hazra came to ISI, he says that he knew very little about the beauty of probability. He says that teachers like Prof. BV Rao, Prof. Alok Goswami, Dr Krishanu Maulik and Prof. Arup Bose inspired him a lot.

Rajat, born in West Bengal, in his school days was fascinated by the idea of writing down a proof. A quality that helped him and made him read different books. The two places that influenced him most in his mathematical career were St Xavier's College in Kolkata for undergraduate studies and Indian Statistical Institute for his Phd. At St Xavier's, the teachers took extra care and taught them advanced subjects and, sometimes, the classes went beyond the normal teaching hours. Also beneficial were the summer fellowships from the Indian Academy of Sciences where he was introduced to various new subjects and, most importantly, had a glimpse of the research world. The programmes like MTTS conducted by the National Board of Higher Mathematics also helped. He went to pursue master's from the Department of Pure Mathematics, University of Calcutta. After obtaining his PhD degree from ISI in 2011, he went to University of Zurich, Switzerland to pursue his postdoctoral studies. There he got more interested in the area of statistical physics due to an active group in which he was involved. He returned to India in 2014 to join ISI, Kolkata as an assistant professor.

One of his major interests lies in the area of random matrices. Consider 100 points and make an array of (random) numbers. You can think of these 100 points, as 100 people. Now pick any two people between these 100 people and ask them to take a coin and toss it. Suppose it falls on its head, then insert a connection between them and if it lands as a tail, then don't put a connection. Now you do this for every pair so that no toss is influenced by any other toss. If one puts in the array 1 whenever there is a connection and 0 whenever there is no connection then it creates an array of ones and zeroes. Since we don't know where the 1's or 0's occur so we call it a random array of numbers. Dr Hazra's study deals with such arrays. As one can see it creates a network also between people so these are helpful in the study of complicated networks. A major part of research has been about finding links between such random arrays and algebraic structures in quantum theory. In the network described above through coin tosses, there are nodes and connections. The connections are generally the part which produces uncertainty in a system. Examples of such complex networks are social networks (like Facebook, Twitter), biological networks or banking networks. The arrays can be understood in the best way

> **"Having patience when things don't work out is the key to being successful."**

Clockwise: With his parents after he was conferred his Phd degree in 2011 at Indian Statistical Institute, Kolkata

During a discussion with his collaborators at TU/Delft

With his son during the annual conference where he received the INSA Young Scientist Award, 2016

During a visit to International Centre for Theoretical Sciences, Bangalore

At work at Indian Statistical Institute, Kolkata. One of his major interests lies in the area of random matrices

Inset: Seeped in thought while figuring out the computations on the chalk board. Research, Dr Hazra believes, is all about collaboration and exchange of ideas

AWARDS

- Shanti Swarup Bhatnagar Award in Mathematical Sciences (2020)
- Young Statistical Scientist Award (2020)
- Fellow, Indian Academy of Sciences (2020)
- Young Scientist Award in Mathematics (2016)
- DST-INSPIRE Young Faculty Fellowship (2014)

PUBLICATIONS

- 'Scaling limit of semiflexible polymers: A phase transition'. *Communications in Mathematical Physics* (2020).
- 'The scaling limit of the membrane model.' *Annals of Probability* (2019).
- 'Scaling limit of the odometer in divisible sandpiles'. *Probability Theory and Related Fields* (2018).
- 'Free subexponentiality'. *Annals of Probability* (2013).
- 'Convergence of joint moments for independent random patterned matrices'. *Annals of Probability* (2011).

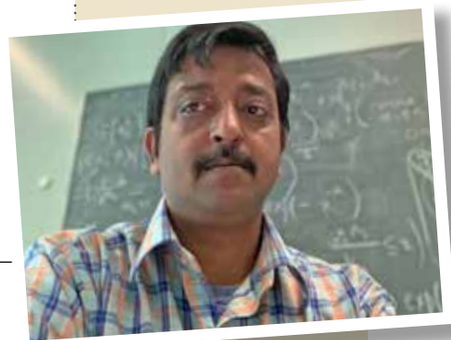
through 'eigenvalues or eigenfunctions' and we call them the spectrum of these arrays. The theory of the spectrum is crucial in understanding many properties of the arrays and Dr Hazra's work is related to it. He has had a fruitful collaboration with Prof. Arup Bose (ISI) and Dr Koushik Saha (IITB), in his early years, where they could relate the patterns in the matrix to the eigenvalues when the dimension of the matrix was large. In his Phd thesis also he worked with relations of power law to convolutions which arise from theory of unbounded operators.

Another area of his interest is closely linked with physics and behaviour of membranes. These broadly classify under study of interfaces. How is an interface formed? Look at Alaknanda and Bhagirathi river at Devprayag, one clearly sees a demarcation which forms when the two rivers meet each other. This demarcation line is sort of a fractal line which has a random/uncertain behaviour. Dr Hazra's recent interest has been to understand the behaviour of such demarcations in large systems and in higher dimensions. He has recently seen that they have connections to sandpile models which are used to model self-organized critical behaviour.

Dr Hazra is looking forward to working in the area of complex networks in future. In today's world, the vast complex networks arise naturally and many interesting mathematical issues are coming forward. The geometry of these networks are not like the standard Euclidean geometry and, hence, new methods are needed to understand the challenges. Also a big step would be to integrate the theory of statistical physics in the complex networks or for dynamics over these networks. With the advent of the big data era, all mathematicians should have exciting days ahead.

Dr Hazra continues the study of statistical physics models on random networks, as he also believes that with the advent of social media, and many large scale complex systems, the study of many physical phenomena needs to be transported to these systems. He is collaborating actively inside India and outside too to understand these models more deeply.

Dr Hazra says that working with students is the most exciting part and also with people from different backgrounds. Research, he believes, is all about collaboration and exchange of ideas. People of one generation of mathematicians believed mathematics was just an art, which needs to be practised alone but it has evolved a bit. One still definitely fights but together can be lot of fun and a lot more interesting also. •



PROF. RAJEEV VARSHNEY

Driven by Greater Good

Prof. Rajeev Varshney grew up in a middle-class family in Bahjoi, a small town in Uttar Pradesh. His father Kishan Lal had a small-scale business and mother Bhagwan Devi was a homemaker. After completing his primary schooling in Bahjoi, he received his bachelor's and master's degree from the Aligarh Muslim University (AMU) in 1993 and 1995, respectively. While pursuing his PhD degree, he worked as a junior/senior research fellow on an R&D project sponsored by Department of Biotechnology under the supervision of Prof. PK Gupta, a well-known name in the field of plant genetics, and Prof. PC Sharma, who became the driving factors behind his choice of career. After receiving his PhD degree in 2001, he joined Leibniz Institute of Plant Genetics & Crop Plant Research (IPK), Gatersleben, Germany, as a post-doctoral research scientist under mentorship of Prof. Andreas Graner.

> **"Give your 100 per cent to any project or activity, but also enjoy while doing that."**

During his stint in Germany, he feels, he found his eureka moment that shaped his research career. He recalls, Prof. Norman Borlaug, a renowned agricultural scientist, whom he heard during a conference in Italy in 2003, challenged the next generation of scientists to embrace new tools and technologies to tackle food security issues in the developing world. These words inspired and motivated him to work on translational aspects of upstream research for development of better crop varieties with improved yield and nutrition in developing countries. As a result, Prof. Varshney joined International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in 2005 and since then he has been working as a researcher, science administrator and thoughtleader in the field of international agriculture.

Prof. Varshney is a firm believer in harnessing the potential of modern genomics tools and molecular breeding approaches as a game changer for accelerated development and delivery of improved crop varieties. To achieve this, the first step is to have the genome sequence and genetic knowledge of agronomic traits in a crop species. In this direction, Prof. Varshney, with Prof. Andreas Graner and Prof. Mark Sorrells, devised the concept of genomics-assisted breeding (GAB) and presented it as a milestone future approach in the 10th anniversary issue of *Trends in Plant Science*, 'Feeding the World: Plant Biotechnology Milestones' in 2005. With changes in time and evolution of technologies, Prof. Varshney with his collaborators, from India and aboard, updated GAB to GAB 2.0, and also provided new concepts, such as 5Gs for crop genetic improvement and the most recent one being fast-forward breeding for a food-secure world.

After joining ICRISAT in 2005, Prof. Varshney was given the responsibility to lead the genomics research on ICRISAT's mandate crops, which include legumes (chickpea, pigeon pea, groundnut) and cereals (pearl millet and sorghum) that are staple and income-generating crops for small-holder farmers in the semi-arid tropic regions of the word. With an objective to implement GAB in crop improvement, majority of these

AWARDS

- Shanti Swarup Bhatnagar Award (2015)
- Rafi Ahmed Kidwai Award (2020)
- Qilu Friendship Award (2016)
- GD Birla Award for Scientific Research (2018)
- Fellow of 12 international and national science academies including INSA (2013), NASI (2015), IASc (2019), NAAS (2010), German National Science Academy (2016), Africa Academy of Sciences (2021)

PUBLICATIONS

- 'Draft genome sequence of chickpea (Cicer arietinum) provides a resource for trait improvement'. *Nature Biotechnology* (2013).
- 'Resequencing of 429 chickpea accessions from 45 countries provides insights into genome diversity, domestication and agronomic traits'. *Nature Genetics* (2019).
- 'A chickpea genetic variation map based on sequencing of 3,366 genomes'. *Nature* (2021).

Clockwise: Receiving the ICRISAT's Doreen Margaret Mashler Award, 2016

Gathering hands-on experience in the ICRISAT CEGSB lab. Prof. Varshney is working to explore deploying machine learning and artificial intelligence approaches by using high-density genomics and large-scale phenotyping data for crop improvement

In deep discussion with his collaborators in Nigeria

Being felicitated by UP Chief Minister Yogi Adityanath, Governor Ram Naik and others

With Prime Minister Narendra Modi and other Shanti Swarup Bhatnagar awardees

Inset: With Bill Gates after a brainstorming meeting on digital revolution for agriculture

crops did not have much genomic resources and were often referred to as 'orphan crops'. A zeal, to help small-holder farmers by enhancing crop productivity, encouraged Prof. Varshney to work on advancing genomics science and integrated it in crop improvement in ICRISAT mandate crops.

While, Prof. Varshney and his team/collaborators decoded genomes of more than 10 crops, which are advancing plant biology and providing cues about molecular mechanism of the tolerance/resistance to abiotic and biotic stresses at international level. On the other hand, adoption and deployment of genomics discoveries in crop breeding programmes at national level have delivered several improved varieties contributing towards food and nutrition security. For example, in the last 3 years, GAB has delivered 7 high-yielding drought-tolerant varieties of chickpeas, namely, 'Pusa 10216', 'IPC L 4-14' and 'BG 4005', and Fusarium wilt-resistant varieties like 'Super Annigeri-1', 'Pusa Chickpea 20211' (aka Pusa Chickpea Manav) and 'IPCMB 19-3' in India; a drought-tolerant variety 'Geletu' in Ethiopia; 2 high Oleic groundnut varieties –Girnar 4 and Girnar 5; and, 2 Fusarium wilt-resistant pigeon pea varieties, namely, Bheema, (GRG-152) and TDRG 59 in India. Now several national institutes are using GAB approaches in their crop improvement programmes. In addition, ICRISAT has won the prestigious Africa Food Prize 2021 for work under the Tropical Legumes (TL) projects, led by Prof. Varshney as Principal Investigator for a period of 7 years (2013-20).

Prof. Varshney has established and continues to nurture a huge network of >180 partners from 35+ countries across six continents. He has published >500 papers in high impact factor journals, including 19 papers in Nature journals. He is the only Indian agricultural scientist/plant biologist who has h-Index >100 with >45,000 citations. He is an editor of 17 books from international publishers. Thomson Reuters (Clarivate Analytics) has recognized him as a highly cited researcher for the last 8 years in a row. He is also recognized as one of the 10 most influential Indian scientists by *The Times of India*, a leading Indian daily newspaper.

To provide new insights, his team has recently completed sequencing of 3,000 chickpea accessions and looks forward to sequencing the remaining 10,000 to 15,000 accessions in the coming years. He is working to explore deploying machine learning and artificial intelligence approaches by using high-density genomics and large-scale phenotyping data for crop improvement. •

DR RAJESH GANAPATHY

Forging Ahead

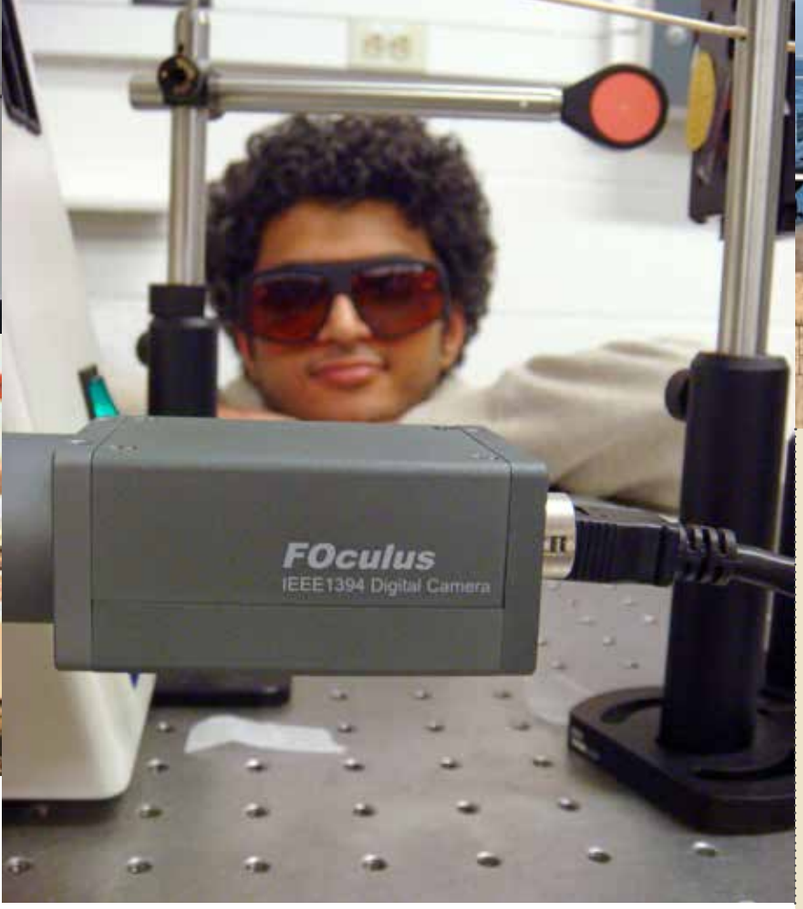
There is a wealth of phenomena that lies outside our realm of understanding simply because we have not figured out yet a way to see their dynamics in real-space. Hence, Dr Rajesh Ganapathy's favourite quote by Yogi Berra, a baseball player with the NY Yankees, 'You can observe a lot by just watching' comes true as he and his students use model soft matter systems to observe the physics at play be it during the growth of thin films or when materials turn glassy, to name a few.

However, a career in physics was the last thing on Rajesh's mind, when he took up the job as a research officer at the Hindustan Unilever Research Centre (HLRC) in Bangalore. Rajesh worked in the Laundry Cleaning section at HLRC (1999-2000) and this was his first formal exposure to the physics of soaps, an area in soft matter physics. While he found physics fascinating, the job was not to Rajesh's liking. He then decided to appear for the IISc PhD interview in experimental physics. A senior researcher at HLRC advised him to talk to Prof. Ajay Sood. According to Rajesh, this singular event changed the course of his life and shaped his academic career. Prof. Sood agreed to guide Rajesh for a PhD in experimental soft matter physics.

The bulk of Rajesh's PhD work (2000-2006) was on flow instabilities in sheared surfactant gels. In a series of remarkable experiments, prior studies from the Sood lab had shown that the rich temporally dynamics of the shear-rate at a fixed stress in the shear-thinning regime of surfactant gels was chaotic and not stochastic as had been thought earlier. However, unlike many other non-linear dynamical systems where the transition to chaotic dynamics occurs through well-defined routes, such as the period-doubling route or the intermittency route, experimental studies on sheared gels were yet to uncover them. In a series of experiments on a slightly modified surfactant gel, Rajesh's experiments revealed the intermittency route to rheochaos. Subsequent to these studies, by coupling a polarized laser light scattering apparatus to the rheometer, Rajesh's experiments showed that orientational order fluctuations of worm-like micelles in the gel were strongly coupled to chaotic dynamics observed in the shear-rate. These simultaneous scattering and rheology measurements left a mark on Dr Ganapathy as they allowed a glimpse of the physics in the sample interior under an external driving. To this day, Rajesh finds himself drawn towards research problems that involve, to a large extent, visualizing physics at play. Following his PhD, Rajesh was a postdoctoral fellow (2007-2009) in the lab of Prof. Itai Cohen (Cornell University, US). At Cornell, Dr Ganapathy exploited the ability to watch particle dynamics in colloidal suspensions to gain insights into thin film growth. His many interactions with Prof. Cohen were instrumental in distilling the essence of the problem and helped adhere to the Cohen lab mantra, which was basically 'ignore the low hanging fruits'. Dr Ganapathy still cherishes writing his colloidal epitaxy paper in Prof. Cohen's house.

> **"When things don't work, push harder."**

Following his postdoctoral fellowship, Dr Ganapathy joined the Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore as a Faculty Fellow in 2009. The enormous encouragement from Bharat Ratna Prof. CNR Rao (FRS) and generous funding from the International Centre for Materials Science (ICMS), JNCASR helped Dr Ganapathy set-up a state-of-the-art



AWARDS

- Shanti Swarup Bhatnagar Prize (2020)
- Swarnajayanti Fellowship (2016)
- NS Satyamurthy Young Scientist Award (2016)

PUBLICATIONS

- 'Emergent stereoselective interactions and self-recognition in polar chiral active ellipsoids'. *Science Advances* (2021).
- 'Structure determines where crystallization occurs in a soft colloidal glass'. *Nature Physics* (2021).
- 'A micrometre-sized heat engine operating between bacterial reservoirs'. *Nature Physics* (2016).
- 'Direct measurements of growing amorphous order and non-monotonic dynamic correlations in a colloidal glass-former'. *Nature Physics* (2015).

Clockwise: At Cohen Lab in Cornell University, 2008. The object to also note in the picture is the recycle bin that has been placed atop an extremely expensive confocal microscope as a quick fix for temperature isolation during epitaxy experiments

With his students at Sheikh Saqr Labs, JNCASR, 2015

Building an optical tweezer apparatus at Cornell (2008)

With his first PhD student Hima K Nagamanasa at Liquids in Portugal (2014)

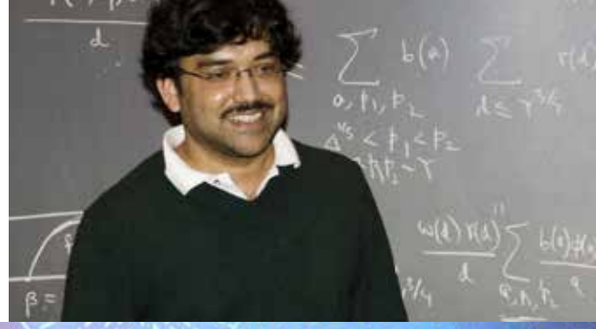
During a demonstration to show that tomato ketchup is a prototypical soft matter system (2010)

With his PhD adviser Prof. Ajay Sood FRS and student Chandan K Mishra

Inset: At the Burj Khalifa, Dubai (2016)

facility to image and manipulate colloidal suspensions and also a confocal-rheometer facility to image submicron structural changes in soft matter systems under a shear. Dr Ganapathy has exploited the fact that the phase behaviour of colloidal suspensions besides being similar to atomic systems also allows visualization of processes to gain insights into defect dynamics in crystals, surface growth, yielding of polycrystalline and amorphous solids, and the bulk of his research focused on the glass transition problem. How flowing liquids transform to glassy solids – the glass transition – without any apparent change in the structure has baffled physicists for over 60 years now. This is further compounded by the fact that fundamentally different theoretical paradigms appear to capture the slowing down of dynamics on approaching the glassy state equally well. Experiments from Dr Ganapathy's lab were the first to evaluate predictions from the kinetic approach of Dynamical Facilitation (DF) theory and also the thermodynamic approach of the random first order transition theory (RFOT) of glasses. Dr Ganapathy still fondly recalls the moment, when he and his coworkers received an email from the late Prof. David Chandler (UCal, Berkeley), the founding father of DF appreciating the experimental findings. Subsequent experiments from Dr Ganapathy's group uncovered a subtle but growing static correlation length and also found that the shapes of dynamical heterogeneities in glasses change shape with supercooling. The latter finding is unique to RFOT of glasses and points towards a thermodynamic view of the glass transition. More recently, experiments in his lab have visualized for the first time the transformation of a glass to a crystal – devitrification – and also utilized machine learning approaches to predict which regions of the glass are likely to devitrify. Understanding devitrification and avoiding it is of paramount importance in the pharmaceutical industry, as well as for technological applications that require stable glassy states. Besides these research activities, Dr Ganapathy's lab currently also works on shear-thickening fluids for smart body armor applications, memory formation active matter and on microscale heat engines. Many of these findings have also featured in popular science outlets both nationally and internationally.

With similar gusto as his professional life Dr Rajesh Ganapathy is passionate about various things in his personal space too. In his free time, he enjoys building Lego models and bots and working on gadgets with his daughter. Xbox gaming, hiking, reading and staying fit are some other interests. •



DR RITABRATA MUNSHI

Going to Great Lengths

From an early age, Dr Ritabrata Munshi was passionate about mathematics and theoretical physics and tried to learn them on his own – venturing well beyond the bounds of the standard school curriculum. Inspired by mathematician, Srinivasa Ramanujan, he started researching on the number theory, while still in school. Since the age of sixteen, David Burton's *Elementary Number Theory* and Tom Apostol's *An Introduction to Analytic Number Theory* were his constant companions.

Dr Munshi became keenly interested in analytic number theory and sought to learn about modular forms. As an undergraduate student at the Indian Statistical Institute, his focus shifted to topology and algebra. This was the time when the scientific world was rocked by Prof. Andrew Wiles's famous proof of a three-hundred-years-old conjecture – Fermat's Last Theorem. The proof was based on techniques from algebra and geometry. A documentary on the work of Prof. Wiles was screened at ISI. This inspired Ritabrata, and he started working on building a firm foundation in these two fields, with a dream of working with Prof. Wiles in the future. As the focus of the curriculum at ISI concentrated more on statistics, he started visiting the Tata Institute of Fundamental Research (TIFR) in Mumbai to learn more about commutative algebra and algebraic geometry. After completing masters from ISI, Ritabrata got an invitation to join the Princeton University graduate school as one of the Centennial Fellows. Soon after reaching Princeton, one fine day he gathered courage to knock at the door of Prof. Andrew Wiles's office at Fine Hall, and to ask him to be his advisor. Prof. Wiles agreed to guide him, but to Ritabrata's surprise, he asked him to dig deeper into Analytic Number Theory. This rekindled Ritabrata's old passion in the field.

After completing his PhD from Princeton, Dr Munshi spent three years as a postdoc at the Rutgers University under the mentorship of Prof. Henryk Iwaniec, and then an year at the Institute for Advanced Study (IAS), Princeton. During the year, devoted to studying Analytic Number Theory at IAS, he started working on the subconvexity problem for L-functions with Prof. Roman Holowinsky. Subconvexity is a central problem in number theory with far-reaching consequences. Soon after his return to India in 2010, Dr Munshi started thinking about the problem from a totally different perspective. After two years of struggle he achieved a breakthrough. By combining a modern version of the circle method – a method which originated in works of Ramanujan – with some elementary new tricks in Analytic Number Theory, he obtained the first subconvexity result for a non self-dual degree three L-functions. His approach was surprisingly 'soft' and avoided the use of the 'trace formula', which had played a crucial role in the previous approaches. At first his work only covered the t-aspect, but later he pushed it further to obtain subconvex bound also for twisted degree three L-functions. The outcome of the project was split into a series of four papers 'The circle method and bounds for L-function' Part I-IV, and they appeared between 2014-2015. The last two papers in the series were most important and they appeared in two top journals of mathematics – *Annals of Mathematics* and *The Journal of the American Mathematical Society* (JAMS) in 2015.

Dr Munshi continued to develop

"A true mathematician thinks out of the box and pursues with deep passion, perseverance and zeal (sometimes with demonic zeal, like that of Ahab)."

Clockwise: Receiving the 2017 Infosys Prize given by the Infosys Science Foundation

Delivering a lecture at a seminar at IAS, Princeton

After receiving the Ramanujan Prize at ICTP, Italy

With his classmates of St Thomas Primary School, Chandannagar (front row, fourth from right)

With Prof. Binod Sahoo (NISER, Bhubaneswar) and Prof. Akshay Venkatesh (IAS Princeton, Fields Medal 2018 winner) at the International Congress for Mathematicians 2018 in Rio de Janerio

Inset: During a conference at IIT Gandhinagar. Dr Munshi has introduced a version of the circle method which is based on the higher rank harmonics, like Fourier coefficients of automorphic forms

AWARDS

- ICTP Ramanujan Prize (2018)
- Invited Speaker at ICM (2018)
- Infosys Prize in Mathematical Sciences (2017)
- Shanti Swarup Bhatnagar Prize in Mathematical Sciences (2015)
- BM Birla Science Award in Mathematics (2013)

PUBLICATIONS

- 'The subconvexity problem for L-functions'. *Proceedings of the International Congress of Mathematicians–Rio de Janeiro* (2018).
- 'The circle method and bounds for L-functions-IV: Subconvexity for twists of GL(3) L-functions'. *Ann of Math.* (2015).
- 'The circle method and bounds for L-functions–III: t-aspect subconvexity for GL(3) L-functions'. *J Amer Math.* (2015).
- 'Bounds for twisted symmetric square L-functions–III'. *Adv Math.* (2013).
- 'Shifted convolution sums for GL(3) GL(2)'. *Duke Math J.* (2013).

his method and started to apply his method in other contexts. Around 2013, he used his level lowering trick to formulate a nested version of the circle method. This yielded an improvement over a classical result of Birch dating back to the 1960s. This important work appeared as 'Pairs of quadrics in 11 variables' in *Compositio Mathematica* in 2015. This work builds on Dr Munshi's previous joint work with Tim Browning, and can even be traced back to his joint work with HenrykIwaniec from his postdoctoral days. Rational points on algebraic varieties is a topic which always remained close to his heart. Indeed, a major part of his Princeton thesis is devoted to this topic. The central theme of the thesis was to blend algebraic and analytic tools to study rational points on families of elliptic curves or an elliptic surface. Later he employed the circle method, as well as the sieve method, to study rational solutions of polynomial equations. During his postdoctoral days, he also looked at the nonvanishing problem of L-functions.

In recent years, however, Dr Munshi has devoted most of his time and energy to develop his novel method in the context of subconvexity of L-functions. In the last five years, he has stretched his method far enough to cover most of the classical results in the field. In particular, he has shown that his method yields the results of Weyl, Burgess and Good. More importantly, the method works even in the case of higher degree L-functions, for example, the degree six Rankin-Selberg convolution of a degree three and a degree two L-function. The paper 'Subconvexity for GL(3)xGL(2) L-functions in t-aspect' is scheduled to appear soon. After his initial breakthroughs in this area, his students and postdocs are working on the project under his guidance, and they themselves are producing important results in the field. The circle method has played an important role in most of Dr Munshi's work. He has introduced several delicate variations in the usual circle method. The classical circle method is based on the harmonics of the circle group. Dr Munshi has introduced a version of the circle method which is based on the higher rank harmonics, like Fourier coefficients of automorphic forms.

He is trying to extend his method, that is, trying to make it work even in the case of the symmetric square L-functions. This notoriously difficult problem has far reaching consequences, and is considered to be well beyond the current state of technology. In the years to come we will find out if Dr Munshi can reach his goal!

Another goal that he tries to fulfill is to draw, Dr Munshi's childhood passion was painting. Even now he likes to draw whenever he gets time. And if not that, he has a keen interest in fixing gadgets. •

DR RITESH AGARWAL

Where There's a Will, There's a Way

Dr Ritesh Agarwal was born in Chennai, his father was an accountant and his mother a homemaker. His parents always wanted him to become a doctor. And he showed an interest in biology when he was in school. Mrs Ezhil Selvi, his biology teacher, motivated him to join the medical school.

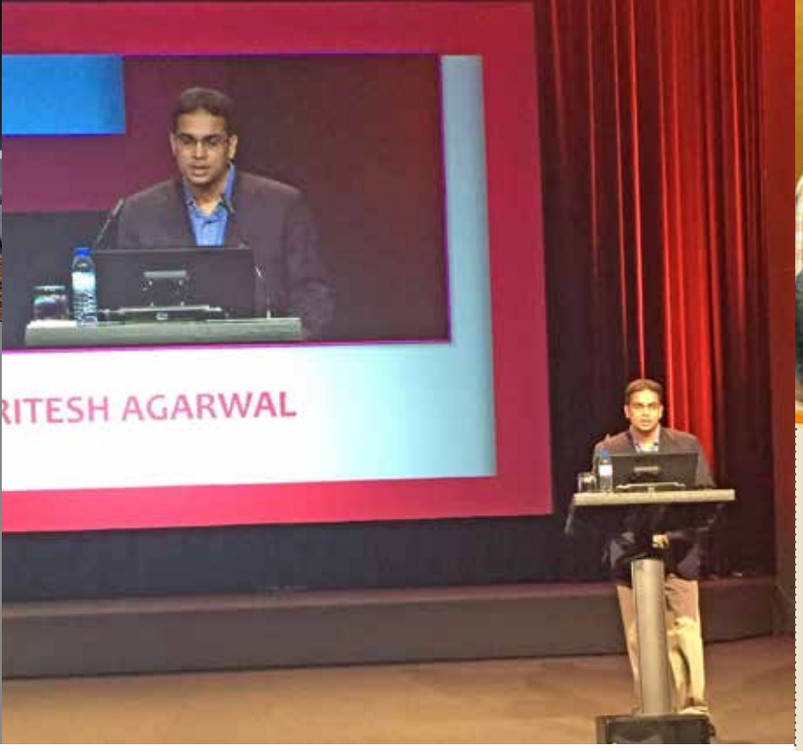
Dr Agarwal completed his medical school in 1998 from Stanley Medical College, Chennai. He was awarded the Jai Gopal Garodia Rheumatology gold medal for the year 1996-1997. During his medical school, his teacher, Prof. RS Muralidharan, inspired him to pursue internal medicine. He then joined the Residency Programme (MD) in internal medicine at the Postgraduate Institute of Medical Education and Research, Chandigarh, in 1998. He was mentored by two superb teachers, Prof. Subhash Varma and Prof. Sanjay Jain. Under their tutelage, he excelled. He was awarded the silver medal for securing the first rank in the final year postgraduate examinations for the year 2001. Subsequently, Dr Agarwal decided to follow a career in Pulmonary and Critical Care Medicine. He completed his Fellowship (DM) from PGI, Chandigarh, in 2004. Initially, he had little interest in pursuing an academic career. However, Prof. Surinder Kumar Jindal, the then head of the department of pulmonary medicine, who was also his chief guide for his MD and DM thesis, directed him towards a career in academic medicine.

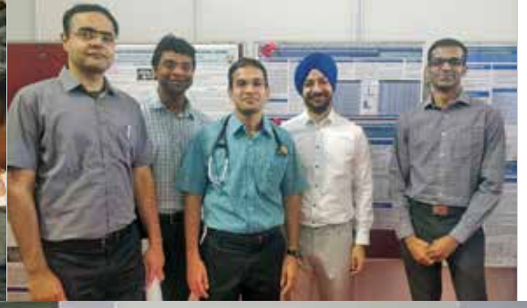
Dr Agarwal joined the department of pulmonary medicine as a faculty in the year 2004. He learnt the nuances of research and statistics from another teacher in the department, Prof. Ashutosh Nath Aggarwal, a master statistician, apart from being a clinician and researcher. The practical art of conducting research and getting it published was taught to Dr Agarwal by Prof. Dheeraj Gupta, another teacher. Dr Gupta was instrumental in guiding Dr Agarwal through his initial research career. Dr Agarwal fondly remembers Prof. Jindal's golden words, 'Choose one research area and work consistently in that area.' A significant turning point in his career was his association with Prof. Arunaloke Chakrabarti, who currently heads the microbiology department at PGI-Chandigarh. Prof. Chakrabarti, a complete workaholic, and a hard taskmaster, directed Dr Agarwal to systematically conduct research in allergic bronchopulmonary aspergillosis (ABPA), a subject chosen by Dr Agarwal for his research career.

> **"Teamwork, punctuality, and discipline will lead you to gain newer heights."**

Dr Agarwal became interested in ABPA when he found many patients with asthma suffering from this disorder. He was disturbed by the fact that the patients were diagnosed late. Also, the disease had been misdiagnosed for decades as there was little awareness about it even among physicians. Dr Agarwal's group began their research by publishing their extensive experience of screening patients with asthma for ABPA. They found a substantial prevalence of this disease in patients with bronchial asthma, which was further confirmed in a systematic review of studies published from across the globe. He then calculated the burden of ABPA in India and found that there are almost 14 lakh cases. These studies emphasized the need for the routine screening of all asthmatics for ABPA.

The next challenge that this investigator realized was the lack of





Clockwise: Attending a workshop with faculty colleagues (sitting second from left)

With his wife and sitar maestro Ustad Shujaat Khan

Delivering a lecture at an international meeting

During a class with his students

With his current faculty colleagues and team

During the inauguration of SJF-DST sponsored TEM among with office and project staff members at IACS during 2015

With his colleagues in the Department of Pulmonary Medicine at PGIMER, Chandigarh

Inset: At his favourite pastime. Crossing the finish line after a 21-km run

AWARDS

- ICMR Kamal Satbir Award (2009)
- NASI-Scopus Young Scientist Award (2011)
- ICMR Shakuntala Amir Chand (2012)
- ICMR Chaturvedi Ghanshyam Das Jaigopal Memorial Award (2019)
- Shanti Swarup Bhatnagar Prize (2020)

PUBLICATIONS

- 'Allergic bronchopulmonary aspergillosis: Lessons from 126 patients attending a chest clinic in north India'. *Chest* (2006).
- 'Allergic bronchopulmonary aspergillosis'. *Chest* (2009).
- 'Allergic bronchopulmonary aspergillosis: review of literature and proposal of new diagnostic and classification criteria'. *Clin Exp Allergy* (2013).
- 'A randomised trial of glucocorticoids in acute-stage ABPA complicating asthma'. *Eur Respir J.* (2016).

uniform diagnostic criteria for ABPA. He worked towards this goal and demonstrated the utility of several of the investigations required to diagnose ABPA. The continued research led to a new diagnostic criterion, and Dr Agarwal is the lead author of that paper. The paper has more than 500 citations on Google Scholar.

While early diagnosis is key to improving outcomes in diseases, treatment directly impacts patients' lives. Dr Agarwal, an ardent believer in evidence-based medicine, explored the treatment options systematically. In different randomized clinical trials (RCT), his group demonstrated that lower doses of glucocorticoids are useful for treating ABPA, thus identifying a less harmful way to treat it. In two different RCTs, he has shown that oral antifungal drugs effectively treat patients with ABPA. This was an exciting concept. It meant that antifungal drugs could benefit patients with ABPA, obviating the need for steroids. The series of RCTs from his group has streamlined the treatment of hitherto under-recognized disease entity. Deservingly, this research work brought Dr Agarwal, his team, and the institute into the limelight.

Each well-conducted research brings forth more questions than answers. The zeal and enthusiasm as a researcher are in trying to find solutions for them patiently. Dr Agarwal perseveres in his work, and his ongoing RCTs are investigating the role of a combination of oral glucocorticoid and itraconazole in the treatment of ABPA. Another trial is currently evaluating the efficacy of deflazacort, a glucocorticoid with lesser potential for side-effects. Dr Agarwal's mid-term goal is to assess the actual prevalence of the disease in the community. This ambitious community project is being funded by the Indian Council of Medical Research. His long-term goal is to evaluate the role of host susceptibility in the pathogenesis of ABPA. He plans to employ whole-genome sequencing among family clusters of ABPA, followed by a larger cohort of unrelated asthmatic patients with and without ABPA.

The research performed by this clinician-cum-researcher has tremendous social implications. Patients with asthma have inferior outcomes once the disease is complicated by ABPA, especially if not treated appropriately. His research has made ABPA a common term in the minds of practising physicians and pulmonary physicians. Doctors in the peripheral hospitals now routinely investigate patients with asthma for ABPA.

Dr Agarwal has more than 500 publications to his credit. He is ranked in the top 1% of scientists globally and was found to be the foremost researcher from India in the field of respiratory medicine according to the recent global ranking performed by the Stanford University. Excelling in his personal life as well, Dr Agarwal is a hardcore running enthusiast. He is also an avid fan of Hindustani classical music especially Ustad Vilayat Khan and Ustad Shujaat Khan's music. •

DR RITU TRIVEDI

Doing Nothing by Halves

They say passion cannot be taught it is in the blood. This is so true for Dr Ritu Trivedi, who showed her scientific temperament from a very young age. She imbibed many things from her parents as both of them are from the science background. Her mother, fondly recalls that Ritu, as a toddler, would carry her father's, Dr BK Dwivedi's, a professor, big fat chemistry book intending to read it and desired to become a teacher like him.

Ritu completed her graduation and postgraduation from Lucknow University. Despite her parent's hesitation about her studying in a different city, Ritu grabbed the opportunity when she got selected for a PhD programme at the Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPGIMS) Lucknow. SGPGIMS allowed her to expand her boundaries from chemistry to endocrinology.

As a PhD student, Dr Trivedi worked on skeletal fluorosis, a condition in which fluoride accumulates in the bone progressively over many years. The camps organized by SGPGIMS around the city, Lucknow, especially in the Unnao area, showed that skeletal fluorosis affected people with stiffness and pain in the joints. In severe cases, the bone structure changed, and ligaments calcified, resulting in muscle impairment and pain. The background had somehow laid the premise for the current research. Her consistent and steady efforts slowly built the hypothesis for study in bone health.

A PhD in endocrinology and postdoctoral experience in developmental biology from the National Institute of Health, Bethesda, US, made things easier for her to establish her laboratory as a scientist at the Central Drug Research Institute, Lucknow. As an endocrinologist at CDRI, her primary area of work is in metabolic bone disorders. She combined her translational and basic research experience. At CDRI, her laboratory focuses on regulating bone resorption and bone formation by declining estrogen hormone with age, termed as post-menopausal osteoporosis and associated fractures. The work also includes effect on the adipocytes (fat-forming cells) in obesity and the aging process of cartilage formed by the chondrocytes (cartilage cells) in osteoarthritis. This regulation could be by glucocorticoids, fatty acids, microRNAs, and small molecules/naturally occurring molecules. These studies involve molecular mechanisms by which signalling molecules exert their effects intracellularly.

> **"Be sincere and persevere in the work you do, and the rest will follow."**

At CDRI, the Ministry of Health (MOH) programme sponsored by the Government of India addressed women's problems, including an anti-fertility programme. This inspired Dr Trivedi to work on an issue in which women are the most affected.

Dr Trivedi feels that what is being done in the lab experimentally, if pursued adequately, has the possibility to be in the market for humankind. This encouraged her to follow up on the project passionately. Dr Trivedi's student observed that *Spinacea oleracea* could proliferate cartilage cells. Her group thought that they would confirm this in animal models where cartilage is lost, especially in diseases like osteoarthritis.

Clockwise: Being felicitated for the technology transfer of *Dalbergiasissoo* for bone health in 2015

Receiving the SPS Teotia Oration Award, 2019

After receiving the SPS Teotia Memorial Oration Award

During the technology transfer event to industry partners for Spinacea Oleracea for osteoarthritis in 2017

During a technology demonstration to the Minister for Science and Technology, Dr Harsh Vardhan

Inset: In her laboratory at CSIR

AWARDS

- TATA Innovation Fellowship (2019)
- Fellow, National Academy of Sciences (2018)
- NASI-Reliance Industries Platinum Jubilee Award (2020)
- P. Sheel Memorial Lecture Award (2019)
- SPS Teotia Oration Award (2019)

PUBLICATIONS

- 'MicroRNA-672-5p identified during weaning reverses osteopenia and sarcopenia in ovariectomized mice'. *Molecular Therapy-Nucleic Acids* (2019).
- 'Glucose dependent miR-451a expression contributes to parathyroid hormone mediated osteoblast differentiation'. *Bone* (2018).
- 'Prevention of articular cartilage degeneration in a rat model of monosodium iodoacetate induced osteoarthritis by oral treatment'. *Journal Biomedicine & Pharmacotherapy* (2018).

Studies in this direction were promising and led to a product called 'Joint Fresh' for osteoarthritis. Joint Fresh was launched in the year 2018 from her laboratory and is available in the market.

On 10 April 2015, the day when technology was transferred for *Dalbergia sissoo* and later 'Reunion' came in the market, then again, in 2017, technology was transferred for *Spinacea oleracea*, and Joint Fresh went in the market for osteoarthritis, these occasions have been high points in her career. Now that she sees these drugs in the market, she finds that this would always remain the most unforgettable and gratifying moment in her research career.

The ultimate goal of Dr Trivedi's work has been to improve the health of the population. Translation from research to prevention and treatment is critical, especially in low- and middle-income countries like India, she feels. According to the statistics, both osteoporosis and osteoarthritis affect both genders but especially women. Dr Trivedi says that any research in this direction and finally, a product will bring women respite. She has garnered tremendous support and acclaim.

Dr Trivedi says that she wants to continue doing good science and ask relevant questions. With two drugs in the market and one completed a one-year clinical trial in postmenopausal women, she wants to do subsequent multi-centric trials.

After the outcome of these trials and the worth of the drugs proven at multi-centric places she wishes to bring these drugs into the relevant government schemes with appropriate strategy to distribute these drugs free of cost under Central government women's health programmes.

Dr Trivedi says that scientific journeys are long, and many people inspire and mentor you. First, it was her mother who made sure to tell her about the plight of women and issues concerning women in India. Through these stories, she ingrained in Dr Trivedi the importance of being a strong and independent woman.

Later, in her career at the institute where she was doing her PhD, an independent woman, inspired her. Science is a male-dominated profession. She learned from her the importance of knowing one's craft well, especially in the area that one works in, so that people not merely hear you but also listen to you.

When Dr Trivedi is not in her lab, she can be found in her garden or pouring over books. A *National Geographic* enthusiast, she makes short documentaries of her work. •

PROF. ROHIT SRIVASTAVA

Going an Extra Mile

As the Head of Department, Prof. Rohit Srivastava has encouraged and motivated the faculty to come together to write Centre of Excellence grants to bring in long-term visibility to the Department of BSBE at IIT Bombay. He has put in extra effort to gather the best faculty for the department. One day, Dr Srivastava hopes to lead an IIT as a director and, he believes, he owes it to mentors like Dr Manju Sharma, Dr Renu Swarup and Prof. G Padmanaban who have helped shape his career.

Rohit completed his schooling from Durgapur, but his plans failed when he could not clear IIT-JEE. Undeterred, he went on to complete an engineering degree from VRCE Nagpur where once again he topped the university exams for 4 years in a row. He completed his degree in 1999 with a job offer from TCS and decided to gain some industry exposure. While at TCS, Rohit realized that this was not the path to get into an IIT and that is when he decided that he had to get a doctorate degree from a university abroad, which would give him an opportunity to come back to India and join an IIT as a faculty. He earned a master's and PhD degree from Louisiana Tech University under very trying times as his father passed away the same year he joined postgraduation. Inspite of such a big loss, he pushed himself to complete the degree requirements in 2005 and managed to graduate with a 4.0 CGPA and a Best Thesis award under his belt. He rejected post-doc offers and applied to several IIT's in India, ultimately, ending up with an offer from the top Institute in India, IIT Bombay where he joined as Senior Lecturer in 2005 and went to on become Professor in 2015 and Head of Department in 2019.

Prof. Srivastava has been able to leverage his training to establish his own successful research programme pursuing micro and nano-scale devices, such as biosensors, bionanotechnology, and finally, mapping out to point-of-care diagnostic devices. He is well-recognized for his translation research in the field of bioelectronics and affordable point-of-care diagnostic technologies for rural and maternal healthcare. He and his team have already commercialized four point-of-care diagnostic devices, such as SYNC-bluetooth integrated glucometer for diabetes management; UChek – routine urine analysis system; ToucHb-non-invasive haemoglobin detection device; CareMother – a smartphone-based platform to integrate doctors and pregnant women to screened and identify risk-prone pregnancies for maternal and neonatal healthcare in the rural areas. Prof. Srivastava along with his team has also clinically validated and transferred numerous healthcare technologies to the companies, such as Smartsense™ – affordable and portable blood electrolyte analyzer with integrated blood plasma centrifuge; Uridsa™ – a low-cost, portable colourimetric device to diagnose kidney-related disorders; ElectroFinder™ – portable and rapid detection device to measure sodium and potassium levels in critical care patients. Prof. Srivastava and his team have clinically validated several technologies like PorFloR™ – fluorescence strips and device for detection of orthopedic implant-associated infection such as C-reactive protein (CRP) and interleukin-6 (IL-6); CholcheckTM-

> **"To bring in positive change in India's un-derdeveloped healthcare sector with affordable healthcare technologies."**

AWARDS

- Shanti Swarup Bhatnagar Prize in Medical Sciences (2021)
- INAE SERB Abdul Kalam Technology Innovation National Fellowship (2019)
- Shri Om Prakash Bhasin Award (2018)
- NASI Reliance Industries Platinum Jubilee Award (2018)
- DBT National Bioscience Award (2018)

PUBLICATIONS

- 'Liposomal Nanotheranostics for Multimode Targeted In Vivo Bioimaging and Near-Infrared Light Mediated Cancer Therapy'. *Nature Communication Biology* (2020).
- 'In Vivo Analysis of Biodegradable Liposome Gold Nanoparticles as Efficient Agents for Photothermal Therapy of Cancer'. *Nano Lett.* (2015).
- 'Ph and Urea Estimation in Urine Samples Using Single Fluorophore and Ratiometric Fluorescent Biosensors'. *Sci. Rep.* (2017).

Clockwise: Being felicitated with the DBT Commercialization Award on the Technology Day

Being felicitated with the Young Investigator Award in 2010

Showcasing his commercialized technologies at the head office

With his thesis advisor Dr Michael J McShane

With his research team at the Nanobios Lab at IIT Bombay

With Chief Guest Dr Renu Swarup at the Departmental Convocation in 2019

With Prime Minister Narendra Modi showcasing affordable healthcare technologies developed by him

Inset: In his office in the Nanobios Lab

Affordable LFA-based complete cholesterol panel and detection device; insulin infusion pump – continuous insulin infusion pump, along with hollow silicon microneedle patch and the flexible reservoir for diabetes management. He is currently working on several challenging technologies, such as rapid detection test for TSH, T3, T4; cardiac biomarkers–Troponin T & I; gestational diabetes for pregnant women; detection of vitamin D ans B12. He has also shown tremendous progress in the field of Nanobiotechnology, where he has been awarded the Fellowship of Royal Society of Chemistry and Royal Society of Biology in 2019. His group has developed many affordable, novel, biodegradable plasmonic nanoparticles for minimally-invasive cancer theranostic application. The promising preclinical results of the developed technology encouraged him to take it forward into Phase I clinical trial. His group has also indigenously developed economical, novel, resorbable bone screw and drug loaded chitosan sponges for orthopedic applications. Prof. Srivastava and his team has also designed and developed cost-effective TB diagnostics and therapeutics.

Prof. Srivastava's record of work is highly impressive. He has not only accumulated a large number of patents and publications in well-respected journals, but he has also contributed papers in very diverse areas. He has established active collaborations with various technical, medical institutes along with hospitals, research centres and companies in India and the world. The results of his collaborations are evident from his high-impact publications and healthcare technologies developed in his lab.

In his stint at IIT Bombay, Prof. Srivastava's lab has supervised 35 PhD students, 75 MTech students and 150+ research interns. He has published in 200+ reputed journals publications and filed about 120 patents, trademarks and IDFs. He has also mentored 25+ Medtech start-ups and helped them to secure grants, developed innovative solutions for healthcare, plastic pollution, heavy metal contamination.

Prof. Srivastava loves reading novels and listening to music in his free time and likes going out on trips with family. •

DR RV NAIR

Stopping at Nothing

The challenge of life is not to let anything hold you back. Dr RV Nair's parents never allowed circumstances to stall or hinder their son's success. His father, Velayudhan Nair, employed with the Ministry of Defence and his mother Radhamani, made sure that he received a good education, sent him to the best school in town and then for a bachelor's in physics to NSS College, Cherthala under Kerala University. Subsequently, he joined St Berchmans College, Changanacherry. During his master's, he attended a workshop on astrophysics, which motivated him to become a scientist. Hence, instead of doing the master's project in his college, he went to MG university to take the project forward, which intensified his research interest, especially in the area of photonics. It also prompted him to pursue a PhD and apply for the CSIR-UGC (JRF) exam. Subsequently, he earned the fellowship and joined the Department of Physics at IIT-Bombay for a PhD.

At IIT-Bombay, Nair heard for the first time the word 'nanophotonics', he was fascinated with this field, especially as to how one can control the reflection of colour by simply structuring materials also known as photonic crystals. Continuing his pursuit for excellence, he went to do a postdoc with one of the pioneer's in the area of nanophotonics – Prof. WLVos at the University of Twente, The Netherlands. During this time, he was fortunate to be associated with two 'firsts' in science: the signature of three-dimensional photonic band gap and discovery of sub-Bragg diffraction in crystals. Dr Nair returned to India in 2010 and joined as Dr KS Krishnan Fellow and later as a scientific officer at BARC, Mumbai. He moved to IIT-Ropar in Punjab in 2013 and started his independent research group with a strong emphasis on undergraduate and postgraduate teaching. At IIT, he initiated an ambitious laboratory for Nanoscale Optics and Metamaterials (LaNOM) in 2014. By 2018, the state-of-the-art experimental facilities, to study the light transport and emission using sub-wavelength photonic structures in both frequency and time domain, were ready. The first exciting moment, Dr Nair feels at IIT-Ropar, was when he developed the micro-reflectivity experimental setup, wherein the reflected light from micron-scale samples can be mapped with 100 nano-meter spatial accuracies. Motivated by the success of micro-reflectivity, he has taken the challenge to build a micro-emission setup to measure the spontaneous emission intensity and rate from the micron-sized samples. These facilities have given remarkable results such as the extent to which emission intensity and rate can be suppressed using nanophotonic structures. He has figured out using precise emission decay rates measurements that the emission suppression scales linearly with sample size, in agreement with theoretical predictions.

"Research requires three 'P's: Passion, Pleasure and Persistence."

In recent years, he has been interested in the quantum nature of light and is curious about the fundamental aspects of manipulating a single photon and spin. This is a paradigm shift in the direction of his research yet, he would like to learn about quantum photonics using the skills and expertise that he has acquired during his adventures in nanophotonics. So he has shifted the focus of his research to quantum nanophotonics using atomic defect in advanced materials like diamond, popularly known as the Nitrogen-vacancy (NV)

AWARDS

- Swarnajayanti Fellowship (2020)
- Senior Member, Optical Society of America (2019)
- Young Scientist Prize, Indian National Science Academy (2015)
- Young Scientist Platinum Jubilee Award, National Academy of Sciences (2012)
- Young Scientist Award, Indian Science Congress Association (2011)

PUBLICATIONS

- 'Selective-frequency-gap-induced negative anisotropic scattering in designer photonic structures with short-range order'. *Physical Review A*. (2020).
- 'Observation of finite-size-induced emission decay rates in self-assembled photonic crystals'. *Physical Review A*. (2020).
- 'Charge-state conversion in nitrogen-vacancy centers mediated by an engineered photonic environment'. *Physical Review A*. (2020).

Clockwise: Receiving the Indian Science Congress Association (ISCA) Young Scientist Prize in physics from President of India Dr APJ Abdul Kalam in 2012

Standing in front of Holy Family High School, Cherthala, Kerala, his alma mater

Sitting behind the experimental set up in the lab at IIT Ropar

During his postdoc days in the Netherlands

Experimenting in his lab

Receiving the National Academy Sciences in India (NASI) Young Scientist Award from Prof. MGK Menon in 2012

Inset: Receiving the Indian National Science Academy (INSA) Young Scientist Prize from Prof. Raghavendra Gadagkar in 2015

centers. In the last couple of years, he has achieved control over the emission properties of NV centers using nanophotonics structures.

The requirement of on-demand single-photon emission with a high rate is indispensable for quantum technologies. However, the efficient generation of single photons using NV centers is limited due to the lower light extraction, slower emission rates, and phonon-induced decoherence. A practical solution to overcome these inherent drawbacks is the use of resonant photonic structures that excite a single resonant mode and suppress all other modes. The tunability of the resonant modes enables one to address any spectral range of NV center broad emission spectra. This is necessary to enhance their R & D prospects in photonic quantum technologies and ultra-sensitive sensing. Dr Nair's lab is now focused on achieving these goals and is designing experiments to achieve single-photon generation and its manipulation.

One of the most prominent requirements of quantum communication is the requirement of on-demand single photons at high emission speed. Many systems are suggested for the generation of single photons ranging from materials to photon mixing using non-linear optical techniques. The atomic defects in advanced materials like diamond, silicon carbide is also proposed as a versatile system for single-photon generation. It is the defect centers in these materials that make it more interesting, for example, the sparkling pink colour in diamond arises due to the defects in diamonds. The NVs, or the silicon-vacancy (SiV), are the promising defect centers for quantum photonics as they possess excellent optical and spin properties. However, their emission properties are required to be spectrally tailored for the efficient generation of photons at high speeds. This can be achieved by using the sub-wavelength photonic structure or in a way, trapping these defect centers in an uneasy electromagnetic environment. Dr Nair is intent on understanding the modification of single photons emission rate, the spin properties of NV centers resulting in better readability. The controlled manipulation of single spins and photons is the need of the hour and would place India as the forerunner in quantum technologies.

Dr Nair credits his success to his teachers, students, family, and friends, particularly his wife Veena and daughter Riddhi who have made maximum sacrifices for whatever he has achieved. •

S

DR S HOTHA
DR S SURESH BABU
PROF. SACHCHIDA NAND TRIPATHI
DR SAKYA S SEN
DR SANDEEP K
DR SANDIP BASU
DR SANJEEV DAS
PROF. SANJIB KUMAR AGARWALLA
PROF. SEBASTIAN C PETER
PROF. SHANTHI PAVAN
DR SHEEBA VASU

DR S HOTHA

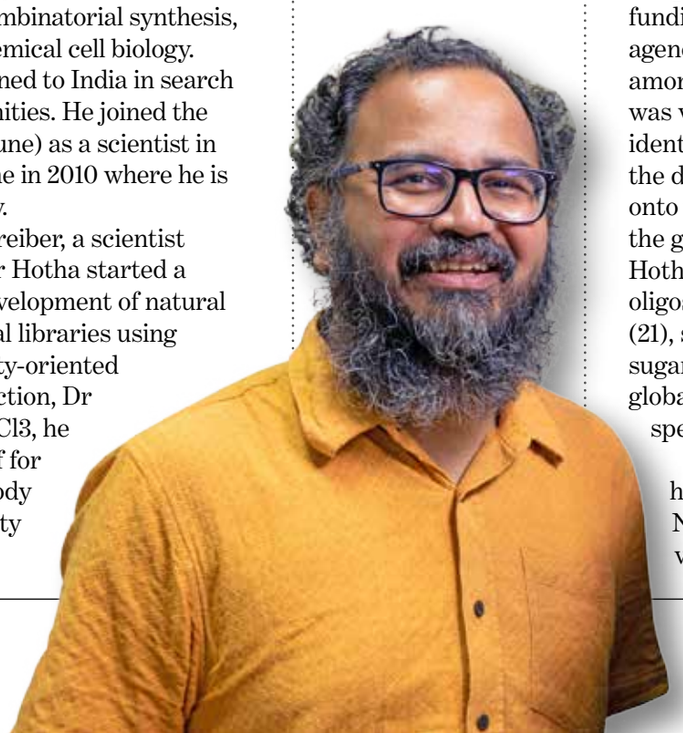
Striking Gold

It is in moments of decision that our destiny gets shaped. Dr Srinivas Hotha believes that it was moment like this that played a role in shaping his career. Professor of Chemistry and former Co-chair of the Department of Chemistry at IISER-Pune, he is an established research scientist in the field of glycochemistry and is best known for the development of gold-catalysed glycosidation and oligosaccharide syntheses.

Dr Hotha received his MSc degree in chemistry from the School of Chemistry, University of Hyderabad and MTech degree in biochemical engineering from Institute of Technology, Banaras Hindu University, Varanasi. Subsequently, he joined the Indian Institute of Chemical Technology (IICT) to pursue his PhD under the tutelage of Dr Mukund K Gurjar and earned his PhD in 2001 from Osmania University, Hyderabad for the work carried out at IICT and National Chemical Laboratory, Pune. While pursuing the PhD programme, Srinivas began working in the area of glycochemistry and continued postdoctoral research at the Rockefeller University, New York, USA as a Charles H Revson Fellow (2001-2003). During his stay at Rockefeller University, Srinivas worked on combinatorial synthesis, high-throughput methods and chemical cell biology. After his postdoc, Dr Hotha returned to India in search of independent research opportunities. He joined the National Chemical Laboratory (Pune) as a scientist in 2003 then relocated to IISER-Pune in 2010 where he is currently a professor in chemistry.

Influenced by Prof. Stuart Schreiber, a scientist at Harvard University, at NCL, Dr Hotha started a major research activity on the development of natural product-like diverse combinatorial libraries using carbohydrate scaffolds on diversity-oriented synthesis platform. In that connection, Dr Hotha had ordered 500 mg of AuCl3, he recalls. Initially, he chided himself for spending ₹3000 on AuCl3 as nobody had taught him about the reactivity pattern of gold. It is believed that gold is inert and hence only for jewellery. Later, from scientific literature, he found that the gold salts have an extraordinary affinity towards alkynes. By then, Dr Hotha was already activating alkynes with cobalt complexes. After a few satisfying results, the process finally culminated in the development of a novel glycosyl donor. Collaborating with practitioners of materials science, Dr Hotha developed photoresponsive nanomaterials and several glycopolymers.

> **“If you don’t get what you want, better use what you have sincerely and seriously. Leave the destiny to Patience, Persistence, Perseverance and Luck.”**



Dr Hotha’s glycosidation is a very fundamental reaction that has applications in fields as diverse as medicine, materials and food science. To further the glycosidation research, Dr Hotha received funding from DST, CEFIPRA and other leading agencies for nurturing gold-catalyzed glycosidations; among those, DST-Swarnajayanti fellowship in 2010 was very important. Seeing the potential of thus identified glycosyl donor chemistry, Dr Hotha left the diversity-oriented synthesis platform and caught onto the discovery-oriented synthesis by nurturing the gold-catalysed glycosidation chemistry. Dr Hotha demonstrated that one can synthesize long oligosaccharides by synthesizing heneicosasaccharide (21), several other saccharides that have more than 15 sugar residues. This placed Dr Hotha’s research on the global pedestal and as a consequence, he was invited to speak at many global research conferences.

However, Dr Hotha suffered from a major health crisis in 2007, when he was diagnosed with Non-Hodgkins Lymphoma, which he faced with valour and won over it without compromising his

Clockwise: Receiving the CSIR Young Scientist Award from Kapil Sibal, Union Minister of Science & Technology, and Dr RA Mashelkar, DG-CSIR

At work in the National Chemical Laboratory, Pune

At work in his lab at IISER-Pune

With Somanchi Laksmi Narasimham, his mentor and guide during his graduation days

In his lab at IT-BHU. It was Dr Gandham Mahendra, his mentor at the university, who encouraged him to pursue research as a career option

Inset: With his younger brother-in-law, Dr Malladi Prabhakaram, who had helped him identify carbohydrates as his research interest

AWARDS

- Revson Fellowship for Biomedical Sciences (2002)
- Young Scientists Medal, Indian National Science Academy (2006)
- Young Scientist Award, Council of Scientific & Industrial Research (2006)
- Swarnajayanti Fellowship (2010)
- Bronze Medal, CRSI (2015)

PUBLICATIONS

- 'Silver Assisted Gold Catalysis for the Formal Synthesis of Anticoagulant Fondaparinux Pentasaccharide'. *Nature's Communications Chemistry* (2021).
- '[Au]/[Ag]-Catalysed expedient synthesis of branched hen eicosa furanosyl arabinogalactan motif of Mycobacterium tuberculosis cell wall'. *Nature Communications* (2017).
- 'Expedient Synthesis of Heneicosasaccharyl Mannose Capped Arabinomannnan of Mycobacterium tuberculosis Cellular Envelope by Glycosyl Carbonate Donors'. *Chem. Sci.* (2017).

commitment to the gold-catalyzed glycosidations.

In 2010, Dr Hotha moved to the Department of Chemistry at IISER-Pune, taking his laboratory with him. He continued nurturing the gold-catalysed glycosidation and found versatile glycosidation process in 2016 wherein he thoughtfully exploited glycosyl carbonates and activated them to behave as a glycosyl donor. This chemistry has received widespread attention and Dr Hotha has shown the utility of this protocol by synthesizing a pentacosasaccharide (glycan with 25 sugar residues) and has brought laurels to the Indian glycochemistry community. Dr Hotha continued his pursuit of excellence and is currently dreaming to synthesize the most complex, highly branched and synthetically challenging *Mycobacterium tuberculosis* cell wall that contains about 135 sugar residues in furanosyl and pyranosyl forms.

In addition, Dr Hotha has made scientific contributions in diverse areas, including glycochemistry and chemical tools, instruments and games. In collaboration with Spire Automation, Dr Hotha has also invented a machine called 'SWADESI' (*Software Assisted Direct Extraction and Sampling Interface*), aluminium heating blocks for the first time in India. Earlier, such units were imported from abroad at an exorbitant cost now they are available at a one-tenth price and are being used by laboratories in IITs, IISERs, NITs, industries and universities.

Dr Hotha is currently working on AtMaCarS (Automatic Machine for Carbohydrates Synthesis), an ambitious project to build an automated machine for carbohydrate synthesis based on the discoveries nurtured in his laboratory over the past 15 years. He wants to use the AtMaCarS for the synthesis of a combinatorial library of oligosaccharides of *Mycobacterium tuberculosis* for exploring them as vaccine candidates. Dr Hotha believes that these studies would pave the way to the discovery of the 'Glycocode' in due course of time. Dr Hotha believes that the method nurtured by his group is extremely suitable for becoming a universal protocol that is amenable for automation as the reactions are catalytic, require minimal purification, excellent yields in short times and environmentally benign chemicals. During the Covid-19 pandemic, Dr Hotha invented a novel chemical oxygen generator (COG), which can be deployed as a stop-gap arrangement for saving patients (up to 100 min) who need oxygen while the main oxygen tank is on its way. Dr Hotha exploited his skill in chemical engineering and chemistry to come with a COG. •

DR S SURESH BABU

A Symbol of Conviction

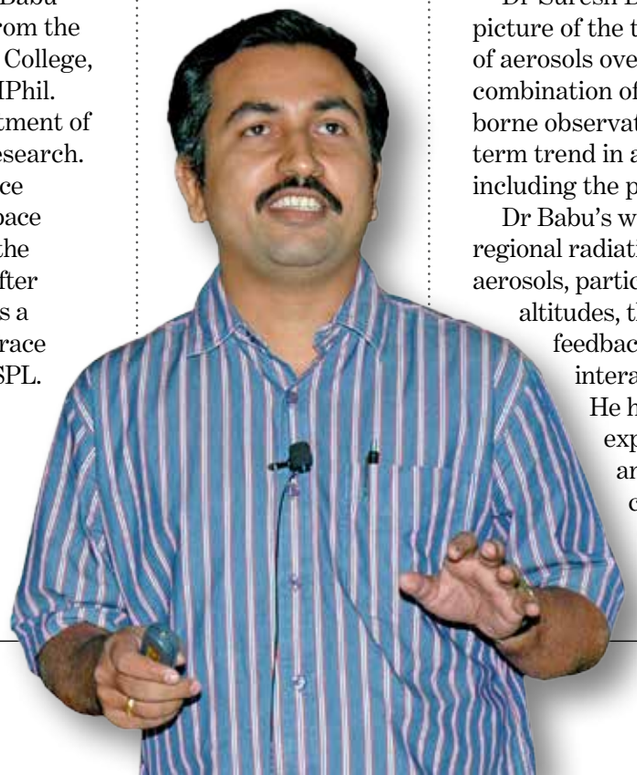
Dr S Suresh Babu has made outstanding contributions to the science of climate impact of aerosols through carefully made observations from the ground-based network and research ships, as well as airborne and space-borne measurements and synergizing them with regional models for impact assessments. He is the Principal Investigator of Aerosol Radiative Forcing over India (ARFI) and Integrated Campaign for Aerosols Gases and Radiation Budget (ICARB) projects of ISRO – Geosphere-Biosphere Program. Based on the scientific results from ARFI and ICARB Projects, he was instrumental in the formulation of the Regional Aerosol Warming Experiment (RAWEX) and conducted a series of aircraft-based and high-altitude balloon-borne experiments to derive the three-dimensional distribution of aerosol characteristics over the Indian region.

Born in the Pathanamthitta district of Kerala to KG Surendran Nair and Santhakumari Amma, Dr Babu completed his pre-degree and BSc in physics from the University of Kerala, and joined the University College, Thiruvananthapuram for a MSc and later an MPhil. The exposure he received at the physics department of the University College oriented him towards research.

He conducted his doctoral research at the Space Physics Laboratory (SPL) of Vikram Sarabhai Space Centre (VSSC) and earned a PhD in 2005 under the excellent mentorship of Dr K Krishnamoorthy. After obtaining a PhD, he joined ISRO at SPL, VSSC, as a scientist. Currently, he is the Head of Aerosols, Trace Gases and Radiative Forcing (ATRF) Branch of SPL.

Dr Babu's area of research is aerosol - cloud - radiation interaction and mainly focus on the generation of a national database on aerosols relevant for climate impact assessment through field observations by the setting up of a countrywide network of aerosol observatories and multi-platform experimental campaigns. This is the need of the hour for India because such a database is valuable for climate negotiations in international forums.

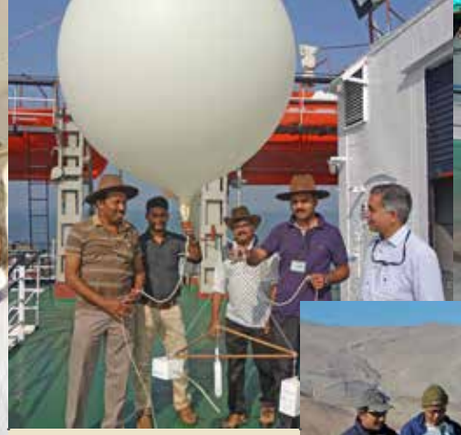
> **"Careful planning, dedication and hard work are the mantras to achieve bigger goals."**



Atmospheric aerosols interact with solar radiation through scattering and absorption thereby affects the radiation balance of the earth-atmosphere system and hence the climate. This is especially significant and challenging over the South Asian region because of its diverse geographical condition, regionally varying anthropogenic activities and seasonally changing airmass and meteorology.

Dr Suresh Babu has brought out a climatological picture of the three-dimensional distribution of aerosols over the Indian region through a combination of ground-based, airborne and space-borne observations, as well as delineating the long-term trend in aerosol loading over the Indian region including the possible causes and impact indicators.

Dr Babu's work leading to the quantification of regional radiative impacts of black carbon (BC) aerosols, particularly when they are present at high altitudes, through atmospheric and cryospheric feedbacks as well as through aerosol-cloud interaction, is first of its kind in the country. He has discovered (using ingenious experiments with high-altitude balloons and aircraft) layers of enhanced BC concentration in the free troposphere (4 to 9 km). This finding has also raised new scientific issues, such as self-lifting of BC to stratosphere leading to slowing



AWARDS

- Fellow, Indian Academy of Sciences (2021)
- National Award of Excellence in Atmospheric Science & Technology, Ministry of Earth Sciences (2020)
- Shanti Swarup Bhatnagar Prize (2017)
- Swarnajayanti Fellowship (2013)
- NASI-SCOPUS Young Scientist Award (2009)

PUBLICATIONS

- 'Radiative properties of Bay-of-Bengal Aerosols: Spatial distinctiveness and source impacts', *Journal of Geophysical Research* (2012).
- 'Trends in Aerosol Optical Depth over Indian region: Potential causes and impact indicators'. *Journal of Geophysical Research* (2013).
- 'Seasonal variation of vertical distribution of aerosol single scattering albedo over Indian sub-continent: RAWEX aircraft observations'. *Atmospheric Environment* (2016).
- 'Anthropogenic emissions from South Asia reverses the aerosol indirect effect over the northern Indian Ocean'. *Scientific Reports* (2020).

Clockwise: Receiving the Shanti Swarup Bhatnagar Award from Prime Minister Narendra Modi

Receiving the NASI-SCOPUS Young Scientist Award from the then Minister of Science and Technology, Prithviraj Chavan

Briefing about the RAWEX to then Director NRSC, Dr VK Dadhwal

Conducting high altitude balloon experiment as part of ICARB-2018 onboard Sagar Kanya for vertical profiling of atmosphere up to 35 km

At the aircraft hangar with the crew members before the Regional Aerosol Warming Experiment (RAWEX)

Setting up of a high-altitude aerosol observatory at Hanle in western Himalayas

Inset: Receiving the INSA Young Scientist Medal award from President of INSA Dr RA Mashelkar

down of ozone recovery, and increased lifetime favoring BC setting up 'their homes' in the upper layers.

His first field experiment, aimed at quantifying the aerosol radiative forcing over an urban location using collocated measurements and delineating the role of BC in reversing the sign of the top of the atmosphere (TOA) forcing, is unique. He further established the importance of the black carbon contribution to the composite aerosols in controlling aerosol-induced atmospheric absorption efficiency over the oceanic regions around India. Dr Babu was the Chief Scientist of the ICARB -2018 experiments conducted over the Arabian Sea and the equatorial Indian Ocean during January-February 2018, which brought out several unparalleled results – the CCN characteristics of South Asian outflow and its association with new particle formation process, role of organic aerosols in the new particle formation over far oceanic regions and the aerosol mixing state of South Asian outflow.

His work on the aerosol-cryosphere interactions over the Himalayan region is crucial for the quantification of anthropogenic impacts on the Himalayan climate and regional hydrological cycle. He has established a chain of aerosol observatories at high-altitude sites in the Himalayas. His studies from Hanle (Ladakh region), the second-highest altitude aerosol observatory in the world, has led to remarkable results. Dr Babu took up aerosol life-cycle research focusing on the new particle formation from precursors and demonstrated the contrasting effects of ocean biogeochemistry and human activities leading to new particle formation over oceanic regions, and the strong solar control on the new particle formation process in the free tropospheric environment of Himalayas. He has quantified the role of long-range transport of aerosols on aerosol forcing over the Arabian Sea, Bay of Bengal and Indian subcontinent and the large absorbing efficiency of Asian dust by interlacing ground-based measurements with satellite data.

He has 165 peer-reviewed publications to his credit with a total citation of 6682 and h-index of 45. His dream is to develop a state-of-the-art facility for aerosols, trace gases and cloud measurements onboard aircraft for India. According to him, such a facility is essential for the country with diverse climatic zones surrounded by oceans and is under the influence of periodically changing airmass type.

Dr Babu's research output is significant in delineating the anthropogenic contribution to aerosol-climate interaction and air quality over South Asia and in the formulation of mitigation strategies by the government agencies. •

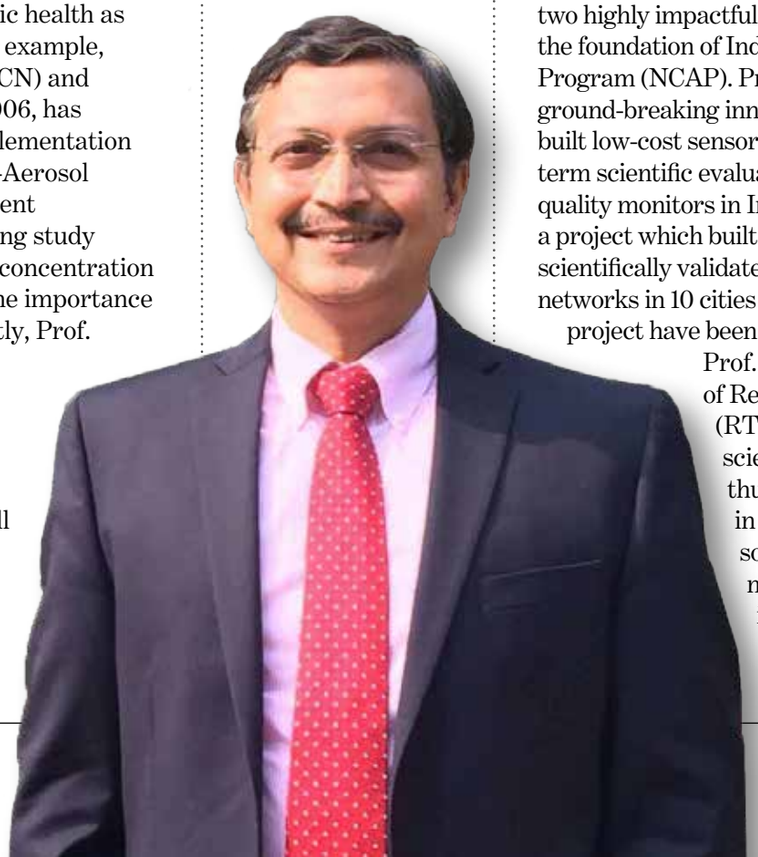
PROF. SACHCHIDA NAND TRIPATHI

Raising the Bar

It was Prof. Sachchida Nand Tripathi's father's elder brother who had ignited his interest and shaped his skills in mathematics, which led him to pursue engineering. Similarly, his physics teacher's challenge prompted him to crack not only JEE but also the University of Roorkee (now IIT-Roorkee) and UP State Engineering college entrance examinations. At the behest of his parents, he chose to stay closer to home and enrolled for undergraduate studies at the Indian Institute of Technology-Banaras Hindu University. He went on to pursue MTech in environmental engineering from the National Institute of Technology, Allahabad (1995) and completed his PhD from the University of Reading, UK, in 2000.

Prof. Tripathi's chosen area of research is aerosols. His contributions address the highly topical environmental questions through a comprehensive science-centric approach. At the same time, he has adopted an interdisciplinary approach imbibing a seamless link between air quality for public health as well as the impact on climate change. For example, the work on cloud condensation nuclei (CCN) and cloud microphysics that he initiated, in 2006, has resulted in the conceptualization and implementation of the Ministry of Earth Sciences – Cloud-Aerosol Interactions and Precipitation Enhancement Experiment (CAIPEX). His recent modeling study showed increasing cloud droplet number concentration with increased aerosols, demonstrating the importance of CCN-cloud feedback over India. Recently, Prof. Tripathi led a study published in *Nature Communication* that provides evidence of aerosol-induced cloud invigoration effect (AIvE) during the Indian summer monsoon. Another study led by him provides robust evidence that high rainfall downwind of metropolitan cities in North India can be an outcome of a synergy of couplings between urban land use and land cover, and CCN-induced AIvE. These findings are significant for future urban planning to avoid flash floods, which are an outcome of severe impacts of extreme rainfall.

> **"Dedication undeterred by failures or criticism, hard work, sustained effort and focused mind and teamwork lead to success."**



Prof. Tripathi's work on the discolouration of Taj Mahal demonstrates his dexterity in instituting an interdisciplinary approach to pin down a compelling cause-effect relation and arrive at a decisive conclusion. This work soon led to policy interventions to stop the discolouration of this iconic monument.

Between 2014 and 2016, Prof. Tripathi has co-authored two highly impactful technical reports that laid down the foundation of India's ambitious National Clean Air Program (NCAP). Prof. Tripathi has also contributed to ground-breaking innovative solutions for indigenously-built low-cost sensors. He has led one of the first long-term scientific evaluations of low-cost sensor-based air quality monitors in India. Prof. Tripathi was integral to a project which built and deployed one of India's first scientifically validated nationwide air quality monitoring networks in 10 cities of India. The findings from this project have been of wide public interest.

Prof. Tripathi pioneered the method of Real-Time Source Apportionment (RTSA), published in top environmental science and technology journals, thus leading India globally in RTSA in 2019. He led multiple studies on source apportionment of particulate matter. His findings supply critical information on PM2.5 composition and sources using state-of-the-art instruments. Even though

Clockwise: Being felicitated by the Department of Science and Technology for collaborative research on air quality monitoring, 2018

After receiving the BTech degree from KC Pant, Deputy Chairman of Planning Commission, at IIT (BHU), 1992

With Prof. Ashutosh Sharma, Secretary DST, during the inauguration of Pseudo-Dynamic Test Facility, IIT-Kanpur, 2019

With the Einstein of oceanography, Prof. Walter Munk, at his residence in San Diego, US, 2016

With the former Governor of California, Jerry Brown

With CM Yogi Adityanath, at the inaugural of the National Knowledge Network, National Clean Air Programme, 2019

Inset: During the setting up of the radiometer at IIT Kanpur, 2016

AWARDS

- Shanti Swarup Bhatnagar Prize (2014)
- JC Bose Fellowship (2021)
- Fellow, Indian National Academy of Engineering (2015)
- Fellow, Indian National Science Academy (2020)
- Distinguished Alumnus Award, Banaras Hindu University (2015)

PUBLICATIONS

- 'The discoloration of the Taj Mahal due to particulate carbon and dust deposition'. *Environmental Science & Technology* (2015).
- 'Aerosol-induced intensification of cooling effect of clouds during Indian summer monsoon'. *Nature Communication* (2018).
- 'Field evaluation of low-cost particulate matter sensors in high and low concentration environments'. *Atmospheric Measurement Techniques* (2018).
- 'Real-time characterization and source apportionment of fine particulate matter in the Delhi megacity area during late winter', *STOTEM* (2021).

Indo-Gangetic Plain is known for large-scale biomass burning, its effect on regional radiative forcing was unknown. Prof. Tripathi estimated changes in radiative forcing due to biomass burning compared to no burning, and reported an increase in surface warming as a consequence. He is among the first who reported the spectral brown carbon-absorbing refractive indices.

Prof. Tripathi's keenness in transferring his research into solutions of societal relevance is evidenced by a seminal study, supported by Central Pollution Control Board (CPCB) undertaken in 2018-19 at three locations in Delhi NCR. In this, he provided a first of its kind, time-resolved percentage apportionment of 12 sources of PM2.5. Prof. Tripathi also has an immense fondness for the pristine air quality of the Himalayas and has worked significantly to preserve it. He has also made significant contributions to planetary sciences. He demonstrated the significance of aerosol and cloud charging to the planetary electrical environment which has an important bearing on the life-forming molecules in planetary atmospheres.

A far-reaching outcome of Prof. Tripathi's research efforts is the establishment of the National Aerosol Facility (NAF) at IIT Kanpur in collaboration with the Bhabha Atomic Research Center. Safety analysis of nuclear reactor is based on certain assumptions all of which are required to be validated with a large number of aerosol experiments. NAF is indeed a first-of-its-kind in an Asian University and it has two phases of study involving several entities of the Department of Atomic Energy including BRNS, BARC and AERB. A series of investigations have already been either completed or underway related to an understanding of nuclear aerosol behaviour: deposition, charging, hygroscopic growth and nucleation.

Looking forward, the low-cost sensors work undertaken by Prof. Tripathi aims to increase air quality monitoring capacity in India. These sensors can scale up the current air quality monitoring network in the country significantly. Base-level monitoring is always required to gauge the effectiveness of new policies, health risks, and episodic changes. The more information is available, the more adept the nation will be to undertake the problem of air quality. In the same vein, real-time source apportionment pioneered by Prof. Tripathi will help explain the observations made by the monitoring network. Knowing the causes with a certain degree of certainty will help in introducing remedial measures and thus air pollution will be mitigated in India. The low-cost sensors and real-time source apportionment will work in tandem to bring about observable change in the near future.

The National Aerosol Facility at IIT Kanpur created by Prof. Tripathi will be a single platform for the validation of nuclear safety codes. This will lead to the safe establishment of nuclear power plants in India, heralding in a new age of development for our country. •

DR SAKYA S SEN

Exploring All Avenues

Born to Sumita Sen, a homemaker, and Debkumar Sen, a school teacher, he was an only child and his parents provided him an academic environment. In his school days, his favourite subjects were linguistics and history. When he was 15 years old, he was gifted a book titled *Brighter than a Thousand Suns: A Personal History of the Atomic Scientists*, which increased his interest in science, especially chemistry. Sen completed his BSc in chemistry, subsequently, obtained his MSc in the same subject from the Indian Institute of Technology, Kharagpur. Sen got the flavour of synthetic chemistry first at Jadavpur University, where he worked in the laboratory of Professor Samaresh Bhattacharya as a summer fellow in 2005 on ruthenium complexes and later at IIT Kharagpur during his MSc thesis, which he did under the guidance of Professor Debasis Ray on the chemistry of first row transition metals. Then he joined the research group of Professor Herbert W Roesky at the University of Göttingen, Germany, where he was introduced to the world of low valent main group chemistry. He received his PhD degree in 2010 with a *summa cum laude* (outstanding). Postdoctoral work followed (2011-2013), working with Professor Holger Braunschweig at the University of Würzburg, Germany, on novel boron compounds, supported by the fellowship from the Alexander von Humboldt Foundation, Germany. During his PhD and postdoc, he began to notice that research in academia was something that he really enjoyed doing. In 2014, he was appointed as a senior scientist at CSIR-National Chemical Laboratory, Pune, where he is currently serving as a Principal Scientist since 2018.

The main interest of Dr Sen's research group is the isolation of compounds with low coordinate heavier main group elements, including cations and multiply bonded species. Much emphasis lies in elucidating the electronic structure and reactivity of such novel compounds, thereby enabling their applications in organic synthesis, catalysis, and material sciences. The spectroscopic and structural characterization, as well as computational and theoretical analyses of these unsaturated molecules has shed new insight into understanding their bonding properties. Dr Sen's group also tries to mimic the chemistry of transition metals by these main group compounds. Many basic catalytic processes require the cleavage, or activation, of strong covalent bonds in ubiquitous and inexpensive small molecules such hydrogen, nitrogen, ammonia, water and carbon dioxide, and typical catalysts used in this reactions are transition metals. His research project focuses on the exciting possibility to perform small molecule activation with main group compounds that, in contrast to many transition metal catalysts, consist entirely of cheap earth abundant elements.

> **"The mantra is in Michael Faraday's three words – Work, Finish, Publish."**

The overall objective of the project is to find new ways to achieve small molecule activation using main group compounds that typically do not display such reactivity.

The other aspect his group is focusing on is to use more benign main group compounds as catalysts for important organic transformations. There is intense current interest in the possibility of using main-group elements in the place of transition metals in moleculars catalysis

Clockwise: Being felicitated with the CSIR-Young Scientist Award in chemical sciences by President of India Ram Nath Kovind in 2017

Receiving the Merck-Young Scientist Medal in chemical sciences in 2019

Working in the Fume-hood. The most exciting thing about Dr Sen's research is that he can make hitherto nonexistent chemical bonding and structures come into existence

Standing in front of the Colosseum, Rome, during a professional tour

With fellow graduate students before receiving the PhD degree in Göttingen, Germany

Inset: Receiving the INSA-Young Scientist Medal in chemical sciences from Prof. AK Sood in 2018

AWARDS

- NCL-Research Foundation Scientist of the Year (2020)
- Merck Young Scientist Award (2019)
- Young Scientists Medal (INSA) (2018)
- CSIR Young Scientist Award in Chemical Science (2017)
- Young Associate of Indian Academy of Science (2017)

PUBLICATIONS

- 'Unsymmetrical sp^2-sp^3'. Disilenes, *Angew. Chem. Int. Ed.* (2021).
- 'Access to diverse germylenes and a six-membered dialane with a flexible β-diketiminate'. *Chem. Commun.* (2020).
- 'C–F Bond Activation by Saturated NHC: Mesoionic Compound Formation and Adduct Formation with $B(C_6F_5)_3$'. *Angew. Chem. Int. Ed.* (2019).
- 'Benz-amidinato calcium iodide catalyzed aldehyde and ketone hydroboration with unprecedented functional group tolerance'. *Chem. Commun.* (2017).

mainly due to the cost of the metals themselves, their low terrestrial abundances, and increasing concerns about the health and environmental impact of the residual metal retained in the products. The chemical sector is the mainstay of industry and agricultural development and provides building blocks for downstream industries. However, it also contributes to about 8.3% of all deaths and 5.7% of the total burden of disease worldwide are related to chemical exposure. Therefore, the industry requires a much-needed change as there is increasing pressure for the catalytic processes with reduced environmental impact, minimal waste production, less energy consumption, and reduction in the generation of toxic substances. Main group elements are cheap, more abundant, and have lesser issues with respect to toxicity. The approach of the Sen group towards accomplishing this target is to use more benign main group compounds such as silicon or calcium as catalysts. Due to low toxicity and relative abundance, silicon or calcium compounds are highly sought after as single component catalysts because a catalytic cycle based on silicon could be sustainable, economical, and green. He has successfully used such catalysts for the hydroboration of unsaturated organic compounds.

Overall, his group is divided into two different types of chemistries: one more focused on reactive compounds and one which investigates catalysis. But Dr Sen thinks that they can both learn a lot from each other, especially in terms of isolating intermediates and catalysts.

Significant results over the past few years were achieved in various independent, highly topical, and competitive sub-areas of (a) low-valent main group compounds and small molecule activation, (b) alkali and alkaline earth metal chemistry and catalysis, and (c) silicon compounds in catalysis. The approach of Dr Sen's group towards organic transformations using silicon and calcium that are not only cheap, but biocompatible per se and will make sure that 'green' and 'chemicals' are words that will sit comfortably with each other.

The most exciting thing about Dr Sen's research is that he can make hitherto non-existent chemical bonding and structures come into existence in the world. His greatest ambition is to change the catalysis world with main group elements. Apart from work, he loves to cook, read books, and watch movies. He is an avid sports lover, whose favourite writer is Rabindranath Tagore. •

DR SANDEEP K

Ahead of the Curve

For Sandeep K the relative ease of studying mathematics compared to other subjects prompted him to take it up as a career option, he confesses. He had a head start, when he completed his pre-degree from Farook College, in Calicut, with a perfect score in mathematics!

Enthused, he enrolled for the BSc mathematics programme in the same college and completed the degree with distinction. By then, he had also made up his mind to continue his studies in mathematics and joined the Department of Mathematics, University of Calicut, for his master's. It was during this period that he realized the opportunities available to study the subject further and learnt about institutions like TIFR (Tata Institute of Fundamental Research). He completed his post graduation with a distinction and enrolled for a PhD at the Tata Institute of Fundamental Research.

> **"First identify your strength, then work hard to pursue your career in that direction."**

At TIFR, he developed an interest in analysis and started working on partial differential equations. Dr Sandeep's research work so far has been around a class of PDEs, which can be broadly classified as semilinear elliptic problems. He was initiated into this area by his academic mentor Prof. Adimurthi during his PhD days. The main source of these equations is problems in differential geometry and also some of the models coming from physics and biology. Many of these issues are associated with a minimization problem, that is, the quantity minimized is associated energy of the model or quantities like area and length. A broad principle exists in the calculus of variation to study these problems. One of the main issues in this broad principle is a property called compactness. In many interesting problems, this property is not satisfied and is intimately connected with phenomena like symmetry breaking. His contributions are precisely towards problems that fall in this category.

One of his notable contributions is in the study of a problem emanating from an astrophysics model. Two astrophysicists had proposed a model in their study of elliptic galaxies and the associated partial differential equation were analysed by some mathematicians and it was found that in some cases this partial differential equation does not admit any solution. He investigated this phenomenon of the nonexistence of solution and showed that this problem is related to an existing inequality of functions known as the Hardy-Sobolev-Mazya equation. The analysis of the problem required the classification of all functions for which equality holds in the above-mentioned inequality. There are similar issues in the literature, however, the existing theories did not answer this problem due to the lack of rotational symmetry for this problem. This lack of symmetry was a major obstacle to studying this problem. Dr Sandeep, along with his collaborators, solved this problem by discovering a hidden symmetry for this problem known as hyperbolic symmetry.

They showed that the problem is indeed equivalent to a partial differential equation in a different geometry called the hyperbolic geometry and developed tools to analyse this problem. This work also led to interesting research in the analysis of partial differential equations in Hyperbolic space.

Another important direction of his research has been the analysis of differential equations coming from geometry especially from conformal geometry. The question of whether one

AWARDS

- INSA Medal for Young Scientist (2005)
- Young Associate of the Indian Academy of Sciences (2008)
- Birla Science Prize in Mathematics (2011)
- Shanti Swarup Bhatnagar Prize for Mathematical Sciences (2015)
- Fellow, Indian Academy of Sciences (2019) and Indian National Science Academy (2020)

PUBLICATIONS

- 'Adams inequality on the Hyperbolic space'. *J. Funct.Anal* (2016).
- 'Nondegeneracy of positive solutions of semilinear elliptic problems in the hyperbolic space'. *Commun. Contemp. Math* (2015).
- 'Moser-Trudinger Inequality on conformal discs'. *Communications in Contemporary Mathematics* (2010).
- 'Hardy-Sobolev extremals, hyperbolic symmetry and scalar curvature equations', *J. Differential Equations* (2009).

Clockwise: Receiving the Shanti Swarup Bhatnagar Prize 2015 from S&T Minister Dr Harsh Vardhan

Receiving the INSA medal for young scientist from Dr RA Mashelkar the then President of the Indian National Science Academy, 2005

After taking oath as a fellow of the Indian National Science Academy in December 2019

Along with Prime Minister Narendra Modi and the other SS Bhatnagar awardees in September 2016

With the Nobel Laureate Ei-ichi Negishi and the B.M. Birla Science prize winners in January 2013

Inset: Giving a talk at the annual meeting of the Indian Academy of Science in November 2019 at the University of Hyderabad

can deform a space conformally with a pre-assigned curvature leads to showing the existence of solutions to certain partial differential equations. This problem, in turn, leads to studying inequalities in these geometries. The focus is on studying the impact of geometry on these inequalities. Dr Sandeep has established many interesting results in this direction known as the Moser-Trudinger inequalities and Adams inequalities.

Dr Sandeep contributions have been appreciated by the scientific community. And, many of his contributions have already found their use in the study of various problems. His work on partial differential equations in the hyperbolic space is likely to play a crucial role in the study of partial differential equations of noncompact type on negatively curved manifolds. He has developed many inequalities in hyperbolic space and also in general spaces known as Hadamard manifolds. These inequalities are motivated by some of the partial differential equations arising in geometric problems. The existence of a solution to these problems in many of these contexts remains a challenge. The problems like prescribing some of the higher-order curvatures lead to partial differential equations of higher-order and new tools and ideas are needed to tackle these problems. The inequalities he has established serve as some of the basic objects in these directions and he hopes these can be developed further to answer these challenging problems.

Dr Sandeep's father, Mannil Radhakrishnan Nair, on a more personal note, is a radio mechanic and Kunnath Subhadra, his mother, a housewife. Having grown up in a village in Kerala he has a liking for football matches. Though like most Indians, he also loves to watch cricket matches. He likes to listen to Malayalam movie songs in his spare time.

Apart from his research he also believes that it is important to train the next generation of mathematicians. This includes the basic training at an undergraduate level, graduate level training and finally exposure to the cutting edge research happening around the world. For this purpose apart from the graduate programme of TIFR, he has been an active participant in various expository and training programmes for students from across the country like Mathematics Training and Talent search programme, workshops of academies and National Centre for Mathematics.•

DR SANDIP BASU

Leading the Way

Dr Sandip Basu is a Consultant Physician and Professor of Nuclear Medicine and the Head of Nuclear Medicine Academic Programme at the Radiation Medicine Centre (Bhabha Atomic Research Centre), Tata Memorial Hospital. He is also the Dean-Academic (Medical and Health-Sciences), BARC at the Homi Bhabha National Institute.

Dr Basu completed his MBBS from the RG Kar Medical College, Kolkata, in 1995, followed by an internship in 1996 and house-staffship in 1997. Subsequently, he specialized in nuclear medicine from the Radiation Medicine Centre, Mumbai, with a diploma in Radiation Medicine (DRM) and Diplomate of National Board (DNB) and joined as the faculty at the same centre.

Dr Basu is one of the pioneers of positron emission tomography (PET)-based molecular imaging in India and has substantially contributed to the establishment of PET-based diagnostics and targeted radionuclide therapy for the treatment of various cancers. His contribution in the field of medical research is evident in over 425 publications in high-impact factor peer-reviewed indexed international and national journals with a large number of citations, 25 textbook chapters, more than 140 national and international talks, editorial board memberships/guest editorships in 17 peer-reviewed journals and peer reviewership in more than 100 international and national journals. He has also served in various capacities for the IAEA nuclear medicine activities (including serving as an expert lecturer in IAEA Therapy Meeting and being its National Coordinator).

Adopting innovative strategies in Radionuclide Therapy is the hallmark of Dr Basu's work. In addition to routine FDG-PET-based cancer staging, Dr Basu has successfully explored innovative applications of PET in infection and inflammatory disorders like sarcoidosis, rheumatoid arthritis, tuberculosis, diabetic foot and non-malignant thoracic disorders; dual tracer (somatostatin receptor and FDG) imaging in neuroendocrine tumors; defining tumor biology, staging and early monitoring of therapy response, especially in gastrointestinal stromal tumors (GIST), lymphoma, Ewing sarcoma family of tumors, prostate carcinoma, brain tumor, breast cancer and bone marrow metastasis in cancer; exploring benign tumors; novel quantitative methods for imaging including image segmentation and using Metabolic Volumetric Product in PET for treatment response monitoring in cancer and other non-cancerous diseased conditions (rheumatoid arthritis, tuberculosis, sarcoidosis). In 2009, Dr Basu had put forth an innovative hypothesis on 'Personalized versus Evidence-Based Medicine with PET Based Imaging in *Nature Reviews on Clinical Oncology*' and pursued his clinical work, in this line, for neuroendocrine tumors and thyroid cancer and developed personalized models based on functional imaging. Based upon this hypothesis and work, PET Clinics of North America published a full issue with him as the guest editor, entitled, 'PET-Based Molecular Imaging in Evolving Personalized Management Design'.

> **"It should be your endeavour to take up challenging assignments as 'Karma-Yoga' of life."**

Dr Basu has worked extensively on the augmentation of various radionuclide therapy services at RMC. He has facilitated the application of indigenously produced new imaging and therapeutic radiopharmaceuticals for the diagnosis and treatment of cancer patients in the country. Apart from his routine diagnostic and therapeutic clinical services, his major focus has been on the clinical implementation of 177-Lutetium-based therapies for the treatment

AWARDS

- Shanti Swarup Bhatnagar Prize (2012)
- DAE Homi Bhabha Science and Technology Award (2017)
- DAE Scientific and Technical Excellence Award (2007)
- Homi Bhabha Memorial Oration, Society of Nuclear Medicine (2019)
- SNM USA Alavi-Mandell Award (2010)

PUBLICATIONS

- 'Personalized versus evidence-based medicine with PET-based imaging'. *Nature Reviews Clinical Oncology*. (2010).
- 'Comparison of triple-negative and estrogen receptor-positive/progesterone receptor-positive/HER2-negative breast carcinoma using quantitative fluorine-18 fluorodeoxyglucose/positron emission tomography imaging parameters: a potentially useful method for disease characterization'. *Cancer*. (2008).

Clockwise: Receiving the DAE Homi Bhabha Science and Technology Prize 2017

Receiving the DAE Group Achievement Award for clinical PRRT services, 2019

With his classmates, the outgoing batch of class X, 1988

Receiving the SSB Prize 2012 from Union Minister Dr Harsh Vardhan

With Prime Minister Narendra Modi and Dr Harsh Vardhan and other Shanti Swarup Bhatnagar Prize winners of 2016 (2nd row; 7th from left)

A standard set-up for ^{177}Lu-DOTATATE Peptide Receptor Radionuclide therapy at RMC

Inset: Delivering the Homi Bhabha Memorial Oration 2019 at the 51st Annual Meeting of the Society of Nuclear Medicine India

of metastatic and advanced neuroendocrine tumors (177Lu-DOTATATE therapy, PRRT); Metastatic Castrate Resistant Prostate Carcinoma (177Lu-PSMA therapy); and, painful skeletal metastasis (177Lu-EDTMP). Between 2010 and 2020, Dr Basu was instrumental in developing a large-volume clinical PRRT service at the centre with the joint efforts of RMC (BARC) and Tata Memorial Hospital (TMH) at the TMH-RMC premises, delivering over 4,000 [177Lu] Lu-DOTATATE therapies for patients with metastatic/advanced neuroendocrine neoplasms and related malignancies making this the largest PRRT setup in the country, an exemplar of successful PRRT programme employing indigenous 177Lutetium production at BARC and resources.

Since 2017, Dr Basu has steered the development of [68Ga]Ga-/[177Lu]Lu-PSMA-based theranostics and peptide receptor radioligand therapy (PRLT) in metastatic castration-resistant prostate carcinoma (mCRPC) patients in the centre. He has designed and developed personalized therapeutic strategies in metastatic and advanced neuroendocrine tumors combining histopathology and molecular imaging. His studies on detection and molecular characterization of cancer tissue heterogeneity amongst patients have led to personalized therapy delivered to these patients. Amongst patients of differentiated thyroid cancer, he has concentrated on the most challenging clinical segment, who harbour elevated serum thyroglobulin (Tg) level with negative radioiodine scintigraphy and where mortality and morbidity are high: he has systematized and developed a step-care clinical protocol that has aided in better understanding and more scientific management of these groups of patients. His other contributions in the domain of therapeutic nuclear medicine include fractionated 131I MIBG therapy regimen for neural crest tumors, defining important considerations while treating thyroid cancer patients with 131I (such as combined anticoagulant and 131I for tumor).

In the next ten years, Dr Basu intends to dedicate his time to 'Theranostics and the Newer and Novel targeted radionuclide therapies' (including developing the radioimmunotherapy services in lymphoma and breast carcinoma), and personalized therapeutic strategies in the malignancies where step-care clinical protocol has aided in better understanding and more scientific management of these groups of patients. He would endeavour to integrate the 'omics' data to functional molecular imaging of these tumors to this end. •

DR SANJEEV DAS

At Full Strength

Dr Sanjeev Das, a scientist at the National Institute of Immunology (NII), is a tinkerer by nature. He likes to learn and understand new things, enjoys problem-solving and gets fascinated by mechanistic details of phenomena. While, research work allows him to generate knowledge beneficial for the society, which he shares enthusiastically through his classes. He takes an introductory course on cancer biology for the new PhD students of the institute. He regularly gives lectures at various educational institutes in the country to inspire young minds towards a career in research.

Dr Sanjeev Das born in Nasirabad Cantt, a place near Ajmer in Rajasthan. His father, Wing Commander PK Das, was an officer with the Indian Air Force and his mother, Gopa Das, a college lecturer. A bright student from his school days, Sanjeev graduated in Chemistry Honours from Calcutta University. Subsequently, he did his postgraduation in biochemistry from Calcutta University. During the course of his education he came across many teachers who ignited the spark of scientific enquiry in his young mind.

Dr Das began his scientific journey as a doctoral student at the well-renowned Indian Institute of Science in Bangalore under the guidance of Prof. Kumaravel Somasundaram. Right from the beginning of his research career, he has been striving to understand the various aspects of cancer. He has carried out extensive studies to unravel the role of papilloma virus in cervical cancer in women. His work has led to the development of a potential therapeutic agent, which was found to promote cervical cancer regression. He then moved to the Harvard Medical School Boston for further training. There he started working on a critical cellular protein called tumor suppressor p53. The tumor suppressor p53 is one of the key players in blocking tumorigenesis and is critical for success of chemotherapy. It is a key molecule invoked by the chemotherapeutic drugs to kill cancer cells. Dr Das's work at the medical school led to an enhanced understanding of regulation of p53 in response to chemotherapeutic drugs. This seminal work was published in the prestigious peer-reviewed scientific journal *Cell*.

> **"Dream big and work hard to accomplish them. Also, have an adaptable approach to be able to face any adversity."**

Dr Das started his own research laboratory at the National Institute of Immunology, New Delhi, in 2008. There he expanded his research work to include diverse families of tumor suppressors including p53, sirtuins and caspases. Using mass spectrometry based approaches, they identified various proteins with which p53 interacts to initiate the chemotherapy response process. The work from Dr Das's laboratory was the first to demonstrate that tight regulation of p53 modifications is a key determinant of p53-mediated cell fate decisions.

New roles of p53 are immensely reshaping the multifarious facets of metabolism. Given the current understanding of tumor metabolism, there is an opportunity to generate a new class of anti-tumor drugs that target altered metabolism in cancer cells. The findings from Dr Das's laboratory help in identifying the therapeutic windows for targeting cancer cell metabolism due to the addiction of cancer cells to specific nutrients to support deregulated cell growth programmes enforced by cancer genes. Elucidating the pathways by which p53 coordinates metabolic adaptation could establish new therapeutic targets in cancers that express wild-type p53.

AWARDS

- Shanti Swarup Bhatnagar Prize (2017)
- Prof. Umakant Sinha Memorial Award (2017)
- Shakuntala Amir Chand Prize (2016)
- Prof. B. K. Bachhawat Memorial Young Scientist Lecture Award (2016)
- National Bioscience Award for Career Development (2015)

PUBLICATIONS

- 'Caspase-10 inhibits ATP-citrate lyase-mediated metabolic and epigenetic reprogramming to suppress tumorigenesis'. *Nature Communications*. (2019).
- 'SIRT6 deacetylates PKM2 to suppress its nuclear localization and oncogenic functions'. *ProcNatlAcadSci USA*. (2016).
- 'HDAC5, a key component in temporal regulation of p53-mediated transactivation in response to genotoxic stress'. *Molecular Cell* (2013).
- 'PGC-1, a key modulator of p53, promotes cell survival upon metabolic stress'. *Molecular Cell* (2011).
- 'Hzf modulates p53 transactivation'. *Cell* (2007).

Clockwise: Receiving the Shanti Swarup Bhatnagar Award from Prime Minister Narendra Modi

During his PhD days at IISc, Bangalore

Receiving the NASI-SCOPUS Young Scientist Award, 2015

from Dr Jitendra Singh, Minister of Science and Technology

With his parents and elder brother

At Harvard University, Boston

In his lab with his current batch of students at the National Institute of Immunology

Inset: With his PhD guide Prof. Kumaravel Somasundaram. His work has led to the development of a potential therapeutic agent, which was found to promote cervical cancer regression

The relative contribution of each of the many p53 metabolic target genes might differ according to cell type, stress signal and other circumstances, and it is quite likely that not all p53 targets will be equally important to the final response. However, increased understanding of the role of p53 in metabolism will provide a rich harvest of new therapeutic targets.

Research at Dr Das's laboratory at NII has also revealed the molecular mechanisms underlying the tumor suppressor functions of sirtuin family member SIRT6. His group has mapped the SIRT6 interactome and delineated the pathways by which SIRT6 blocks the expression of cancer promoting genes. Their studies have led to the elucidation of key role of SIRT6 in preventing hepatocellular carcinoma. Previous studies have demonstrated that SIRT6 plays critical roles in maintaining genomic stability and metabolic homeostasis, thereby impacting several pathways pertinent to cancer, metabolism and aging. Dr Das's work throws light on SIRT6 regulation and the crosstalk between SIRT6 and other metabolic regulators. His findings present for the first time an in-depth analysis of transcriptional regulation of metabolic processes and provide a robust platform for further studies to fully discover the activities of this important protein in mammalian pathophysiology. Since metabolic reprogramming is intrinsic to tumorigenesis, his work helps to understand how modulating SIRT6 activity could provide therapeutic benefits under conditions of metabolic imbalance observed in tumors.

The research work being carried out in Dr Das's laboratory using proteomics- and metabolomics-based approaches will aid in strengthening the concerted national research efforts towards a major killer disease. The expertise and research tools being developed in his lab can be utilized for multi-disciplinary collaborative projects to accelerate the pace of research as advanced analytical methods in metabolite profiling, as well as wide scale systems biology, mathematical modelling and networking based approaches would be necessary to integrate information from diverse areas of metabolism and cancer biology.

Besides being involved in research, he is a keen reader and an avid traveller. He also takes part in various sports activities and is a good swimmer and table tennis player. He is actively involved in administrative affairs of the institute. He is currently the warden of the students' hostel and is responsible for the well-being of the students. •

PROF. SANJIB KUMAR AGARWALLA

Unraveling the Mysteries of Neutrinos

An Associate Professor at Institute of Physics, Bhubaneswar, Prof. Sanjib Kumar Agarwalla's field of specialization is high energy particle physics. An internationally prominent and well-recognized expert in neutrino physics, he is a Swarnajayanti Fellow of the Department of Science & Technology (DST), Government of India, a SIMONS Associate of ICTP, and the sole winner of the prestigious BM Birla Science Prize in Physics, 2018. He is actively involved in training students, postdocs and promoting science outreach.

Sanjib was born and brought up in a small town called Plassey in the Nadia district of West Bengal. Plassey is known for the 'Battle of Plassey' fought in June 1757, between the private army of the British East India Company and the army of the king of Bengal, Nawab Siraj-ud-Daulah. His mother, Sabitri Debi, always motivated him to pursue higher studies. Sanjib's father, Buddhadeb Agarwalla, ensured the best higher education for him and encouraged Sanjib to make his own career choice.

After schooling, Sanjib moved to Kolkata for his college education. He did his BSc from the Scottish Church College and MSc from the University of Calcutta, Kolkata. During MSc, Prof. Amitava Raychaudhuri's (Sir Tarak Nath Palit Chair Professor at the Physics Department of the Rajabazar Science College, University of Calcutta) charismatic teaching and in-depth discussions in the class motivated him to pursue a research career in particle physics, a turning point in his life. Similarly, Professor Soumitra Sengupta at the Indian Association for the Cultivation of Science (IACS, Kolkata) from whom Sanjib took the quantum field theory course influenced him towards research. He completed his PhD under Prof. Raychaudhuri's guidance from the University of Calcutta.

Prof. Agarwalla's main emphasis is on exploring the fundamental properties of massive neutrinos, one of the exciting topics of research in modern particle physics. Neutrino physics has seen remarkable progress over the last two decades, propelled by the astonishing discoveries that neutrinos have mass and they change their flavor as they move in space and time. Prof. Agarwalla and his neutrino group at the Institute of Physics (IOP) have been pursuing an active research program to shed light on these fundamental issues in detail. Through their high-quality cutting-edge research, they have already been able to make an impact at the national and international level. The scope of their research work is global and it is in tune with the international research program in the field of neutrino physics.

Prof. Agarwalla has made several outstanding contributions in neutrino physics. He has studied the role of high-energy astrophysical neutrinos detected by the IceCube detector at the South Pole to unravel new fundamental particles and interactions, probing energy and distance scales far exceeding those accessible in the laboratory. He has contributed significantly in identifying novel methods to determine the neutrino mass ordering, mixing angles, and CP-violation in the lepton sector, all of which are pressing fundamental unsolved issues. He has been playing an important role in studying the impact of a light eV-scale sterile neutrino and non-standard neutrino interactions in

> **"Always dream big and work very hard to fulfil them no matter what the circumstances are."**

AWARDS

- Swarnajayanti Fellowship (2020)
- NS Satya Murthy Memorial Award (2020)
- BM Birla Science Award in Physics (2018)
- SIMONS Associate, The Abdus Salam International Centre for Theoretical Physics (2015)
- Medal for Young Scientists, Indian National Science Academy (2014)

PUBLICATIONS

- 'Universe's Worth of Electrons to Probe Long-Range Interactions of High-Energy Astrophysical Neutrinos'. *Physical Review Letters* (2019).
- 'Octant of θ_{23} in danger with a light sterile neutrino'. *Physical Review Letters* (2017).
- 'Degeneracy between θ_{23} octant and neutrino non-standard interactions at *DUNE'. Physics Letters B* (2016).
- 'Enhancing sensitivity to neutrino parameters at INO combining muon and hadron information'. *Journal of High Energy Physics* (2014).
- 'Resolving the octant of θ_{23} with T2K and NOνA'. *Journal of High Energy Physics* (2013).

Clockwise: Receiving the NASI-SCOPUS Young Scientist Award, 2016 from DST Secretary Prof. Ashutosh Sharma, Prof. Akhilesh K Tyagi, former President, National Academy of Sciences and Dr Youngsuk Chi, Chairman, Elsevier

Being felicitated by Prof. Amitava Raychaudhuri, Institute of Physics, Bhubaneswar

In his office at Institute of Physics, Bhubaneswar

Addressing the audience at the Institute

With professors Jnanadeva Maharana, Sudhakar Panda, Jogesh Chandra Pati and Sandip Pakvasa

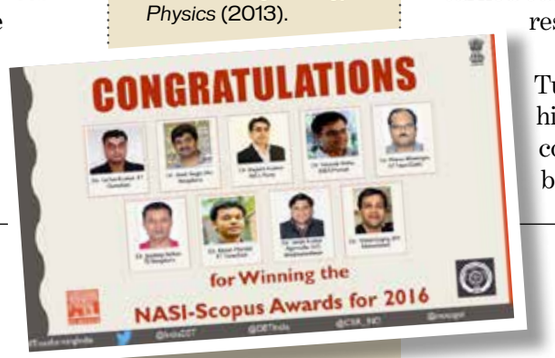
Inset: A tweet by Dr Harsh Vardhan celebrating the NASI-SCOPUS Young Scientist Awardees in Physics for the year 2016

oscillation experiments. Another facet of his activity has been on the indirect detection of dark matter, another fundamental puzzle of our Universe. Prof. Agarwalla is also actively involved in the India-based Neutrino Observatory (INO) project and spending a substantial amount of his research time on INO-related activities.

Over the last two decades, several world-class experiments have firmly established the phenomenon of neutrino flavor oscillation which implies that neutrinos have mass and they mix with each other. Since neutrinos are massless in the basic Standard Model (SM) of particle physics, we need to invoke physics beyond the Standard Model (BSM) to accommodate non-zero neutrino mass and mixing. Many models of BSM physics suggest the existence of new fundamental particles and interactions, new sources of CP-invariance violation, lepton number, and lepton flavor violations. Prof. Agarwalla has plans to probe these BSM scenarios at very high (TeV-PeV) energies (beyond the reach of modern colliders) by detecting astrophysical neutrinos from cosmic distances using giant neutrino telescopes, such as the IceCube detector at the South Pole, future IceCube-Gen2, and KM3NeT in the Mediterranean Sea. The group will also unravel these new physics models at low (MeV-GeV) energies using the accelerator and atmospheric neutrinos travelling terrestrial distances. Future high-precision accelerator long-baseline neutrino oscillation experiments, such as DUNE (Deep Underground Neutrino Experiment) in the USA and T2HK (Tokai to Hyper-Kamiokande) in Japan and atmospheric neutrino experiment at the upcoming India-based Neutrino Observatory (INO) facility are supposed to measure the neutrino oscillation parameters with precision around a few percent and therefore, these next-generation experiments may be sensitive to various sub-leading BSM effects which Prof. Agarwalla and his group will study in near future.

Exploring fundamental neutrino properties has become an ongoing enterprise in the intensity frontier of high energy particle physics, both experimentally and theoretically. Constructive efforts are being made on several fronts to probe their masses, mixings, interactions, Dirac vs Majorana nature, and so on. Neutrinos have always been full of surprises! Almost all of our previous assumptions made about neutrinos have turned out to be incorrect one way or another, making research in this field very exciting.

Prof. Agarwalla's wife, Deepali, and daughter, Tulsi, have been playing an important role in his successful research career through their constant support, daily encouragement, and boundless love, which are priceless. •



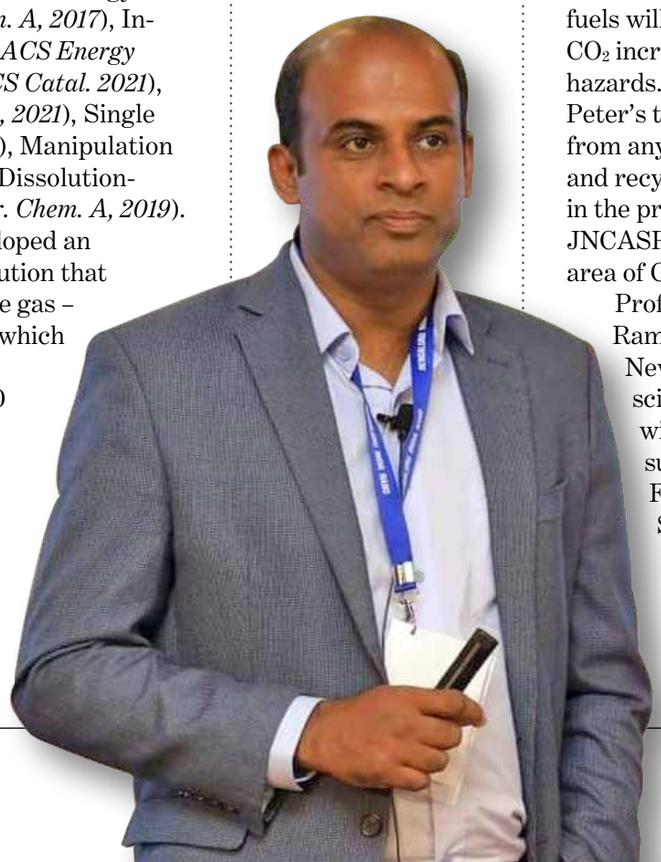
PROF. SEBASTIAN C PETER

A Catalyst for Positive Change

Prof. Sebastian C Peter, Associate Professor at Jawaharlal Nehru Centre for Advanced Scientific Research, has translated fundamental research in catalytic chemistry to recycle carbon into a technological solution to tackle the global grand-challenge of climate change and energy. Particularly noteworthy is his project on CO_2 Capture and Utilization (CCU), initiated with a small funding from DST nanomission in 2015-16. Within a span of 4-5 years, he developed a world-class facility at JNCASR for fundamental and translational research. Utilizing basic concepts of chemistry, he controlled the structural chemistry of materials to enhance their catalytic performance towards a selected reaction. His innovative strategies include Alloying (*J. Mater. Chem. A, 2017*), Inverse Strain Effect (*ACS Energy Lett., 2018*), Dealloying (*J. Mater. Chem. A, 2017*), In-situ Generation of Metastable Phase (*ACS Energy Lett., 2021*), Tuning Lattice Strain (*ACS Catal. 2021*), Structural Ordering (*J. Power Sources, 2021*), Single Atom Design (*J. Mater. Chem. A, 2021,*), Manipulation of Deficiency (*Chem. Mater. 2015*) and Dissolution-tuned Active Site Protection (*J. Mater. Chem. A, 2019*).

In the CCU technology, he has developed an economic, sustainable and scalable solution that reduces the most dominant greenhouse gas – CO_2 – into a useful product, methanol, which can be used as a fuel. The atmospheric CO_2 concentration increased from ~270 ppm in the pre-industrialization era to ~413 ppm in January 2020, leading to serious climate change issues and detrimental ocean acidification. As a result, various global initiatives like the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Climate Change Conference (COP21, Paris, 2015) have emphasized the urgency to mitigate CO_2 emissions by at least one-half of the current value by 2050 to deter the average global temperature increase to a maximum of 2°C. On the other hand, with increasing energy demand, the global consumption of energy per hour is predicted to reach 1.1 x 1021 J by 2050, which is 80% more than what can be derived from fossil fuel resources. No practical and economical solution for the CO_2 crisis being found, the use of fossil fuels will indirectly be constrained by the levels of CO_2 increase and the accompanying environmental hazards. In line with these visions and plans, Prof. Peter's team aims to capture carbon in the form of CO_2 from any source and eventually from the atmosphere and recycle it into new chemicals and fuels. He is in the process of establishing a dedicated centre at JNCASR for R&D and translational research in the area of CO_2 capture and reduction.

> **"The passion to take calculated risks with positive attitude is one of the major reasons for success."**



Prof. Sebastian C Peter joined JNCASR as a Ramanujan Fellow in November 2010 in the New Chemistry Unit and in the last decade, his scientific career has exponentially progressed with the immense support of DST. This includes substantial funding in the form Ramanujan Fellowship, fast track for young scientists, Swarnajayanti Fellowship, Core Research Grant, Nanomission and various special calls including Mission Innovation (IC3 and IC5) and HFC-2018. He has also received international funding such as DST-DAAD, DST-Poland, CEFIPRA and UKIERI.

Clockwise: At a Plenary Lecture during Bangalore Nano 2020

With Prof. Denis Kramer, an Associate Professor, at the University of Southampton, UK

During EXAFS measurements at Synchrotron facility in Elettra, Italy

With participants of the RAKCAM meeting in Ras-Al-Khaimah, UAE

With the NRG-COSIA Carbon XPRIZE competition finalists in New York in 2018

With Canadian Minister during XPRIZE finalist announcement

Inset: Receiving Dintinguished Alumni Award from his alma mater – St Thomas College, Thrissur, Kerala in 2018

AWARDS

- Swarnajayanti Fellowship (2018)
- National Award, DST (2021)
- Chemical Research Society of India Medal (2020)
- Materials Research Society of India Medal (2016)
- Emerging Young Investigator in Solid-state Chemistry, ACS (2014)
- Led Breathe Applied Sciences Pvt Ltd to the finals of NRG-COSIA Carbon XPRIZE Competition (2016)

PUBLICATIONS

- 'Operando Generated Ordered Heterogeneous Catalyst for the Selective Conversion of CO2 to Methanol'. *ACS Energy Lett.* (2021).
- 'Unveiling the Roles of Lattice Strain and Descriptor Species on Pt-Like Oxygen Reduction Activity in Pd-Bi Catalysts'. *ACS Catal.* (2021).
- '"Inverse Strain Effect in Atomic Scale" - Enhanced Hydrogen Evolution Activity and Durability in Cu substituted Palladseite'. *ACS Energy Lett.* (2018).

Apart from scientific research activities as a faculty at JNCASR, Dr Peter is also the Co-founder and Director of the start-up, Breathe Applied Sciences Pvt Lt, based in Bengaluru. The vision of the start-up is to convert anthropogenic CO_2 to useful chemicals and fuels by scaling up technology developed in the laboratory scale in JNCASR. It is rare to find an academic entrepreneur, especially in India, who can translate their successful laboratory work into the industry. Dr Peter has made a team of chemists, chemical engineers and physicists, who have successfully developed a new technology for the conversion of CO_2 to methanol and other chemicals. This facility will be capable of producing methanol from CO_2 with an estimated cost of 13-15 ₹/litre, which is much cheaper than the market price of ~30-35 ₹/litre of methanol.

Dr Peter led an only Indian team (Breathe) at NRG-COSIA XPRIZE, a global competition which has a 20 million USD prize, on waste CO_2 utilization and entered into its final round. Breathe has been selected as one of the best start-ups by Karnataka State Government through Elevate-100 in 2017 out of ~1800 contestants. Breathe was selected as best runner up in the category of 'Excellence in the field of Environmental Technology research' in CleanEquity Monaco, 2019. Finally, his team won the National Award from Technology Development Board, DST, in May 2021 for CO_2 to methanol technology development.

As an independent researcher, Dr Peter has published 180 publications with more than 100 papers as the corresponding author. During the course of this scientific development, he has trained several young researchers including 13 PhD students (5 completed), 25 postdoctoral, 27 R&D students, more than 50 summer students and 7 visiting faculty members from various universities.

PROF. SHANTHI PAVAN

Surging Ahead

When Prof. Shanthi Pavan's class IXth chemistry teacher gave him the task of explaining the manufacturing and properties of sulphuric acid to the entire class, the joy a successful lesson brought to him made him realize that he enjoyed teaching. Prof. Shanthi Pavan grew up in Bangalore, where his father, Gopala Rao, worked as an electronics engineer and his mother, Uma, was a homemaker.

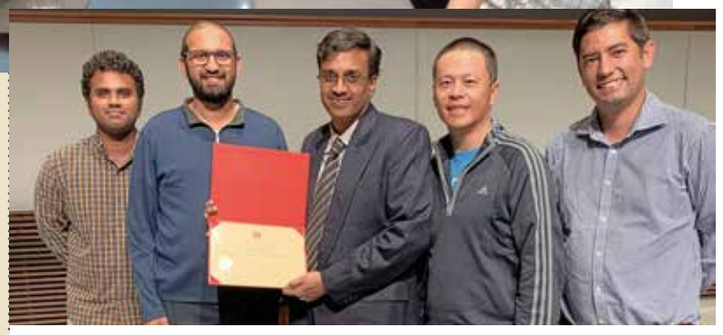
Prof. Shanthi Pavan, the NT Alexander Institute Chair Professor of Electrical Engineering at IIT-Madras, works in the area of analog and mixed-signal integrated circuit (VLSI) design. It was during his BTech at IIT-Madras that he was introduced to the area of analog electronics. In the early nineties, the analog area was not popular as everyone believed that the whole world was going digital (DSP chips were introduced in the mid-1980s). In fact, most American universities had rid their curricula of analog courses. Fortunately, IIT-Madras had outstanding faculty members in this area in the form of Prof. Anthony Reddy and Radhakrishna Rao, who ran a sequence of excellent analog courses. Shanthi was smitten, and could not but resist from going into this area. After the BTech, he went to Columbia University, New York, for his doctoral degree. There he worked with Prof. Yannis Tsividis, a pioneer in the area and a professor of worldwide repute. Meanwhile, in the late nineties, the mobile-telephony and internet boom began to take root, and analog electronics suddenly became immensely popular in demand.

Prof. Shanthi Pavan returned to his alma-mater in 2002 after a five-year stint in the VLSI industry in various companies in the US. The opportunity to be part of the IIT-Madras faculty was too good to forego. However, VLSI design needed expensive computing and CAD tools, as well as funds to fabricate chips and equipment for measuring them. Research funding was scarce. This changed soon and research funds became increasingly easily available from 2005 onwards. The thrust of the government to improve the prevailing talent pool in the VLSI area also helped matters. Slowly but surely, a group, under Prof. Pavan's tutelage, of analog mixed-signal IC design emerged and soon acquired a worldwide reputation for its quality of teaching and research.

> **"Chips don't lie - if you are sloppy, your silicon will not work."**

A major thrust in Prof. Shanthi Pavan's research has been the design of high-performance analog-to-digital converters or ADCs. A technique of realizing ADCs, called delta-sigma data conversion, has been the subject of much of Prof. Shanthi Pavan's research. Delta-sigma ADCs are the workhorse of modern mixed-signal electronics. They are used virtually everywhere, ranging from sensor front-end electronics to wireless transceivers. A smart phone is estimated to employ more than a dozen such ADCs to make sense of real world signals. Such signals, which are analog in nature, need to be converted into digital form, so that they can be stored and processed by a digital signal processor (DSP). Extending battery life of portable electronics is critical and is the driver for low power electronic components. Researchers are, therefore, always attempting to achieve better performance with a lower power dissipation. ADC design is thus not only an intellectual challenge, but also immensely relevant in practice.

One of Prof. Shanthi Pavan's important contributions is the book 'Understanding Delta-Sigma Data Converters' (2nd Edition, along with Richard Schreier and Gabor Temes). It is the 'standard' textbook in the area



Clockwise: With Prime Minister Narendra Modi, Minister for Science and Technology Dr Harsh Vardhan, CSIR Director General Dr.Girish Sahni and other awardees at the award ceremony for the Shanti Swarup Bhatnagar Prize

Being felicitated by Prof. Bram Nauta, President IEEE Solid-State Circuits Society after he was conferred the IEEE fellowship

With the Integrated Circuits and Systems group-members at IIT Madras

Being felicitated after delivering the speech at the Distinguished Lecturer Program for the IEEE Solid-State Circuits Society

Inset: Being awarded the IEEE fellowship by Prof.Yong Lian, President of the IEEE Circuits and Systems Society

AWARDS

- Wiley-IEEE Press Outstanding Professional Book Award (2020)
- IEEE Fellow (2018)
- Shanti Swarup Bhatnagar Award in Engineering Sciences (2012)
- Swarnajayanti Fellowship Award (2009)
- IEEE Circuits and Systems Society Darlington Best Paper Award (2009)

PUBLICATIONS

- 'Widely programmable high-frequency continuous-time filters in digital CMOS technology'. *IEEE Journal of Solid-State Circuits* (2000).
- 'Design Techniques for Wideband Single-Bit Continuous-Time Modulators With FIR Feedback DACs'. *IEEE Journal of Solid-State Circuits* (2012).
- 'Design Techniques for High-Resolution Continuous-Time Delta-Sigma Converters With Low In-Band Noise Spectral Density'. *IEEE Journal of Solid-State Circuits* (2020).

and is the go-to resource in academia and industry alike. The design innovations originating in papers published by Prof. Pavan's research groups have been adopted by many academic groups and semiconductor companies worldwide, and have been used in multiple industrial products. Prof. Pavan's current effort is to challenge ideas that have been in vogue for more than 35 years and to thereby improve the power efficiency and performance of systems ranging from 5G transceivers to sensor front ends.

During the process of chip design innovation, one conceives of an idea that improves performance in one or more dimensions (power dissipation, area, speed, or precision). Chip design is a long and expensive process, the feasiblity of the idea(s) is first checked by computer simulations using sophisticated CAD tools. This, however, is not enough. There are many a slip between the cup and the lip and scientists are all too familiar with seemingly great ideas falling flat in practice. The proof of the pudding is, therefore, in the eating – the efficacy of these innovative ideas has to be experimentally demonstrated before one is able to claim success of one's schemes.

IC fabrication yields a physical piece of silicon, which the researcher tests using state-of-the-art measurement equipment. If all goes well, the designer is able to unambiguously show that improvements in performance are due to design innovation. Other designers and researchers pick up these improvements and use them in their own works.

The success of a chip is particularly sweet, as the design-fabricate-test cycle can be as long as two years, and since there are way too many potential reasons that can derail the process. A working complex chip is a testament to the creativity, patience, meticulousness and industry of the designer, and is a source of immense joy and satisfaction beyond words. One can fool oneself (and others) by specious arguments and simulations, but it is impossible to get a physical piece of working silicon with flawed assumptions. As Prof. Pavan tells his students, 'Chips don't lie'.

One of Prof. Pavan's pet peeves is that the power of computers and programming has fundamentally altered people's mindset in the sense that errors are easy to fix. Similarly working with computers and software enables one to pass on programmes and code that are not thoroughly checked, since bad code can 'always be patched later'. This attitude, unfortunately, is a strict no-no in IC design, due to the long time taken for a design cycle. Sensitizing the students to this reality is a significant aspect of his work.

Prof. Shanthi Pavan likes to unwind by listening to classical music (Western and Indian) and travelling, apart from spending time with his family. •

DR SHEEBA VASU

A Clockwork World

Dr Sheeba Vasu grew up not far from the Indian Institute of Science Campus in Bengaluru and as a student, she recalls gazing at the leafy campus and the granite buildings in awe on her way to and back from school. She remembers her parents and extended family consisting of a large number of teachers, instilling the importance of gaining knowledge, at a very young age. Her parents did not miss any opportunity to make the connection between what is learnt in textbooks to applying it in the real world. She recalls being an avid reader who would voraciously read any piece of paper she could get her hands on, including the wrapper around packages from the grocery stores. Her father brought home many books – especially encyclopedias and magazines – that introduced her to various countries and cultures around the world and the flora and fauna that inhabited them. As a child she thought she would grow up to be a teacher. Her science teachers in high school Dr Balachandra and Mrs Ananthalakshmi were greatly responsible for sparking a desire to become a scientist.

She pursued her PhD studies at the Jawaharlal Nehru Centre for Advanced Scientific Research in Jakkur, Bengaluru, where a new department called the Animal Behaviour Unit had just been established. The intense conversations on diverse topics from science to philosophy and culture between the scientists, who had established their labs there, including Dr Amitabh Joshi and Dr Vijay Kumar Sharma under the leadership of Prof. MK Chandrashekaran proved to be a turning point in the life and scientific career of Dr Vasu. Her PhD research project set out to empirically test the idea of the adaptive significance of circadian rhythms a phenomenon that is exhibited by almost all living organisms – which show daily rhythms in behaviour and physiology.

> **“Be open to new ideas while having a strong foundation in the basics. Foresight and patience is the key.”**

While it is common knowledge that life-forms are strongly influenced by daily changes in environmental factors, such as light intensity, temperature and humidity, it is also now known that several daily rhythms at the molecular, cellular, physiological and behavioral levels are driven by endogenous timekeepers or ‘circadian clocks’. These clocks have the ability to measure the passage of time and keep local time and thus enabling organisms to time cellular process, physiology and behaviour to occur at the most appropriate time of the day. Dr Vasu’s earliest research examined populations of fruitflies that had been maintained in the absence of daily time cues for over 600 generations to find out whether their circadian clocks had been in any way compromised due to the lack of time cues in their

AWARDS

- Charles E Culpeper Foundation Grant for Biomedical Pilot Initiative (2003)
- Ramanujan Fellowship (2009)

PUBLICATIONS

- 'Large ventral lateral neurons modulate arousal and sleep in Drosophila'. *Current Biology* (2008).
- 'Pigment dispersing factor-dependent and -independent circadian locomotor behavioral rhythms'. *Journal of Neuroscience* (2008).
- 'Significance of activity peaks in fruit flies, Drosophila melanogaster, under seminatural conditions'. *Proc Natl Acad Sci USA* (2013).
- 'Wakefulness is promoted during day time by PDFR signalling to dopaminergic neurons in *Drosophila melanogaster*'.*eNeuro* (2018).
- 'Gap junction protein Innexin2 modulates the period of free-running rhythms in *Drosophila melanogaster*'. *iScience* (2021).

Clockwise: At the desk in Neuroscience Unit, JNCASR

Discussion with lab members at JNCASR

Interacting with college students as part of outreach programme

Experimenting with fruit flies, which serve as model organisms for her research

With the research team at JNCASR

With distinguished scientists at the 5th World Congress for Chronobiology, Suzhou

Delivering a lecture at the Serge Daan Memorial Symposium, 2019

Inset: Postdoctoral research presented at the Society for Neuroscience 2005

recent evolutionary history. Since she found that these animals continued to possess robust clocks, she concluded that such rhythms may confer an intrinsic adaptive advantage, that is, they probably enable flies to co-ordinate internal processes such as various physiological, biochemical and biophysical pathways to be properly in-sync with each other and thus being beneficial to the organism, in general.

Subsequently, her postdoctoral research was carried out under Prof. Todd Holmes in New York University and UC Irvine where she turned her attention to a very different aspect of circadian rhythms, namely the neuronal circuitry that generates and modulates rhythmic locomotor activity of the fly. Her studies characterized some important aspects of this circuitry, including electrophysiological features of the small and large ventral lateral neurons which are key components of the circadian pacemaker circuit.

Upon her return to India and by establishing her own research group at JNCASR she started to examine other closely related and sympatric Drosophilid species in terms of both circadian rhythms in behaviour and also the underlying neuronal circuit architecture. Her research team has been exploring other aspects such as the neuronal pathways via which cyclic temperature cues are perceived by the circadian clock. Her group has also been trying to unravel the anatomical connections and the physiological interactions between the circadian pacemaker neurons and the non-clock sleep centres in the brain. She has been using this neuronal circuit to model human neurodegenerative conditions by expressing mutated forms of human proteins known to cause neurodegeneration. Recently, her laboratory has identified the role of electrical synapse or gap junction forming proteins in the fly pacemaker circuit. •

S

PROF. SHIRAZ MINWALLA
PROF. SK SATHEESH
DR SOUVIK MAITI
PROF. SUBI J GEORGE
DR SUBIMAL GHOSH
DR SUHRIT GHOSH
PROF. SUMAN CHAKRABORTY
PROF. SUNIL KUMAR SINGH
PROF. SURAJIT DHARA
DR SUVENDRA NATH BHATTACHARYYA

PROF. SHIRAZ MINWALLA

Knowledge is Its Own Reward

Prof. Shiraz Minwalla feels that the knowledge obtained out of research is its own reward. He takes satisfaction in feeling that he is contributing to the most audacious adventure yet embarked upon by human beings – the quest to discover all of natural laws and to come one step nearer to answering some of the questions that have always posed themselves to human beings: *How did it all begin? What is everything made of? How will it all end?*

Shiraz's journey started in Bombay where his father, Naval Gustad Minwalla, was a businessman, his mother, Khadija Naval Minwalla, a housewife who also helped with the family business. After passing his ICSE examination from Campion School, Shiraz went to study science at St. Xavier's College. Shiraz moved to IIT Kanpur, where he enrolled in a 5-year integrated MSc course in Physics. In 1995 Shiraz graduated from IIT Kanpur with the President's Gold Medal, and then moved to Princeton University where he enrolled for a doctoral programme in theoretical physics. At Princeton, Shiraz worked under the supervision of Prof. Nathan Seiberg, graduating with a Phd degree in 2000. Prof. Minwalla then moved to Harvard University, where he was elected a Junior Fellow of the Harvard Society of Fellows. In 2001, Prof. Minwalla was appointed Assistant Professor at the Department of Physics at Harvard. Prof. Andrew Strominger was his principal mentor there. In 2004, he accepted an appointment as a Reader at the Tata Institute of Fundamental Research (TIFR), Mumbai. Over the next two years, he split his time between Harvard University and TIFR, and then moved permanently to TIFR in 2006 as an Associate Professor and continues to work there till today. Prof. Spenta Wadia was his principal mentor during the early years at TIFR. He became a Professor in 2009 and a Senior Professor in 2017.

> **"Immerse yourself in what you really want to do. Work for pleasure and satisfaction rather than striving for recognition and success."**

Over his research career spanning a period of over 24 years, Prof. Minwalla has made several key contributions to the study of quantum field theory, gravity and their inter relationship via the AdS/CFT correspondence of string theory.

Prof. Minwalla is best known for uncovering a deep connection between the equations of fluid dynamics and Einstein equations of general relativity, the so-called fluid gravity correspondence. Together with his collaborators, Prof. Minwalla has established that the Einstein's equations with a negative cosmological constant reduce the relativistic Navier-Stokes equations of hydrodynamics in a particular long wavelength sector. This discovery unifies two of the best-studied nonlinear partial differential equations in physics. In practical terms, it has led to the discovery of new terms in the equations of charged relativistic hydrodynamics, the so-called chiral vorticity and chiral magnetic terms that could possibly be observed in the quark gluon plasma produced at LHC.

His more recent and continuing studies of non-supersymmetric 3d Chern Simons gauge theories coupled to matter in the fundamental representation at large N has led to the discovery of new

Clockwise: Being felicitated with the Shanti Swarup Bhatnagar Award by the then Prime Minister Manmohan Singh

Delivering a lecture on string theory at TIFR

After receiving the ICTP Prize at ICTP Trieste

Delivering a talk on black holes in IISER, Pune

During a lecture at ICTS, Bengaluru. Prof. Minwalla is best known for uncovering a deep connection between the equations of fluid dynamics and Einstein equations of general relativity, the so-called fluid gravity correspondence

Inset: Delivering a lecture at the Indian Institute of Mathematical Sciences in Chennai

AWARDS

- New Horizons in Physics Prize (2013)
- Infosys Prize in the Physical Sciences (2013)
- TWAS Award, The World Academy of Science (2016)
- Shanti Swarup Bhatnagar Award (2011)
- Inaugural Nishina Asia Award (2013)

PUBLICATIONS

- 'Nonlinear Fluid Dynamics from gravity'. *JHEP 02* (2008).
- 'An Index for 4 dimensional super conformal theories'. *Commun. Math. Phys* (2007).
- 'Chern-Simons Theory with Vector Fermion Matter'. *Eur. Phys. J. C* (2012).
- 'The Hagedorn/deconfinement phase transition in weakly coupled large N gauge theories'. *Advances in Theoretical and Mathematical Phys*. (2004).
- 'Classifying and constraining local four photon and four graviton S-matrices'. *JHEP, 02* (2020).

nonsupersymmetric strong weak coupling dualities in 3 dimensions, with surprising applications in condensed matter physics. His recent studies of gravity at large D provide a new angle on black hole dynamics, giving a precise context and derivation for the long suspected connection between black hole and membrane dynamics. His detailed studies of superconformal representation theory and, especially, his invention of the superconformal index, have had a deep and continuing impact on the study of the dynamics of superconformal field theories.

The work on the thermodynamics of large N gauge theories has provided new insights into the deconfinement transition and the connection thereof to black hole dynamics. His studies of non-commutative field theories have been very influential. And his early analysis of three point functions in ${\cal N}=4$ Yang Mills theory supplied among the earliest nontrivial bits of evidence for the famous AdS/CFT correspondence of string theory. Most recently, Prof. Minwalla and collaborators have noted a surprising rigidity in the structure of tree level S gravitational S matrices, and have conjectured it will be possible to classify all consistent gravitational S matrices from general low energy consistency conditions. If this suggestion proves to be correct, it could lead to a proof that tree level string theory is the only possible classical extension of Einstein gravity.

Prof. Minwalla's work has had significant impact. According to the Spires database, as of September 2021, his 73 published papers had been cited on over 10,400 occasions, at an average of over 140 citations per paper. Forty-five of his papers had been cited over 50 times, and 31 of these have been cited over a hundred times; 5 of these, in turn, have received over 500 citations.

Over the years, Prof. Minwalla has given over 120 invited presentations at international conferences, including 11 plenary and one special session talk at the prestigious annual Strings conferences. He has also presented over 30 separate lecture courses at summer and winter schools around the world. Sixteen students have received their Phds under his supervision; seven of them currently hold faculty positions in prestigious universities and institutes in India, the US and Europe. Prof. Minwalla's work has been recognized through several major awards and fellowships.

Over the forseeable future, Prof. Minwalla sees himself continuing to grapple with the mysteries of quantum gravity and quantum field theory from as many different angles as possible. •

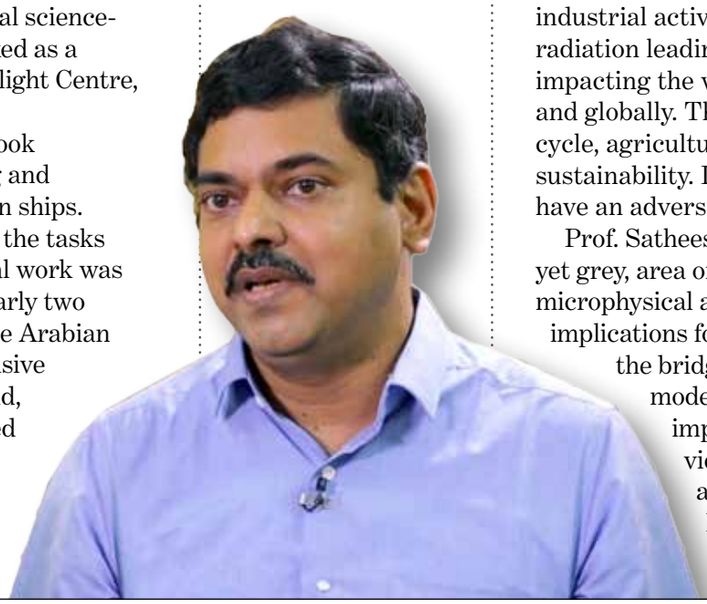
PROF. SK SATHEESH

A Multifaceted Personality

It is noteworthy that Prof. SK Satheesh realized his passion for atmospheric science really early on. Born in Perumkadavila, a remote village in Thiruvananthapuram, Kerala, Satheesh after his schooling graduated in physics in 1990. In 1990-92, he moved to the Kariavattom campus of Kerala University for his master's in physics, with a specialization in applied electronics. After his master's, Satheesh joined the Space Physics Laboratory, Vikram Sarabhai Space Centre, ISRO, for his doctoral work. He received a PhD degree in 1997 from the University of Kerala. He, then, moved to the Scripps Institution of Oceanography, University of California, as postdoctoral research physicist. In 2000, he joined the Indian Institute of Science (IISc), Bengaluru, as a faculty member and continues to work there as a Professor in the Centre for Atmospheric and Oceanic Sciences; Chair, Divecha Centre for Climate Change; and Dean (Planning & Infrastructure) of IISc. He is also the Chief Editor of *Current Science* journal and the Executive Director of 'Future Earth' South Asia, an international science-cum-policy programme. He has also worked as a Senior Fellow at NASA Goddard Space Flight Centre, US, for a year on sabbatical.

During his PhD days, Satheesh undertook observational programmes in challenging and remote oceanic regions and islands and on ships. Despite logistical constraints, he handled the tasks almost single-handedly. While his doctoral work was mostly based on the data collected for nearly two years from Minicoy, a remote island, in the Arabian Sea, his postdoctoral work involved extensive data collection from another remote island, Kaashidhoo, in the Maldives. He developed newer models of atmospheric aerosols using this data and quantified the impact of the interaction with the solar radiation with implications to regional and global climate. The hypothesis was fortified in the later years while working at the IISc, with carefully executed field campaigns aboard instrumented mobile platforms, instrumented aircrafts, research ships and balloons.

> **"Hard and focused work, sincerity to the conscience, dedication and, above all, clear and logic-supported independent thinking go a long way."**



Gradually, his research shaped into addressing the impact of light-absorbing atmospheric aerosols, such as black carbon on the radiation balance of the earth-atmosphere system and consequent impact on regional climate including monsoon. These aerosol particles, mainly produced from fossil fuel and biomass burning, vehicular emissions and industrial activities, strongly absorb incoming solar radiation leading to warming of the atmosphere and impacting the weather and climate locally, regionally and globally. This also has implications for water cycle, agriculture, and crop yield and, therefore, on sustainability. In addition, these submicron particles have an adverse impact on human health.

Prof. Satheesh has been focusing on the challenging, yet grey, area of influence of atmospheric aerosols on microphysical and radiative properties of clouds and implications for monsoon rainfall. His efforts aim at the bridging the current gap in cloud system modelling over Indian region through improved parameterization. With a view to get better insight into complex aerosol-cloud-monsoon interactions, Prof. Satheesh has formulated several national and international

AWARDS

- Shanti Swarup Bhatnagar Prize (2009)
- TWAS Prize, The World Academy of Sciences (2011)
- Devendra Lal Memorial Medal (2017)
- INFOSYS Prize (2018)
- Gujar Mal Modi Innovative Science and Technology Award (2019)

PUBLICATIONS

- 'Large Difference in Tropical Aerosol Forcing at the Top of the Atmosphere and Earth's Surface'. *Nature*. (2000).
- 'Climate Implications of large warming by elevated aerosols over India'. *Geophys. Res. Lett.* (2008).
- 'New Directions: Elevated layers of anthropogenic aerosols aggravate stratospheric ozone loss?' *Atmospheric Environment*. (2013).
- 'Decreasing Trend in Black Carbon Aerosols Over the Indian Region'. *Goephys. Res. Lett.* (2019).

Clockwise: Receiving the Devendra Lal Memorial Medal from Prof. Eric Davidson, President of the American Geophysical Union

Receiving the Shanti Swarup Bhatnagar Prize 2009 from Dr Manmohan Singh, Prime Minister of India

During a campaign organised by the National Remote Sensing Centre in 2006

With Prof. Abhijit Banerjee and Jury Chairs of Infosys Prize in 2018

With former President of India Dr APJ Abdul Kalam at the Rashtrapati Bhavan

Being felicitated for the Gujar Mal Modi Innovative Science & Technology Award 2019 by Vice President of India M Venkaiah Naidu

Inset: Working in his laboratory at IISc, Bengaluru

field experiments jointly with domain experts. The Integrated Campaign for Aerosols gases and Radiation Budget (ICARB) campaigns have been the biggest and most extensive such efforts in India. These were followed with a joint Indo-US field experiment (Ganges Valley Aerosol Experiment, GVAX) as the Indian Principle Investigator and, more recently, the joint Indo-UK project as part of 'Drivers of Variability in the Indian Monsoon' programme of MoES (India)–NERC (UK).

The immediate future direction of Prof. Satheesh's research activity focuses on an emerging domain, that is, Free Space Optical (FSO) communication, a technology to provide very large bandwidths for large volume data transfer. Prof. Satheesh's research has quantified the links between aerosol loading and pulse broadening leading to adjacency effects or inter-signal interference. Through a synergy of experimental observation and analytical treatment, Prof. Satheesh has worked out the link budget for near infrared links, estimated the effects of attenuation and the beam wander and provided the optimum scenario to reduce the deleterious effects and reduction in the number of adaptive optics units.

A multifaceted personality, Prof Satheesh is an active scientist, an earnest teacher, a researcher, a social scientist trying to link the scientific knowledge to societal benefit and, above all, an able administrator. He is an excellent mentor and has contributed extensively to scientific capacity building in the country. Several students have completed their PhD under his supervision and are currently faculty members in institutions in India and abroad. •

DR SOUVIK MAITI

On Point

Research from Dr Souvik Maiti's group has made significant contributions in the biophysical analysis of DNA and RNA structures. The anti-cancer potential of four-stranded quadruplex structures in DNA arises in part from the formation of DNA quadruplexes at telomere ends, as well as in the promoter region of several oncogenes like c-myc and c-kit. His group has demonstrated that these structures are in competition with normal Watson-Crick B-type DNA and need to be considered in the specialized design of anti-cancer therapeutics. Using a combination of structural biology, computational biology and chemical biology approach his group has provided a novel structural framework for understanding quadruplexes as therapeutic targets. His group has also developed a series of oligopeptides from a novel furan amino acid in collaboration with Prof. Tushar K Chakraborty to target such structures selectively and their comparative analysis of the binding data of these ligands with G-quadruplex and double-strand DNA shows that 24-membered cyclic peptides can be used as a scaffold to target quadruplex structures at the genomic level. His group has demonstrated that quadruplexes may have a greater role at the RNA level as usually, it is free of competition with normal Watson Crick duplexes.

Dr Maiti's interest in RNA structure and gene regulation has led to contributions in the targeting of microRNA. His group has developed molecular tools and pharmacological agents to target these small, medically important, regulatory RNAs. The group has shown that aminoglycosides can act as scaffolds for designing anti-cancer agents that target oncogenic microRNAs. They have invented antagomiRzyme – a hybrid anti-sense molecule that combines the stability of locked nucleic acid and catalytic activity of ribozymes to target microRNA. His group has also developed several small molecules against microRNA. They have demonstrated the use of modified oligonucleotides known as locked nucleic acids to trap such higher-order DNA structures, which can inhibit the activity of the proteins expressed selectively in cancer cells. Research from his group has also contributed significantly towards understanding the biophysical aspect of locked nucleic acids, promising modified oligonucleotides.

"Thorough knowledge, consistent hard work and an open-minded approach will help you succeed."

The group has also started exploring CRISPR-Cas9 based genome editing from a chemical biology perspective. The group is involved in developing this technology to correct sickle cell disease-causing mutation with high specificity. A team lead by Dr Maiti and Dr Debojyoti Chakraborty, a scientist at the Institute of Genomics and Integrative Biology (CSIR-IGIB), has characterized a naturally occurring Cas9 from *Francisellanovicida* (FnCas9) that shows negligible binding affinity to off-targets and showed its potential in therapeutic genome editing by correcting the sickle cell disease mutation in patient-derived induced pluripotent stem cells. They have also demonstrated that a structure and chemical modification based rational design of sgRNAs can enhance the efficiency of Cas9 cleavage in vivo.

In collaboration with his colleague, Dr Debojyoti Chakraborty, his group has developed a technology using a bacterial CRISPR CasRibonucleoprotein complex for detecting single nucleotide variants in RNA or DNA or more broadly, any DNA or

Clockwise: In his office at the Proteomics and Structural Biology Unit of the Institute of Genomics and Integrative Biology, CSIR

With the students from NIT-Nagaland at a training session under the Twinning R&D programme for the North East Region funded by Department of Biotechnology, Government of India

In his laboratory

With his colleague cum collaborator Dr Debojyoti Chakraborty and students, who developed FELUDA (2020)

With the participants of a workshop on genome editing at the CSIR-Institute of Genomics and Integrative Biology organized by Dr Souvik Maiti's group

Inset: With Dr Debojyoti Chakraborty in his office in 2018

AWARDS

- Swarnajayanti Fellowship (2009)
- NASI-SCOPUS Young Scientist Award (2010)
- Shanti Swarup Bhatnagar Prize (2014)
- DBT Bioscience Award (2015)
- DBT-TATA Innovation Fellowship (2021)

PUBLICATIONS

- 'Rapid and accurate nucleobase detection using FnCas9 and its application in COVID-19 diagnosis'. *Biosens Bioelectron* (2021).
- 'Rapid identification and tracking of SARS-CoV-2 variants of concern'. *Lancet* (2021).
- 'Francisella novicida Cas9 interrogates genomic DNA with very high specificity and can be used for mammalian genome editing'. *Proc Natl Acad Sci USA* (2019).
- 'A G-quadruplex motif at the 3' end of sgRNAs improves CRISPR-Cas9 based genome editing efficiency'. *Chem Commun* (Camb) (2018).
- 'CRISPR/Cas9: a historical and chemical biology perspective of targeted genome engineering'. *Chem Soc Rev*. (2016).

RNA fragment, without the need for sequencing, known as FELUDA. The most important advantage of this invention as a detection tool over the closest prior art is the combination of speed, reliability, robustness and universal applicability for all DNA and RNA variations. Meanwhile, technology for detecting COVID-19 has been transferred to TATA Medical and Diagnostics for commercial production of test kits and TATA Medical and Diagnostics has obtained ICMR and DCGI approval for commercialization and launched the product in Indian and international markets.

In the first 15 years as an independent scientist, Dr Maiti had focused on fundamental aspects of nucleic acid structure and function. However, a turning point was a growing urge within him to address a problem of societal relevance. Getting funding for the Sickle Cell Anemia research mission and finding a collaborator in Dr Debojyoti Chakraborty was pivotal.

Dr Maiti plans to take Genome Editing Technologies for correction of Sickle Cell Anaemia and other similar genetic diseases up to clinical studies, completing in-depth pre-clinical studies, in collaboration with Dr Debojyoti Chakraborty.

Dr Maiti was born in the Medinipur district of West Bengal. His father Dr Sukumar Maiti was a school teacher in Bengali literature and an active researcher, from where he gets his motivation from. His mother, Gita Maiti, was a school teacher. After schooling in his native village, Souvik joined Jadavpur University for a bachelor's and a master's degree in chemistry and was awarded the national scholarship for his higher studies by West Bengal government. He pursued a PhD in polymer chemistry under Dr Prabha R Chatterji from the Indian Institute of Chemical Technology, Hyderabad, India and then he carried out postdoctoral research on biophysical aspects of DNA secondary structures in Professor Luis A Marky's laboratory at UNMC, USA. He has also worked as a post-doctoral fellow on designing and developing DNA based nano-materials in Professor Francis Rondelez's laboratory, Physics Department, Curie University, France. He is currently a research faculty in the Proteomics and Structural Biology Unit of the Institute of Genomics and Integrative Biology, CSIR.

While Dr Maiti is excited about understanding the complexity of biology from the viewpoint of chemistry, he enjoys spending time with his large network of friends, students and colleagues. He particularly enjoys finding opportunities and alerting people that match well with their aspirations who may not be aware of them. •

PROF. SUBI J GEORGE

Implementing Solutions

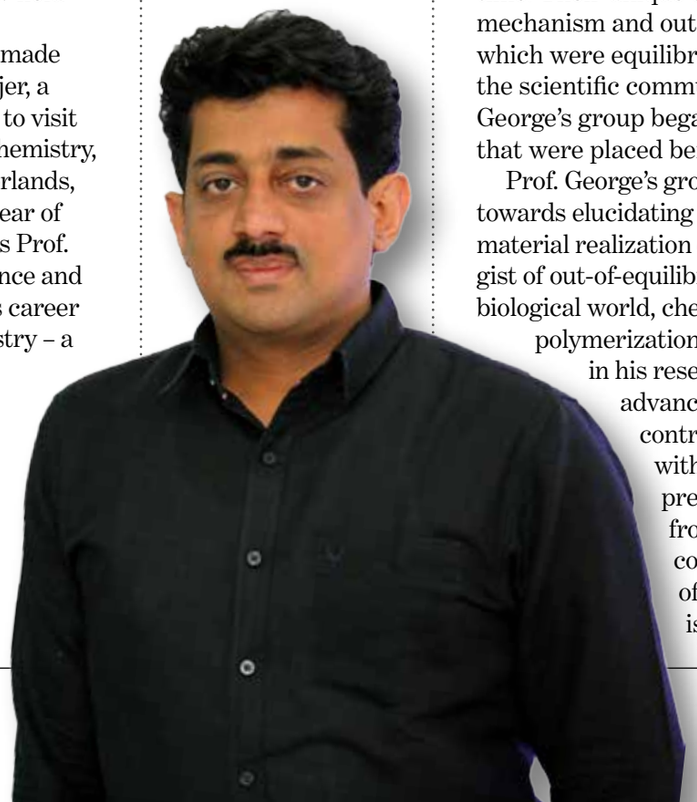
Prof. Subi J George, was born to George Jacob, an agriculturalist and Lovely George, a housewife, in a quaint village in Kochi, Kerala, popularly known as God's own country. After completing his schooling from a Malayalam-medium school, Subi pursued graduation in chemistry and a master's in organic chemistry.

At the start of his PhD studies, within a span of six months, he chanced upon a serendipitous observation where one of the new molecules synthesized by him formed a jelly material in an organic solvent, while this was left over the weekend for crystallization. It was later identified as organogles, due to the extended organization of molecules through weak non-covalent interaction to form fibrous network, which trap the solvents. The discovery was, subsequently, published as a communication in the *Journal of the American Chemical Society* (JACS), which incidentally was his first paper. The findings opened up a whole new field known as pi-electronic gels.

Due to the striking impact of the observation made by Prof. George, he was invited by Prof. EW Meijer, a pioneer in the field of supramolecular polymers, to visit the laboratory of macromolecular and organic chemistry, Technology University of Eindhoven, The Netherlands, for a period of three months during his second year of PhD (2002). Working with a scientific stalwart as Prof. Meijer made him change his perspective on science and its intricacies, after which he set out to carve his career in the fascinating field of supramolecular chemistry – a chemistry beyond molecules.

Prof. George's group has been working on supramolecular chemistry, a branch of chemistry, which deals with chemistry beyond the molecules, as coined by its father JM Lehn, and with ensembles of molecules associated with weak intermolecular interactions like most of the biological assemblies such as proteins and nucleosides, a class of biomaterials.

"Determination and hard work definitely pay off, sooner or later."



Prof. George's initial attempt in this field was to understand the mechanism of supramolecular polymers, this being the focus of the field, at the time. Their unique contributions to predicting the mechanism and outcome of supramolecular polymers, which were equilibrium-driven were appreciated by the scientific community worldwide. And thus, Prof. George's group began working on these new challenges that were placed before them.

Prof. George's group has made significant inroads towards elucidating the synthetic strategies towards a material realization of these concepts. Extracting the gist of out-of-equilibrium, fuel-driven networks from the biological world, chemical fuel-driven supramolecular polymerization strategies have been pioneered in his research laboratory, fundamentally advancing the frontiers of constructing controllable and adaptive materials with mono-disperse structure and predictive sequence. This control pans from growth kinetics to dimensional control on the one end, to lifetime of materials on the other. Thus, he is involved in the study of life-like

AWARDS

- Shanti Swarup Bhatnagar Award (2020)
- Fellow, Indian Academy of Sciences, Bangalore (2019)
- Swarnajayanti Fellowship (2017)
- NASI-SCOPUS Young Scientist Award (2015)

PUBLICATIONS

- 'Self-Sorted, Random, and Block Supramolecular Copolymers via Sequence Controlled, Multicomponent Self-Assembly'. *J. Am. Chem. Soc.* (2020).
- 'Chemical fuel-driven living and transient supramolecular polymerization'. *Nature Communications* (2019).
- 'Biomimetic temporal self-assembly via fuel-driven controlled supramolecular polymerization'. *Nature Communications* (2018).
- 'Adenosine-Phosphate-Fueled, Temporally Programmed Supramolecular Polymers with Multiple Transient States'. *J. Am. Chem. Soc.* (2017).
- 'Transient Helicity: Fuel-Driven Temporal Control over Conformational Switching in a Supramolecular Polymer'. *Angew. Chem. Int. Ed.* (2017).

Clockwise: With Nobel Laureate Prof. Ben Feringa and Bharat Ratna Prof. CNR Rao in 2019

With Prof. Frank Wurthner in 2004

Receiving the NASI-SCOPUS Young Scientist Award in 2015

Being felicitated for his contribution to chemistry during 2015. Prof. George's work constitute a significant breakthrough and advance in the basic research of dynamic supramolecular polymers

With Prof. EW Meijer (post-doc mentor and pioneer in supramolecular polymers), and Prof. AA Ajayaghosh (PhD supervisor) and Prof. Roeland Nolte (renowned supramolecular chemist)

Inset: With Prof. Takuzo Aida, a pioneer in supramolecular polymers, University of Tokyo, Japan

synthetic materials by synthesizing materials away from equilibrium and is credited with the creation of a new category of self-assembled materials called as transient materials, which can have potential applications in sensing, security and drug delivery. Such a temporally controlled living and transient self-assembly approach is not only a conceptual synonym to a much bigger and complex biological relative, but also provides primed precursors of complex active materials in the years to come. This highly competitive and active area of research has witnessed seminal works from leading groups around the world. However, their applied strategies remain specific to systems and inherent molecular structures as the entailing characteristics such as mechanism, energetic parameters, and monomer exchange dynamics are significantly diverse among various classes of supramolecular polymers. In this context, the chemical fuel-driven approach introduced by his group provides a general strategy applicable to a wide domain of monomers and materials. Prof. George's approach is reminiscent of well-known reversible-deactivation radical polymerization methods (also known as living radical polymerization) in the field of polymer chemistry for the controlled synthesis of covalent polymers with precise degree of polymerization, dispersity and sequence. Hence Prof. George's contributions constitute a significant breakthrough and advance in the basic research of dynamic supramolecular polymers.

Prof George's group is working on a new class of fascinating materials called supramolecular polymers. It is well know that, the high stability of polymers leads to an increasing sustainability issue in the form of accumulating plastic waste in the environment. In this context supramolecular polymers offers a viable alternative option as a completely recyclable, re-processable, and self-repairable plastics.

Prof. George acknowledges Prof. CNR Rao for his direction and guidance. He feels, his dream chemistry would be to create life-like materials such as the creation of protocells with synthetic chemical reaction networks and supramolecular polymeric network and responders. He also feels that supramolecular polymers has already grown into a very important branch of chemistry and he envisage that in the next three decades, supramolecular polymers will be in applications in the form of 'recyclable plastics'.

When not spending time with his group, Prof. George can be found watching a game of sport or a film, his passions. He also enjoys a bit of reading, cooking and spending time with his family during his spare time. •

DR SUBIMAL GHOSH

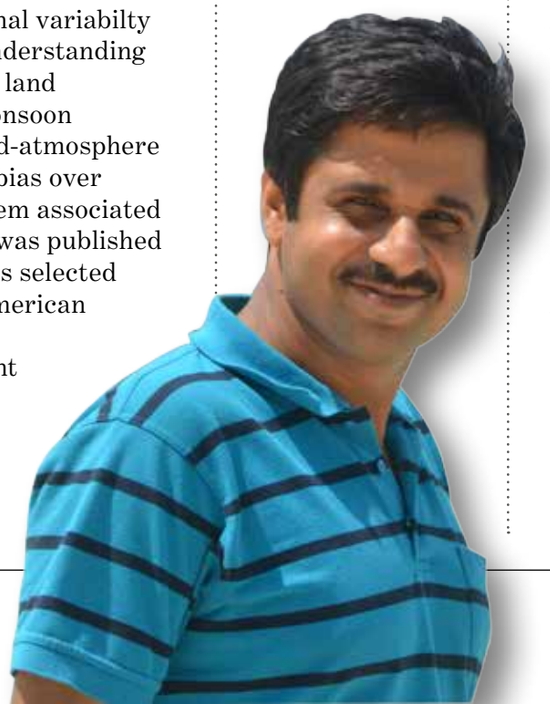
Chasing the Monsoon

To call him India's monsoon man won't be too far from the truth. Dr Subimal Ghosh works in the area of Indian summer monsoon and its extremes, namely, regional modeling, land-atmosphere interactions in the South Asian monsoon regions, improving predictions of monsoon characteristics using innovative dynamic-statistical modeling and assessing impacts of climate variability and changes in water resources in India.

Dr Ghosh's most significant contribution has been in understanding land-atmosphere interaction in the complex South Asian Summer Monsoon System. The monsoon was traditionally believed to be impacted by large-scale patterns and the contributions from land sources were neglected in literature, before Dr Ghosh published a breakthrough work in *Journal of Hydrometeorology* that showed 20-25% of the moisture contributing to precipitation in India during the end of summer monsoon has terrestrial origin. In his subsequent publications, he showed the contributions from land towards inter-annual and intra-seasonal variabilty of summer monsoon. With a better understanding of moisture circulation processes and land contributions, Dr Ghosh improved monsoon simulation using regional coupled land-atmosphere model resulting in a reduction in dry bias over India, which was an unresolved problem associated with monsoon circulation. This work was published in *Geophysical Research Letters* and was selected as the Research Spotlight of AGU (American Geophysical Union).

Dr Ghosh has also played a significant role in understanding the area of meteorological extremes. His work on increasing spatial variability of monsoon extremes in India and the possibility of associations with local drivers stands apart as a unique contribution. This work published in *Nature Climate Change* is followed by researchers worldwide. While, his work on the increase of widespread extremes over Central India and land surface processes being the second highest contributors to such increases has been published in *Nature Communications*. This has reestablished the significant role of land surface processes on monsoon rainfall. An increase in urban precipitation and urban flooding has been one of India's major disasters, resulting in huge human and financial loss. Dr Ghosh has performed a number of analyses highlighting urban feedback phenomena and the resulting increase in extreme urban precipitation. He has also shown the role of urban morphology and an urban structure in generating eddies that results in instabilities with intensification on extremes in few urban pockets and increase in spatial variability. Dr Ghosh led the development of India's first end to end real-time urban flood forecasting system with a team of 30 scientists from 8 Institutions.

> **"Success comes in those activities which a person enjoys. Having fun is essential for doing any work efficiently."**



Subimal Ghosh was born in Kolkata and completed his schooling from Ramakrishna Vivekananda Mission Vidyabhawan, Barrackpore, West Bengal. His father, Subir Kumar Ghosh, was a government service holder, and his mother, Supriya Ghosh, a housewife. His mother's passion towards science and mathematics made him excel in the subjects. After completing his schooling, Subimal joined Jadavpur University for his Bachelor of Engineering degree in civil engineering and then the Indian Institute of

AWARDS

- DL Memorial Medal and Fellowship, American Geophysical Union (2020)
- Shanti Swarup Bhatnagar Prize (2019)
- Swarnajayanti Fellowship (2018-19)
- Physical Research Laboratory Award (2019)
- Young Scientist Award, Indian National Science Academy (2012)

PUBLICATIONS

- 'Precipitation Recycling in the Indian Subcontinent during Summer Monsoon'. *Journal of Hydrometeorology* (2014).
- 'A threefold rise in widespread extreme rain events over central India'. *Nature Communications* (2017).
- 'Coupled land atmosphere regional model reduces dry bias in Indian summer monsoon rainfall simulated by CFSv2'. *Geophysical Research Letters* (2018).
- 'Choice of Irrigation Water Management Practice affects Indian Summer Monsoon Rainfall and its Extremes'. *Geophysical Research Letters* (2019).

Clockwise: Receiving the PRL Award (2019)

With his PhD supervisor Prof. PP Mujumdar and colleague Prof. Subhankar Karmakar at IISc (2005)

Receiving the Indian Science Congress Association's Young Scientist Award from Dr APJ Abdul Kalam, former President of India (2010)

With his wife, Chaitali, when she completed her MS from IIT Madras (2007)

With his research students

At the IPCC lead authors' meeting held in Guangzhou, China (2018)

Inset: With his collaborator Prof. Auroop Ganguly from the Northeastern University (2011)

Science, Bangalore for a master's in engineering. He completed PhD from IISc, Bangalore, in 2007. He did his ME project and PhD under the supervision of Prof. PP Mujumdar, who was an excellent mentor not only for his PhD but for his entire career. He was awarded Prof. NS Govinda Rao gold medal for best PhD thesis from IISc-Bangalore and joined the Indian Institute of Technology Bombay immediately after completing his PhD. He received the BOYSCAST fellowship from DST in 2010 and spent six months at the Oak Ridge National Laboratory, USA, with Prof. Auroop Ganguly. Working with Prof. Ganguly was an excellent training for him to perform high-impact research. Since his PhD days, he has been collaborating with his colleague and friend, Prof. Subhankar Karmakar. Many of his research derivations have resulted from the discussions and collaborations with him. Dr Ghosh is also fortunate to have Prof. Raghu Murtugudde, a visiting professor at his institute, as one of his colleagues and collaborators.

Dr Ghosh had started working in hydrometeorology during his PhD, when he developed statistical techniques for modeling regional climate addressing model uncertainty. He continued his work during the post-PhD period and at the same time started focussing on understanding feedback from the land to the atmosphere. The work was completed in collaboration with Prof. Praveen Kumar of the University of Illinois at Urbana-Champaign.

Dr Ghosh's rich research contributions have been published in high impact journals, such as *Nature Climate Change, Science Advances, Nature Communications, Geophysical Research Letters, Scientific Reports, Environmental Research Letters, Water Resources Research, Journal of Geophysical Research, Climate Dynamics, Journal of Hydrology, Advances in Water Resources, Journal of Climate* and *Journal of Hydrometeorology*. In recognition of his significant research contributions, Subimal has been selected as a Lead Author of Chapter 11 (Weather and Climate Extremes), Working Group 1 of IPCC Assessment Report 6 (AR6). One to give credit where its due, Dr Ghosh considers himself fortunate to have a fantastic group of students who are passionate about research. Apart from research, he is passionate about travelling and spending time with his family. •

DR SUHRIT GHOSH

Translating Vision into Reality

Despite significant progress in the field of synthetic molecular and macromolecular assemblies, the level of sophistication in the internal order and mesoscopic structure have not yet come up to the mark for predictable interaction with biological targets and regulating important functions. Dr Suhrit Ghosh's, Professor and Chairman of the School of Applied and Interdisciplinary Sciences at the Indian Association for the Cultivation of Sciences (IACS), group aims to develop a better fundamental understanding of structural precision of polymer and biopolymer (protein) assemblies by directional supramolecular interaction and explore them for applications in biomedicine.

The group works in the area of supramolecular assembly of polymers and pi-conjugated chromophores and studies their biological and optoelectronic properties. Dr Ghosh was introduced to polymer chemistry by Prof. Manas Chanda and Prof. S Ramakrishnan during his master's coursework at IISc. He learnt about supramolecular chemistry when he did a short-term research project during summer 1999, with Prof. Uday Maitra in the Department of Organic Chemistry at IISc. Exposure to these emerging topics, before a PhD, motivated him to pursue a research career in an interdisciplinary field combining supramolecular and polymer chemistry.

Dr Ghosh's research group at the IACS Kolkata has made a noteworthy contribution in achieving structural precision in supramolecular and polymeric self- assembled systems by elegant designs involving the interplay of different non-covalent interactions. They have established generalized supramolecular strategies for segregated or alternating co-assembly of donor/ acceptor building blocks, which is of paramount interest in organic optoelectronics. They have recently demonstrated predictable control over the surface functional group display of unsymmetrical vesicles, which has been a long-standing problem in this research field. This helps in efficient multivalent binding with biological targetsand, therefore, may make a lasting impact for developing new supramolecular biomaterials. His group has demonstrated that even a tiny supramolecular structure-directing unit is capable of driving precision assembly of appended polymers and/ or proteins by superseding the existing rule-based on packing parameters in amorphous systems. By virtue of such compact self-assembly, they could stabilize proteins from enzymatic degradation and thermal denaturation, which is highly encouraging for protein-based therapy.

> **"Self-belief, passion, dedication and optimism are four mantras of success."**

Dr Ghosh's group for the first time has developed a versatile methodology for the synthesis of functional poly(disulfide)s (PDSs) and shown their utility as a promising scaffold for drug delivery application.

They have synthesized functional polyurethanes, a well-known bio-degradable and biocompatible scaffold, and developed a thorough understanding of the structure-property relationship in controlling their folding and assembly in solution.

Working in interdisciplinary research problems helps young students to get exposure to different areas and develop a broad scientific outlook,

AWARDS

- Bronze Medal, Chemical Research Society of India (2017)
- K. Kishore Memorial Award, Society of Polymer Science, India (2016)
- Swarnajayanti Fellowship (2014)
- BM Birla Science Award in Chemistry (2013)
- Associate, Indian Academy of Sciences (2009)

PUBLICATIONS

- 'Redox Responsive Activity Regulation in Exceptionally Stable Supramolecular Assembly and Co-Assembly of a Protein'. *Chem. Sci.* (2021).
- 'Hydrogen Bonding Regulated Supramolecular Nanostructures and Impact on Multivalent Binding'. *Angew. Chem. Int. Ed.* (2019).
- 'Supramolecularly Engineered Amphiphilic Macromolecules: Molecular Interaction Overrules Packing Parameters'. *Angew. Chem. Int. Ed.* (2017).
- 'H-Bond Regulated Distinct Functional Group Display at the Inner and Outer Wall of Vesicles'. *Angew. Chem. Int. Ed.* (2015).

Clockwise: Working in the laboratory at IISc-Bangalore during his PhD days

With Consulate General of the Federal Republic of Germany, Kolkata, who visited IACS in 2012 to inaugurate a fluorimeter donated by the Humboldt Foundation, Germany, under its Alumni programme

Experimenting at IISc laboratory during the course of his PhD

With Indian and US delegates and students during the Indo-US joint symposium that he organized in 2013 with generous support from the IUSSTF

With graduate students at the Kyoto University, Japan, after delivering a lecture in 2019

Inset: Receiving the CRSI Bronze Medal from Prof. N Sathyamurthy, CRSI President, in 2018

which serves the purpose of quality education and human resource generation. In addition, his work on the development of new polymeric scaffolds containing fully bio-reducible polydisulfide backbone appears highly promising for drug delivery application. Noteworthy that cancer cells have an elevated level of glutathione which can cleave the disulfide linkage and thus polydisulfide-based delivery vehicles exhibit selective drug release in cancer cells which may help to minimize the side effects. They have recently developed new biodegradable polymers which exhibit excellent antibacterial activity and are rare examples to show selectivity against Gram-negative bacteria. To address the emerging global health concern on drug resistance bacteria, it is essential to develop new antibacterial materials, which are less susceptible to resistance development. This is precisely where novel polymeric materials developed by Dr Ghosh's group are relevant as they kill bacteria by less-specific cell-membrane destruction mechanism (similar to the Host Defense Peptides of the innate immunity system) rather than the lock- and-key mechanism of action by classical antibiotics. His contribution in supramolecular donor-acceptor assemblies greatly facilitates the charge transport phenomenon and thus may find relevance in the context of organic electronic devices related to energy harvesting and others. Recently, his group has demonstrated such π-assemblies can be obtained in an aqueous medium with precise functional group display, which may enable the development of new supramolecular materials for applications in biomedicine.

Suhrit completed his PhD on conformational control of synthetic polymers with Professor S Ramakrishnan in the Department of Inorganic and Physical Chemistry, IISc Bangalore. He received the Dr JC Ghosh medal for the best thesis submitted in the department. Then he moved to the University of Massachusetts, Amherst, USA and worked as a postdoctoral research associate (2005-2007) with Professor S Thayumanavan on amphiphilic polymers and their applications in the biological domain. Subsequently, moved to the group of Professor Frank Würthner in the University of Würzburg, where he was introduced to supramolecular polymers, built by non-covalent interaction like hydrogen-bond. In 2008 he came back to India and joined as an Assistant Professor in the Polymer Science Unit of the Indian Association for the Cultivation of Science, Kolkata. He was promoted to Associate Professor in 2012 and Professor in 2016. He served as the Head of the Department of the Polymer Science Unit at IACS (2016-2018) and since 2018 he has been serving as the Chairman of the School of Applied and Interdisciplinary Science at IACS.

He has delivered >90 lectures in India and abroad including in Germany, France, Japan and other countries. He was selected as an Associate (2009-2012) of the Indian Academy of Sciences. •

PROF. SUMAN CHAKRABORTY

Pushing the Envelope

Prof. Suman Chakraborty, Professor, Indian Institute of Technology, Kharagpur, and Dean of Sponsored Research and Industrial Consultancy, as well as J.C. Bose National Fellow, is known for his extremely fundamental contributions to fluid dynamics in tiny devices, which have paved the foundation for unique frugal medical technologies that have been translated into affordable diagnostic platforms to cater to the outstanding needs of the rural population. He has resolved several long-standing apparent paradoxes, including novel findings and insights on roughness-induced slippery flow in hydrophobic nanochannels contrary to a presumably obvious stick, massive augmentation of electrically driven pumping in hydrophobic nanochannels, sticky flow of liquid water on atomistically designed hydrophobic surfaces instead of intuitive slip, programmable electrical modulation of droplets in directions misaligned with the electric field, generating controlled microbubbles and droplets on a spinning disc, reversing the thermally-driven motion of extremely tiny droplets. He has unravelled a unique bio-physical mechanism responsible for puzzling anti-biotic resistance in critical infectious diseases via a demonstrative lab-on-a-chip platform capable of generating chemo-attractant concentration profiles on demand. He has also introduced niche low-cost fabrication and analytical tools to probe the fluid dynamics in human-body micro-circulatory network via bio-mimetic micro-chips. This has led to the recent discovery of hitherto-unknown mechanisms of collective dynamics of red blood cells in flexible micro-vascular pathways, enabling the resolution of long-standing questions in medical science. He has also been a pioneer in innovating unique microfluidic devices for cancer diagnostics and management. His innovated microscopy technique on a chip has proven the capability of assessing the metastatic potential of cancer cells as the disease spreads, aiding screening novel anti-cancer drugs, and throwing light on the efficacy of suggestive cancer treatment protocols. This tumour-on-a-chip technology has further enabled the discovery of oscillatory shear stress induced calcium flickers in osteoblast cells that is often instrumental in health and disease of bones.

“Work selflessly with discipline, honesty, dedication, sincerity and inculcate joyousness and positivity that promotes holistic development.”

Dr Chakraborty was the first to demonstrate an unprecedented capacity of graphene oxide for salt water purification on a piece of paper. He has also developed a miniaturized novel instant power generation device from an air-breathing paper-and pencil-based bacterial bio-fuel cell. Also, he has been the first to demonstrate water flow to electrical energy conversion on a paper strip. His group has recently shown electrical power generation in wet textile, drawing analogies with water transport across the parts of a living plant and that this electricity generation may be up-scaled massively by systematically drying a set of regular wearable garments under the sun-light.

Prof. Chakraborty obtained his undergraduate degree in mechanical engineering from Jadavpur University and a master’s degree from the Indian Institute of Science (IISc), Bangalore. After a brief teaching stint at Jadavpur University, he joined the PhD programme at the IISc towards the end of the year 2000, mentored by Prof. Pradip Dutta.

After his PhD, Prof. Chakraborty joined the Indian Institute of Technology Kharagpur as an Assistant Professor and set up the first ‘Microfluidics’ laboratory in the country. Prof. Chakraborty has been one of the pioneers in the world in developing microneedles for blood extraction and drug delivery, by mimicking mosquito’s blood sampling mechanism. He has also been the

AWARDS

- GD Birla Award for Scientific Research (2020)
- Shanti Swarup Bhatnagar Prize (2013)
- Scopus Young Scientist Award (2008)
- INAE Young Engineer Award (2004)
- INSA Medal for Young Scientist (2003)

PUBLICATIONS

- 'Smartphone-Enabled Paper-Based Hemoglobin Sensor for Extreme Point of Care Diagnostics', *ACS Sensors* (2021).
- 'Electrical power generation from wet textile mediated by spontaneous nano-scale evaporation'. *Nano Letters* (2019).
- 'Order parameter description of electrochemical-hydrodynamic interactions in nanochannels'. *Physical Review Letters* (2008).
- 'Dynamics of capillary flow of blood into a microfluidic channel'. *Lab on a chip* (2005).

Clockwise: Receiving the Shanti Swarup Bhatnagar Prize from Dr Harsh Vardhan

On his tenth birthday with his parents, Dr Dilip Kumar Chakraborty and Shibani Chakraborty, and Father DAbrew, Headmaster of St Lawrence High School, Kolkata

Under seawater in Dubai, with wife Sharmistha and son Sutanu

Working on COVIRAP, a unique low-cost nucleic acid based portable COVID testing device, with colleagues and students

With mentor Prof. Marc Madou, UC Irvine, US

During the clinical trial of one of innovated medical diagnostic device at a hospital

Inset: Being conferred the Indian National Science Academy fellowship

first researcher to develop a deep fundamental theory on electrically-modulated movement of blood in a micro-capillary, which has subsequently been translated as a fundamental design basis of modern lab-on-a-chip devices for blood pathology. His recently innovated diagnostic device, premised on pattern formation in a blood droplet on a pre-wetted paper strip due to fluid dynamic instabilities, has opened up new vistas for chemical-free haematological examination, acting as an ultra-low-cost preliminary decision-making tool for the screening of anaemic patients in resource-limited settings. Prof. Chakraborty has also designed a simple low-cost spinning disc to perform a Complete Blood Count (CBC). Prof. Chakraborty has patented a unique miniaturized blood perfusion imaging device for screening of oral pre-cancer and cancer, circumventing the obvious clinical constraints of traditional laser Doppler or laser speckle perfusion imagers. This device has successfully passed clinical trial for early diagnostics of oral cancer and is being adapted for the estimation of residual cancer of cervix before brachytherapy. Prof. Chakraborty was also the first in the world to introduce 'Paper and Pencil Microfluidics' – a new class of miniaturized devices – a a breakthrough in manufacturing low-cost medical diagnostic devices, as well as demonstrated unique functionalities of water purification and energy harvesting on simple paper strips.

As the country was battling the pandemic, Prof. Chakraborty developed a low-cost method and device for COVID-19 diagnostics (COVIRAP), a simple and user-friendly rapid nucleic acid test nearly as accurate as the gold-standard RT-PCR test. Being a first of this kind 'low-cost Rapid Accurate Nucleic Acid 2019-NCOV Test Providing a High Level of Accuracy for the Asymptomatic with the Cost and Simplicity of a Rapid Test', this has emerged as a lifeline amidst the pandemic.

Prof. Chakraborty has further mastered a highly innovative pathway of translating high-end laboratory research to green fields at extreme point-of-care. His innovated blood glucose and haemoglobin measuring devices, available at ultra-low cost without any compromised accuracy, have become backbones of many rural healthcare centres. He has provided leadership in establishing a common research and technology hub on affordable healthcare, with the support of the Department of Scientific and Industrial Research, Ministry of Science and Technology, Government of India, where the innovated products are being mass-manufactured. As a major achievement, Prof. Chakraborty has set up unique healthcare delivery ecosystems for the under-served in collaboration with a not-for-profit medical expert team. •

PROF. SUNIL KUMAR SINGH

A Model for Imitation

Usually, the choice not circumstance decides success, however, for Prof. Sunil Singh it was a mix of both. After completing his graduation in physics honours, Sunil joined a master's course in geophysics at the Banaras Hindu University, Varanasi. The reason being, he wanted a job in an oil company, however, by the time he completed his PhD, the oil sector was no longer as lucrative. While he was contemplating other options, he came across an advertisement in the newspaper to join a research programme in earth sciences at the Physical Research Laboratory (PRL), Ahmedabad. Under the brilliant guidance of Prof. S Krishnaswami, he started his PhD research at PRL and soon it became his passion. He received his degree from MS University, Vadodara. Later, he joined CNRS-CRPG, Nancy, France as a postdoctoral fellow.

Prof. Singh joined PRL in 2002 as a scientist and, has served as Reader, Associate Professor and Professor before taking charge of the Directorship at CSIR-National Institute of Oceanography, Goa in June 2017.

During the past few decades, the applications of radiogenic and non-traditional isotopes and trace elements have considerably advanced the understanding of a variety of earth surface and marine processes. Prof. Singh has contributed significantly to these advances particularly to characterize and quantify selected processes in aqueous systems through the use of chemical and isotope ($^{87}Sr/^{86}Sr$, εNd, $^{187}Os/^{188}Os$, $\delta^{98}Mo$, $\delta^{30}Si$) composition of water and sediments from rivers and oceans and has made fundamental contributions to characterize and quantify dynamic geological processes occurring at or near the earth surface and in oceans.

Prof. Singh has also made a remarkable contribution in the field of geochronology of sedimentary deposits. He has pioneered in establishing the Re-Os chronometry in India to determine the absolute chronology of organic carbon-rich sedimentary deposits. He has successfully applied this method to provide the first radiometric ages of black shales from Tal formation from the Himalaya and Lower Kaimur from the Vindhyan, confirming the Krol-Tal boundary as the Pc-C boundary in the Himalaya and a long hiatus in the sedimentary deposition between the Lower and Upper Vindhyan. This method will be used to date directly the various sedimentary sequences in India to chronologically interpret geological records stored in them.

> **"Get completely immersed in work, by being passionate you will love your profession."**

Prof. Singh's study on erosion over the Himalaya has demonstrated the coupling among the climate-erosion-tectonics. His study revealed the heterogeneous nature of physical erosion over the Himalaya, being dominated by a few hotspots, the Eastern Syntaxis (Brahmaputra basin) and the Gandak (Ganga basin) regions accelerated by intense precipitation over regions of high relief. These hotspots constituting only about one-tenth of the total area supply about half of the sediments to the Bay of Bengal and can facilitate regional uplift through isostatic rebound. This study has direct relevance to the global carbon cycle as physical erosion regulates the transport and burial of organic carbon influencing the long-term climate.

The recent researches carried out by Prof. Singh focus on the distribution of trace elements and isotopes (TEIs) in estuaries and in the Indian Ocean to characterize and quantify their source functions, internal cycling and sinks and elucidating the impact of global change on their budget

AWARDS

- Shanti Swarup Bhatnagar Prize (2016)
- National Geoscience Award in Basic Geosciences (2012)
- Fellow, Indian Academy of Sciences (2016)
- Fellow, Indian National Science Academy (2018)
- Fellow, National Academy of Sciences, India (2019)

PUBLICATIONS

- 'Re-Os systematics of black shales from the Lesser Himalaya: Their chronology and role in the 1870s/1860s evolution of seawater'. *Geochim. Cosmochim. Acta*. (1999).
- 'Sr and Nd isotopes in river sediments from the Ganga Basin: Sediment provenance and spatial variability in physical erosion'. *Journal of Geophysical Research* (2008).
- 'Spatial distribution of dissolved neodymium and εNd in the Bay of Bengal: Role of particulate matter and mixing of water masses'. *Geochim. Cosmochim. Acta, 94* (2012).
- 'Dissolved aluminium cycling in the northern, equatorial and subtropical gyre region of the Indian Ocean', *Geochim. Cosmochim. Acta* (2020).

Clockwise: Receiving the Shanti Swarup Bhatnagar Prize from Prime Minister Narendra Modi, 2016

Welcoming Vice President of India M Venkaiah Naidu to CSIR-National Institute of Oceanography, Goa

Sampling a laterite section in Kachchh, Gujarat

Demonstrating the sediment core repository facility to Dr Shekhar C Mande, DG, CSIR

Demonstrating the CTD system to VP Singh Badnore, Governor of Punjab

During the inaugural ceremony of the MC-ICPMS facility at CSIR-National Institute of Oceanography, Goa, with Dr Girish Sahani, ex DG, CSIR

Inset: Receiving the Honorary Doctorate Degree from the Chief Minister of Goa, Dr Pramod Sawant

and biogeochemistry. These studies are challenging, as they require ultraclean sampling of seawater and measurement of trace elements and isotopes present in very low concentration in seawater, which were not available in India. Prof. Singh has established successfully the clean sampling system and measurements techniques of trace elements and isotopes in seawater in India and carried out several important studies in this field. His work on εNd distribution in the Bay of Bengal and the Arabian sea not only demonstrated the major role of particles in contributing to dissolved Nd and εNd in these waters but also identified the source of particles and estimated the quantum of Nd release contributing significantly to the missing Nd of the global oceans. Such 'particle–water interaction' acts as an important source of many elements (Mo, Fe, Nd) and isotopes to the global ocean controlling their oceanic budgets significantly.

One of the important outcomes of Prof. Singh's study in the field of chemical oceanography is the identification of the missing source of lighter Mo in the oceanic budget of Mo. His results in estuaries and the Bay of Bengal demonstrated that Fe-Mn hydroxide coating of the riverine particles incorporates lighter Mo from river water releases lighter Mo under the sub-oxic condition prevailing in the water column of the northern Bay of Bengal. This result is directly relevant to the application of Mo isotope composition of seawater in tracking paleo-redox condition as it requires a better understanding of sources and sinks of Mo isotopes and their fractionation during water-particle interactions.

Prof. Sunil Singh has established many traditional/non-traditional isotope systematics in India which enables researchers to undertake high-quality research work in India. He has played a major role in setting up the new TIMS laboratory and clean chemical laboratory at PRL and CSIR-NIO.

As a part of this process, he has trained many PhD students and mentored post-doctoral fellows, project associates and summer students. Prof. Singh's researches have resulted in about 65 publications in leading peer-reviewed journals (total citations for all his papers as per Google Scholar are more than 3100 with h-index 31).

Prof. Singh's future focus will be to trace the origin and evolution of atmospheric oxygen, ocean chemistry and life on earth archived in sedimentary sequences of various ages in India. Further, Prof. Singh plans to investigate how ocean microbes acquire essential metals and how the biological activity is affected by metal availability using omics studies. •

PROF. SURAJIT DHARA

Blazing a Trail

That his pioneering spirit is alive and well can be seen from the fact that after joining the University of Hyderabad, in 2006, Prof. Surajit Dhara immediately set up a modern laboratory for research in the new area of liquid crystal called bent-core liquid crystals. He made important and fundamental contributions in understanding the structure-property correlation of several bent-core liquid crystals. His work was recognized by the Indian Physics Association by conferring on him the NS Satya Murthy Memorial Award in 2012.

Prof. Dhara was working on unconventional liquid crystals to find new physical effects or phenomena, which could be useful for applications. He discovered a new orientational transition in special types of liquid crystals, which are potential for new generation display and rewritable memory devices. This effort earned him the Michi-Nakata Prize by the International Liquid Crystal Society (ILCS) in 2010.

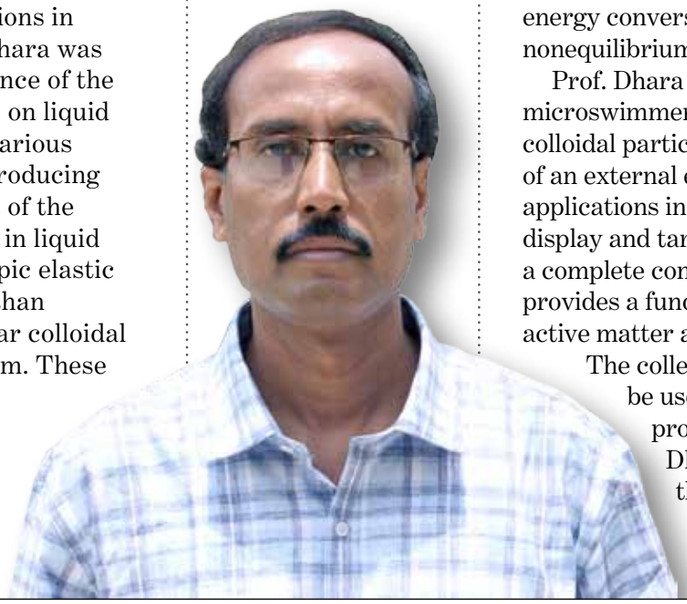
His current and main research interest is liquid crystal colloids in which topological defects play an important role. It has emerged as an interdisciplinary area in which fundamental concepts of topology find useful applications in materials science and photonics. Prof. Dhara was always fascinated by the beauty and science of the defects in liquid crystals. He has focused on liquid crystals in which topological defects of various types and strengths are stabilized by introducing colloidal particles. One important aspect of the liquid crystal colloid is that the particles in liquid crystals interact via long-range anisotropic elastic forces. These forces are much stronger than conventional short-range forces in regular colloidal systems in an isotropic dispersive medium. These striking features attracted him so much that he changed his research interest, for which he received the prestigious Swarnajayanti Fellowship in 2015.

Prof. Dhara has also made an important contribution in understanding the defects, fundamental properties of interaction and topology enabled directed-assembly of colloidal particles. He has studied the defects and interaction of highly anisotropic and electrically and magnetically responsive particles. The fundamental phenomena observed helped him to develop new colloidal organizations with complex architecture, which are potential for designing tunable colloidal crystals for photonic band-gap materials and developing new programmable materials with specific morphologies. This new class of materials, in which topological defects and elasticity of nematic plays a crucial role in the dynamic structure, as well as assembly and energy conversion have created a new direction in nonequilibrium physics.

Prof. Dhara has also developed artificial microswimmers in liquid crystals in which the colloidal particles swim by transducing the energy of an external electric field. This could be useful for applications in colloidal segregation, electrophoretic display and targeted delivery. They have achieved a complete command over colloidal mobility. This provides a fundamental platform for developing active matter and new nano- and micro-devices.

The collective behaviour of such particles may be useful in understanding some real-life problems of living microorganisms. Prof. Dhara has been collaborating with the renowned theorist Prof. Sriram Ramaswamy for understanding some of these experimental observations.

“Hard work, sincerity, discipline and dedication are very important in achieving desired goals. It is also important that one should enjoy the work.”



AWARDS

- Shanti Swarup Bhatnagar Prize (2020)
- Swarnajayanti Fellowship (2015)
- Chancellor Award for Excellence in Teaching and Research (2013)
- N. S. Satya Murthy Memorial Award for Young Scientists (2012)
- Michi-Nakata Prize (2010)

PUBLICATIONS

- 'Omnidirectional transport and navigation of Janus particles through a nematic liquid crystal film'. *Physical Review Research* (2020).
- 'Orientation dependent interaction of magnetic cubic colloids in a nematic liquid crystal'. *Advanced Optical Materials* (2020).
- 'Electrically switchable whispering gallery mode lasing from ferroelectric liquid crystal microdroplets'. *Applied Physics Letters* (2019).
- 'Splay-bend elasticity of a bent-core nematic liquid crystal'. *Phys. Rev. E (Rapid Com.)* (2010).
- 'Anchoring transitions of transversely polar liquid-crystal molecules on perfluoropolymer surfaces'. *Phys. Rev. E (Rapid Com.)* (2009).

Clockwise: Receiving the NS Satya Murthy Memorial Award in Physics for Young Scientists (2012) by Indian Physics Association

At Raman Research Institute, Bangalore during his PhD (2001)

Working with indigenously developed bench top rubbing machine

In the optical tweezers laboratory in the School of Physics at Hyderabad Central University

Receiving the Michi-Nakata Prize in 2010 by International Liquid Crystal Society in recognition for the discovery of discontinuous transition

With Prof. Igor Musevic at Jozef Stefan Institute, Ljubljana, Slovenia (2018)

Inset: Receiving the Chancellor's Award from Hanumantha Rao, Chancellor, University of Hyderabad (2013)

Another of his important contribution has been in developing liquid crystal microdroplet-based optical microcavity and microlasers. These optical micro components are easily tunable by external electric and magnetic fields. The tunable microlasers are essential components in designing miniaturized devices and developing next-generation soft optical chips, analogous to electrical chips.

Besides extensive research on emerging topics in liquid crystals, he has indigenously developed an automatic benchtop rubbing machine, which is a crucial tool for aligning the molecules in liquid crystal displays (LCDs), and transferred the technology to HolmarcOpto-Mechatronics Pvt. Ltd. It is the cheapest rubbing machine designed to make affordable LCDs in India. This instrument has been exported to many foreign countries including the USA, Russia, China and Singapore.

At present, his group is working on liquid crystal based tunable microlasers, which can be implanted in biological cells or the human body in future. He is also working on active microparticles, which can be remotely controlled at the microscopic level for various applications such as controlled reaction, sorting, guided transport and directed assembly.

Dr Surajit Dhara hails from the Hooghly district of West Bengal. His father was a person with a progressive mind, who always encouraged him to study and get higher education. His uncle, mentored him in science and mathematics and hence he developed a keen interest in physics and joined Ramananda College at Bishnupur, Bankura to study Physics Honours and then the University of Burdwan for an MSc in physics. After his MSc, he joined the Raman Research Institute, Bangalore, for a PhD under the supervision of Prof. NV Madhusudana. He mentioned that working with Prof. Madhusudana has created an immense impact on his passion for work on liquid crystals. His supervisor not only encouraged him but also provided support and gave him the freedom to learn and work. Jointly with Prof. Madhusudana, he contributed immensely to the fundamental aspects of liquid crystals. After finishing his PhD, he went to teach at the Birla Institute of Technology and Science, Pilani. After teaching for more than two years he moved to the University of Hyderabad to pursue teaching and independent research. And, when he is not working, he loves listening to music, spending time with his family and friends and going for long drives during holidays. •

DR SUVENDRA NATH BHATTACHARYYA

Paving the Way

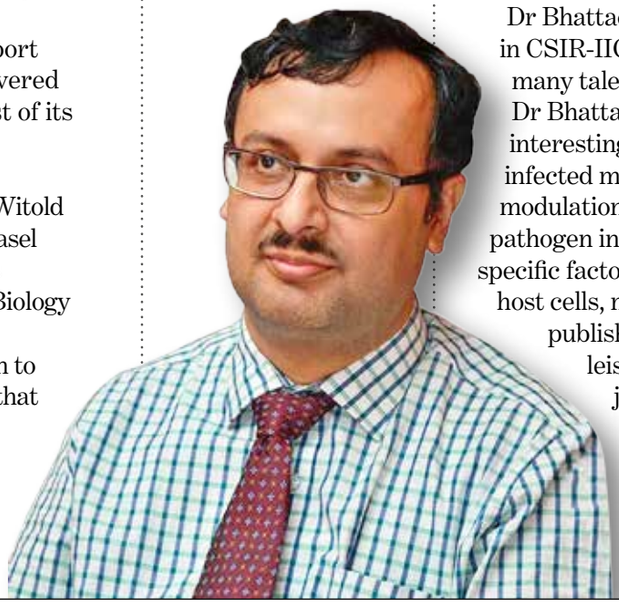
How much control a tiny regulator miRNA can have on gene regulation is what excited Dr Suvendra Nath Bhattacharyya to explore its potential as new-age drugs and biomarkers. That is why Dr Bhattacharyya's long-term goal is to establish a new-age epigenetic research institute in India dedicated to exploring the complexity of gene regulation in a disease context using interdisciplinary comprehensive approaches.

Inspired by his mother, Suvendra opted to study chemistry as his main subject in BSc and his training as a chemist was shaped as a student at Presidency College, Kolkata. His teacher Dr Debkumar Mitra at Presidency College played a key role in his choice to study and opt for a research career in biochemistry. Following the chosen trajectory, he joined the Department of Biochemistry, University of Calcutta for his postgraduation.

A meeting with Dr Samit Adhya who was working on a very fundamental problem of tRNA transport across biomembranes prompted Suvendra to join the Indian Institute of Chemical Biology in Kolkata, as a PhD student. Under the guidance of Dr Adhya at the Genetic Engineering Laboratory, while pursuing research on mitochondrial tRNA import process. During his PhD days, Suvendra discovered a mitochondrial RNA Import Complex, the first of its kind, and published a series of papers.

In March 2004, Dr Bhattacharyya joined the laboratory of the famous RNA biochemist Prof. Witold Filipowicz at the Friedrich Miescher Institute, Basel Switzerland. He was selected for two prestigious fellowships supports from European Molecular Biology Organization (EMBO) and International Human Frontiers in Science Program (HFSP) foundation to pursue his post-doctoral research work. During that time, he published two breakthrough papers in two famous journals *Science* and *Cell* to elucidate the reversible mechanism of gene repression by miRNAs that primarily affects the protein synthesis process at the initiation step.

"Think deep work hard. Deep thinking process is an essential part of the research approach complemented with hard and methodical work."



In 2008, he returned to India and joined the Molecular Genetics Division of CSIR-Indian Institute of Chemical Biology (IICB) as a senior scientist. During the initial phase, Suvendra has availed two prestigious research grants, the HFSP Career Development Award fund and The Wellcome Trust, London International Senior Research Fellowship fund to boost his research in India. Dr Bhattacharyya and Prof. Filipowicz continue to collaborate on a project funded by the Department of Science and Technology, Government of India and SNF, Switzerland.

Dr Bhattacharyya started his research group in CSIR-IICB in early 2008 and was joined by many talented PhD students to work with him. Dr Bhattacharyya's group had adopted a very interesting model of a parasite (*Leishmania donovani*) infected mammalian macrophage cells to study the modulation of miRNA function during the host and pathogen interaction. His discovery of pathogen-specific factors, capable of altering miRNA function in host cells, made newspaper headlines when his group published a pioneering paper on miRNAs role in leishmaniasis (Kala-Azar) in the prestigious journal *Cell Host* and *Microbe*.

Another aspect of miRNA research that emerged from the group's initial research, that is, the contribution of subcellular structures and organelles like mitochondria in the gene

AWARDS

- Shanti Swarup Bhatnagar Prize (2016)
- National Bioscience Award (2016)
- Swarnajayanti Fellowship (2015)
- NASI-Scopus Young Scientist Award (2015)
- AAAS/Science Young Scientist Award (2004)

PUBLICATIONS

- 'Non-Canonical Ago Loading of EV-Derived Exogenous Single Stranded miRNA in Recipient Cells'. J *Cell Sci.* (2021).
- 'MicroRNA exporter HuR clears the internalized pathogens by promoting pro-inflammatory response in infected macrophages'. *EMBO Mol Med.* (2020).
- 'Reversible HuR-microRNA binding controls extracellular export of miR-122 & augments stress response'. *EMBO Reports* (2016).
- 'Target dependent biogenesis of cognate miRNAs in mammalian cells'. *Nature Communications* (2016).

Clockwise: Receiving the Shanti Swarup Bhatnagar Prize from Prime Minister Narendra Modi

In discussion with other fellow scientists at an award function

With his wife Dr Kamalika Mukherjee after receiving the Scopus Young Scientist Award in Delhi in 2015

With his group members in the RNA Biology Research Laboratory, CSIR-IICB, Kolkata

Receiving the GE Healthcare-AAAS Science Young Scientist Award, 2005, in Washington, DC, USA, from Dr Shirley Ann Jackson, President, AAAS and Dr Alan I Leshner; CEO, AAAS

Inset: Receiving the Khosla National Award from the Director of IIT Roorkee in 2020

regulation process was becoming prominent. Dr Bhattacharyya has been the leader in proposing the concept of compartmentalization of miRNA-mediated gene repression steps in animal cells. His group has identified the steps that are taking place in different subcellular compartments, while each of these steps was found to be regulated by organellar interaction and dynamics.

Meanwhile, miRNAs have become more important and interesting in the biomedical research field as they are found to be the key mediator of intercellular communication. From the fundamental science point of view, the understanding of mechanistic detail of miRNA packaging and export from mammalian cells to extracellular milieu was a key question that Dr Bhattacharyya's lab has currently taken up as a challenge. His team has identified the key protein HuR that does the miRNA export process for a liver-specific miRNA, miR-122, from human liver cells – a process important for liver cells to sustain metabolic homeostasis and liver function. And, he, in collaboration with his wife Dr Kamalika Mukherjee, has published a series of interesting papers on this subject.

Dr Bhattacharyya's research on miR-122 and its interactor protein HuR has highlighted the therapeutic potential of these molecules against the drug-resistant form of visceral leishmaniasis. His research on extracellular vesicles entrapped miRNAs also suggests the role of miRNAs in cancer prevention as these could augment the innate immune response in our body.

Dr Bhattacharyya is currently working on the use of the knowledge he gathered on the miRNA-mediated gene regulation process to develop potential inhibitors and modulators against specific steps to help us in controlling several communicable and metabolic diseases. This will be the new world medicine altogether with RNA being used as a drug. His pioneering work in the field of miRNA transport across cell boundaries has made it an exciting gene modulation tool that can be used for a wide range of application including cancer cell proliferation control or regulation of infection process by a pathogen. This would lead us to a whole new world of next-generation RNA based therapeutics against deadly diseases.

During his off-hours, Dr Bhattacharyya explores his creative writing skill. He also likes to listen to Indian and western classical music. He is a great fan of Mohan Bagan football club. •

T-V

PROF. TAPAS K MAJI
PROF. TNC VIDYA
DR VIDITA VAIDYA

PROF. TAPAS K MAJI

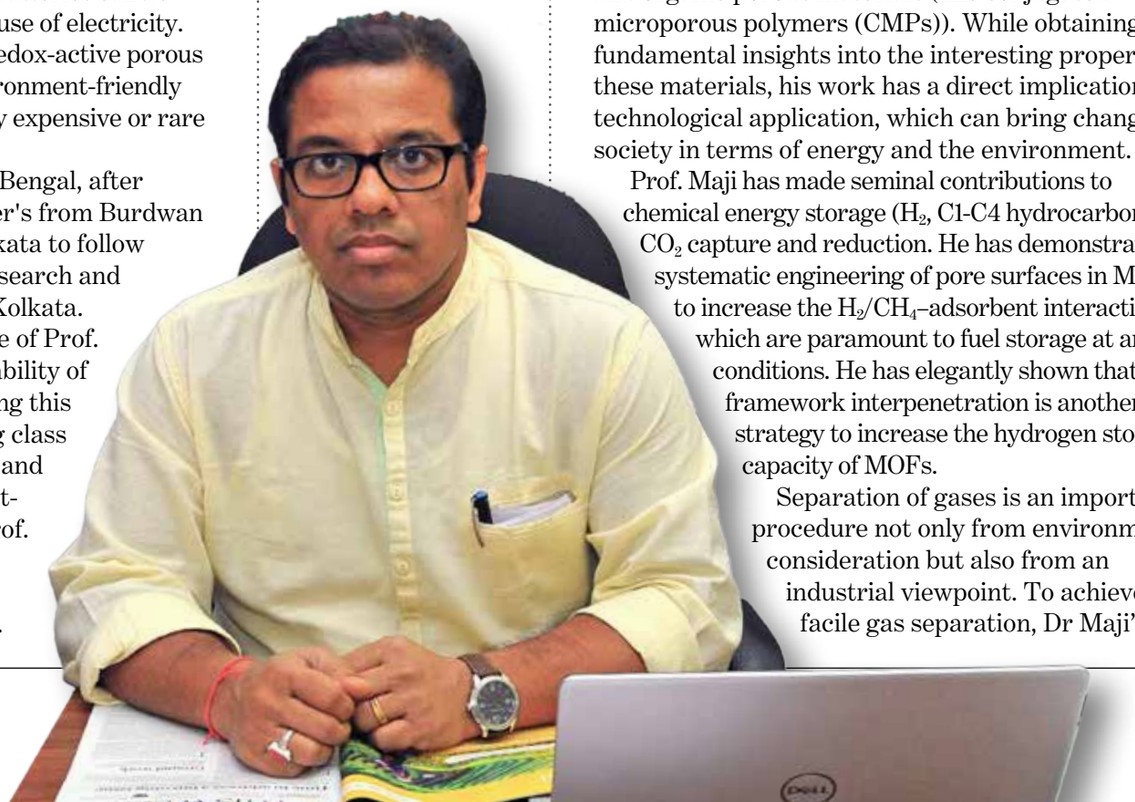
A Front-runner

Armed with a comprehensive synthetic toolkit, Prof. Tapas K Maji's group has ventured into the world of porous materials to explore its impact on renewable energy. As the search for green alternatives continues, one of the major focuses in energy research continues to be separation of chemical feedstock for the calorific upgradation of the individual components. This is a prime bottleneck in green technology. Energy-efficient adsorptive chemical separation based on functionalized porous materials is a topic of interest that is of immense value both in terms of environmental sustainability and energy efficiency.

Prof. Maji is also working on the development of clean and environment-friendly materials for eco-friendly and inexpensive rechargeable metal-air batteries. The main challenge towards the fabrication of such rechargeable metal-air batteries is the development of bifunctional cathode materials, which is active towards oxygen reduction (ORR) for discharging and oxygen evolution reactions (OER) for charging of the battery. The proposed metal-air batteries can be recharged mechanically without the use of electricity. The group is committed to develop redox-active porous materials, which can be used as environment-friendly cathode materials that do not use any expensive or rare noble metals for catalytic purpose.

Born in Bankura district of West Bengal, after completing his bachelor's and master's from Burdwan University, Prof. Maji moved to Kolkata to follow his dream of a career in scientific research and received a PhD degree from IACS, Kolkata. There he worked under the guidance of Prof. N Ray Chaudhuri on the thermal stability of different metal complexes. It is during this time that he read about an emerging class of metal-organic hybrid compounds and wanted to explore those. For his post-doctoral research, Dr Maji joined Prof. Susumu Kitagawa's group in Japan, one of the leaders in the field of Metal-organic Frameworks (MOFs).

"Sheer hard work, dedication, strong motivation and self-belief are all that one needs to achieve one's dreams."



After a very successful postdoctoral stint, Prof. Maji started his group at the Chemistry and Physics of Materials Unit, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru.

Over the past decade, Prof. Maji has established a world-class laboratory with cutting-edge research facilities and instrumentation. Prof. Maji's primary research focus has been the design and synthesis of inorganic-organic hybrid materials (discrete cluster or polyhedra to extended MOFs in bulk and nanoscale, and organic porous materials (like conjugated microporous polymers (CMPs)). While obtaining fundamental insights into the interesting properties of these materials, his work has a direct implication for technological application, which can bring change in society in terms of energy and the environment.

Prof. Maji has made seminal contributions to chemical energy storage (H_2, C1-C4 hydrocarbons) and CO_2 capture and reduction. He has demonstrated systematic engineering of pore surfaces in MOFs to increase the H_2/CH_4–adsorbent interactions, which are paramount to fuel storage at ambient conditions. He has elegantly shown that framework interpenetration is another strategy to increase the hydrogen storage capacity of MOFs.

Separation of gases is an important procedure not only from environmental consideration but also from an industrial viewpoint. To achieve facile gas separation, Dr Maji's

AWARDS

- Shanti Swarup Bhatnagar Prize (2019)
- Fellow, Royal Society of Chemistry (2019)
- Fellow, Indian Academy of Sciences (2018)
- Alexander von Humboldt Fellow (2015)
- Bronze Medal for Contributions in Chemistry, Chemical Research Society of India (2012)

PUBLICATIONS

- 'Covalent Grafting of Molecular Photosensitizer and Catalyst on MOF-808: Effect of Pore Confinement Toward Visible Light-driven CO2 Reduction in Water'. *Energy Environ. Sci.* (2021).
- 'Guest-Responsive Reversible Electron Transfer in a Crystalline Porous Framework Supported by Dynamic Building Node'. *Angew. Chem. Int. Ed.* (2020).
- 'Binder Driven Self-assembly of Metal-Organic Cubes towards Functional Hydrogels'. *Nature Commun.* (2018).
- 'MOF Nano Vesicles and Toroids: Self assembled Porous Soft Hybrids for Light Harvesting'. *Adv. Funct. Mater* (2013).

Clockwise: Being felicitated at JNCASR by Prof. A Sundaresan, Chair, CPMU and Bharat Ratna Prof. CNR Rao after receiving the Shanti Swarup Bhatnagar Prize in Chemical Sciences, 2019

Receiving the Bronze Medal from then CRSI President Prof. S Chandrasekaran at the Banaras Hindu University, 2012

Working in his lab at JNCASR, Bangalore

With his current research group at JNCASR, Bangalore

With the speakers at the Indo-UK seminar on 'Complex Materials for a Sustainable Energy Future: Linking Computational and Experiment' in London, 2013

Inset: With his student who was awarded the silver medal in KPIT Sparkle: I Innovate Challenge 2020

group has judiciously designed framework structures by incorporating polar functional groups like F-, -OH-, -NH_2 on the pore surfaces, which interact effectively with the quadrupolar CO_2 molecules and, subsequently, affect adsorption selectivity. His group has shown that hydrophobic MOFs based on fluorinated linkers are more effective in selective capture of CO_2 which is important to the separation of CO_2 from the flue gas mixture. Such MOF materials were further exploited for separation of CO_2 from CO_2/N_2 mixture (V: V / 15: 85) based on the flue gas composition or from CO_2/CH_4 mixture at ambient condition for natural gas purification, since a certain percentage of noncalorific CO_2 is present in CH_4 obtained from natural gas reserves. In a pioneering work, Prof. Maji has demonstrated the separation of CO_2 from CO_2/N_2 or CO_2/CH_4 or C_2H_2 from C_2H_2/C_2H_4 at ambient conditions based on MOF or MOF/graphene or MOF/clay nanocomposite materials in a novel breakthrough measurement setup built by him at JNCASR. Dr Maji has also contributed to the field of nanoscale MOFs. Scaling down MOFs to nanometre length-scale would provide better solution processability, which is essential for device fabrication and biological applications. Prof. Maji's group has been working on nanoscale MOFs (NMOF), based on the self assembly of bola-amphiphilic chromophoric systems like oligo-p-phenyleneethynylenes (OPEs) with different alkyl or glycol side chains. By specific ligand design, he has reported NMOF materials prepared in one step that mimic the lotus leaf in its self-cleaning property and subsequent oil-water separation.

To further enhance the processability of such hybrid materials, he developed 'soft' gel materials by self-assembling low molecular weight gelators (LMWG) with different metal ions. These soft materials were exploited for light-emitting, including white light, catalysis based on the synergistic effect of metal ions and LMWG. Prof. Maji has made a significant contribution to the field of porous organic polymers (POPs) for energy harvesting, generation and conversion. Prof. Maji's group has put forward a design strategy to fabricate metal-free photo-catalytic conjugated microporous polymers (CMPs) by linking donor nodes and acceptor spacers for H2 production from water. His group has successfully shown excellent electrocatalytic activity from metal-free, purely organic systems, as well as MOF, derived carbon materials for electrocatalytic (ORR, OER and HER) activities. Further, he showed metal-free POPs for photocatalytic water splitting for H2 generation and opened up a new avenue to developing materials for conversion of solar/chemical energy to clean fuel generation. His research works also encompass stimuli-responsive optoelectronic materials for molecular recognition. •

PROF. TNC VIDYA

Science in the Forest

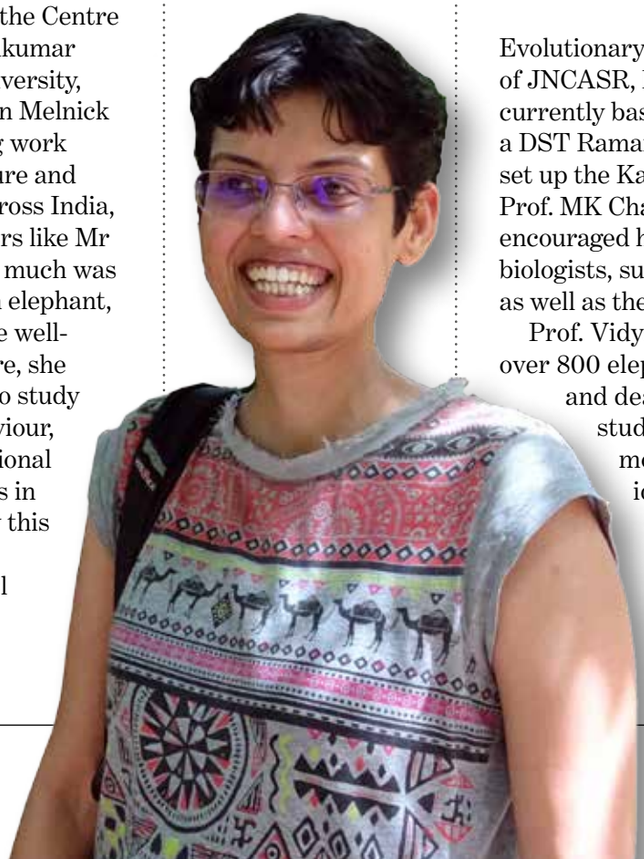
Prof. TNC Vidya, inspired by Salim Ali and Gerald Durell, grew up fascinated by the living world. She credits her family, especially her siblings and parents, for being extraordinarily supportive.

Prof. TNC Vidya's mother, Kamala Rangarajan, was a bank clerk before resigning to raise a family, and her father, TNC Rangarajan, was a Central government employee and High Court judge much later. After excelling at academics and sports in school, Vidya did her BSc in botany, zoology, and chemistry, and was awarded the Dr VSR Grandi's Gold Medal in 1997 for best academic performance, as well as the best all-rounder award. Vidya credits her school, St. Michael's Academy, Chennai, and St. Francis' College, Hyderabad, for a wonderful education.

Vidya joined the Integrated PhD programme at the Indian Institute of Science (IISc), Bengaluru, in 1997, in order to study animals, and was impressed by the courses of Prof. R Gadagkar and Prof. V Nanjundiah. Her PhD (2005) research was carried out at the Centre for Ecological Sciences, IISc, with Prof. R Sukumar as thesis advisor, and partly at Columbia University, New York, in collaboration with late Prof. Don Melnick and Dr Prithiviraj Fernando. This pioneering work on Asian elephant population genetic structure and phylogeography led her to work in forests across India, and with inordinately skilled elephant trackers like Mr Krishna in Mudumalai. She realised that not much was known about the social organisation of Asian elephant, which was thought to be similar to that of the well-studied African savannah elephant. Therefore, she proposed to set up a long-term programme to study Asian elephant social organisation and behaviour, and identified Nagarahole and Bandipur National Parks, centred around the Kabini backwaters in southern India, as the ideal field site to carry this out.

After a post-doctoral stint at Prof. Michael Cherry's lab at Stellenbosch University, South Africa, to study a different system – social mongooses, Prof. Vidya joined the Evolutionary and Organismal Biology Unit (EOBU) of JNCASR, Bengaluru, in August 2008, where she is currently based. She was among the first to receive a DST Ramanujan Fellowship, which allowed her to set up the Kabini Elephant Project. Eminent biologist, Prof. MK Chandrasekharan, then Chair of EOBU, encouraged her in this, as have other renowned wildlife biologists, such as Prof. Mewa Singh and Ajay Desai, as well as the Karnataka Forest Department.

> **"Success comes from reading, cogitating, teaching, and researching, with the desire to understand."**



Prof. Vidya's group has individually identified over 800 elephants and recorded scores of births and deaths; this is the only such long-term study in India (and one of a few worldwide) monitoring hundreds of individually identified Asian elephants. The group collects multidimensional data, on physical IDs, multilocus genotypes from dung-extracted DNA, demography, resources, locations, and behaviour. They have elucidated the social structure of female and male Asian

AWARDS

- Young Scientist Award, Indian National Science Academy (2007)
- Prof. CNR Rao Oration Award (2017)
- Nominated by INSA as a Young Leader at the Young Leaders' Programme (2014)

PUBLICATIONS

- 'Group size differences may mask underlying similarities in social structure: a comparison of female elephant societies'. *Behavioral Ecology* (2018).
- 'Seasonal variation in female Asian elephant social structure in Nagarahole-Bandipur, southern India'. *Animal Behaviour* (2017).
- 'A range-wide phylogeography of the Asian elephant (*Elephas maximus*) based on mitochondrial DNA'. *Proceedings of the Royal Society of London, Series B* (2009).
- 'Musth and its effects on male-male and malefemale associations in Asian elephants'. *Journal of Mammalogy* (2020).
- 'Rethinking inheritance, yet again: inheritomes, contextomes and dynamic phenotypes'. *Journal of Genetics* (2015).

Clockwise: Feeding a visitor of a different species at JNCASR, Bengaluru

Going to the field during her postgraduation in Mudumalai during 1999

Scanning for elephants at Kabini, Nagarahole and Bandipur National Parks

Approaching a seagull in South Africa

Measuring an elephant footprint in Nagarahole National Park. Prof. Vidya's group has individually identified over 800 elephants and recorded scores of births and deaths; this is the only such long-term study in India (and one of a few worldwide)

During a field visit in Borneo during 2019

Inset: INSA Young Scientist Medal

elephants, shown how group size constraints resulting from different ecologies might result in differences between the social structures of related species, and have tested predictions from classical socioecological theory, relating food resource availability, agonistic interactions, and dominance relationships. Current work involves examining the role of calves in female elephant society, food competition amongst males, and analysing the paternity of males to estimate the variance in reproductive success. Prof. Vidya credits her excellent students with making all this work possible. Long-term monitoring provides a treasure trove of data that can be used to address many other questions also in the future.

Prof. Vidya's lab has also worked on communal roosting in mynas, comparative phylogeography of large mammals in the Western Ghats, agent-based simulations for population size estimation, and conservation genetics issues using noninvasive sampling. The latter involved helping the Karnataka Forest Department estimate the minimum population size of elephants in a high elephant-human conflict area of Hassan district, and inferring social structure, which had management implications for the capture or translocation of those elephants. She is also part of the Foundations of Genetics and Evolution Group, an informal collaboration with professors Sutirth Dey, Amitabh Joshi, and NG Prasad. This group works on foundational issues in evolutionary biology, such as an extended conceptual framework of inheritance and niche construction.

After some uncertain and challenging times at the end of the Ramanujan Fellowship, Vidya became a Faculty Fellow and, subsequently, Associate Professor in 2017. She enjoys spending time in the field, watching elephants and other wildlife, as well as teaching and interacting with students.

Prof. Vidya received the INSA Young Scientist Award in 2007, and Prof. CNR Rao Oration Award in 2017. She also represented the country, as a nominee of the Indian National Science Academy, as a Young Leader at the Science and Technology in Society Forum, Kyoto, in 2014. She is a Founding Member and Fellow of the Indian Society of Evolutionary Biologists (ISEB) since 2018, and Member of the IUCN-SSC Asian Elephant Specialist Group since 2007. She also handles substantial teaching and editorial responsibilities, including being an editor of *Resonance – Journal of Science Education*, published by the Indian Academy of Sciences. •

DR VIDITA VAIDYA

For the Love of Science

Dr Vidita Vaidya spent her early childhood on a verdant research campus in Goregaon, Mumbai, as her parents are doctors and clinical researchers. Additionally, during her graduation, the experience of working in her paternal uncle, a molecular parasitologist's, laboratory in the US hooked her to science.

With an undergraduate degree in life sciences and biochemistry from St Xavier's College Mumbai, she went to pursue her PhD in neuroscience from Yale University under the mentorship of Professor Ronald Duman. Following two postdoctoral fellowships, with Prof. Ernest Arenas at the Karolinska Institutet, Stockholm, Sweden, and Prof. David Grahame-Smith, Oxford University, UK, she returned to India to set up her laboratory in the Department of Biological Sciences at the Tata Institute of Fundamental Research (TIFR) in 2000.

The purpose of Dr Vaidya's laboratory is to understand the molecular and cellular mechanisms that contribute to the neurobiology of mood disorders. Her research team has made important contributions to this field using two major approaches: first through a study of key adaptive changes that are evoked by monoaminergic pathways in response to chronic antidepressant treatments, and second by examining the persistent alterations in animal models of depression, in particular those based on early adversity.

Dr Vaidya's seminal contributions to this area of work come through an understanding of the mechanisms that regulate hippocampal neurogenesis demonstrating a key role for monoamines and monoaminergic receptors, as well as thyroid hormone and the TRalpha1 receptor.

Dr Vaidya's group was the first to show that norepinephrine regulates adult hippocampal neurogenesis, and that specific noradrenergic receptors regulate multiple stages of the process of hippocampal neurogenesis. Despite, the strongly pro-proliferative effects of norepinephrine, alpha2-adrenoceptors robustly down regulate progenitor turn. Dr Vaidya's team has provided an elegant demonstration that by using a targeted strategy of blocking effects on the alpha2-adrenoceptor at the same time as elevating norepinephrine levels through the use of a classical antidepressant. Her group's work capitalizes on behavioral models with face validity for human depression, and has important translational implications. These studies strongly implicated the alpha2-adrenoceptor as a key target for fast-acting antidepressant treatments.

> **"Share your joy and love for science – a sense of wonder is a contagious thing so surround yourself with those who seek it."**

Dr Vaidya's work has also helped in understanding the effects on plasticity evoked by neurohormones, like the thyroid hormone. Her group provided the first evidence that thyroid hormone regulates adult hippocampal neurogenesis. Specific thyroid hormone receptors (TRs) regulate hippocampal neurogenesis with a role for TRbeta in proliferation and TRα1 in the postmitotic survival of progenitors. Their work established for the first time the role of TRα1in mediating the key proneurogenic switch during adult neural stem cell development. Dr Vaidya's work showed that unliganded TRα1 is a key mediator

AWARDS

- Fellow, Indian Academy of Sciences (2021)
- Nature Award for Excellence (2019)
- Shanti Swarup Bhatnagar Award (2015)
- Fellow, Indian National Science Academy (2015)
- National Bioscience Award (2012)

PUBLICATIONS

- 'Chronic postnatal chemogenetic activation of forebrainexcitatoryneuronsevokes persistent changes in moodbehavior'. *ELife* (2020).
- 'Serotonin regulates mitochondrial biogenesis and function in rodent cortical neurons via the 5-HT2A receptor and SIRT1-PGC-1α axis'. *PNAS* (2019).
- 'Hippocampal HDAC4 contributes to postnatal fluoxetine-evokedepression-likebehavior'. *Neuropsychopharmacology* (2014).
- 'Early stress evokes-age-dependentbiphasic changes in hippocampalneurogenesis, Bdnf expression and cognition'. *BiolPsychiatry* (2013).

Clockwise: Receiving the 2019 Nature Excellence in Mentoring Award

During a training session with her students in 2021

Discussing data for a manuscript with her co-authors

During an outreach activity session with school children at the Brain Camp, 2018

With co-organizers Rene Hen (L), Amar Sahay (R) at the Adult Neurogenesis' conference, TIFR, 2015

With her colleagues on the occasion of receiving the Shanti Swarup Bhatnagar Award

Inset: Speaking after receiving 2019 Nature Mentoring Award

of the deleterious effects of hypothyroidism on adult hippocampal neurogenesis. Strikingly, her group also showed that faster-acting antidepressant treatments, and adjunct treatments with thyroid hormone tap into developmental signaling pathways, such as Sonic Hedgehog (Shh), thus hastening effects on structural plasticity. This work has identified key leads for future drug development of rapid-action antidepressants, and has opened up the possibility that fast-acting antidepressants may exert their effects on adaptive plasticity by reactivating developmental pathways within the adult brain.

Most recently, her group has demonstrated a profoundly important role for the mood-modulatory neurotransmitter, serotonin, demonstrating that it increases mitochondrial biogenesis and bioenergetics in cortical neurons. Dr Vaidya and colleagues have elegantly dissected the entire pathway that mediates these effects, demonstrating a key role for the serotonin 5-HT_{2A} receptor and the sirtuin, Sirt1.

Dr Vaidya's group has worked on identifying persistent alterations in emotional neurocircuitry that arise in animal models of depression. Using the maternal separation (MS) model of depression, the nominee has shown that MS animals exhibit enhanced 5-HT_{2A} receptor-mediated responses across the life-span, and that pharmacological blockade of the 5-HT_{2A} receptor during early life, reverts anxiety and depressive behaviours to normal. Their work has also shown that postnatal elevation of serotonin exerts persistent pro-anxiogenic and pro-depressive effects via the 5-HT_{2A} receptor. Using state-of-the-art chemogenetic tools, Dr Vaidya's team has demonstrated that activation of Gq-mediated signaling in excitatory neurons of the forebrain during a critical postnatal window is sufficient to programme life-long increases in anxiety, despair and schizophrenia-like behaviour. This work has made significant contributions towards identifying the precise neurocircuits that early adversity impinges upon, that in turn mediate the persistent behavioral consequences of early trauma.

Dr Vaidya's work has shown that diverse stressors regulate brain-derived neurotrophic factor (BDNF) expression in an age and stressor-specific fashion. Early stress evokes persistent epigenetic signatures that result in a life-long dysregulation of BDNF expression accompanied by neurogenic and cognitive changes.

Her work has far-reaching implications for India which is facing the burgeoning crisis of mental health disorders, and an aging population with enhanced risk for neurodegenerative disorders. •

INDEX

INDEX