

Indian Academy of Sciences, Bengaluru – Annual Meeting*

The 84th Annual Meeting of the Indian Academy of Sciences saw enthusiastic participation of members from the scientific and teaching community across the nation, with 89 Fellows and Associates of the Academy and 44 invited teachers attending the event. Spread across two and a half days, the meeting featured two special lectures, two public lectures, inaugural lectures by newly elected Fellows and Associates of the Academy and two symposia. The book *Institution Building – The Story of IISERs* was released by C. N. R. Rao (JNCASR, Bengaluru) during this event.

The presidential address by Ram Ramaswamy (JNU, New Delhi), was on the role of chance in nature. Indeed, nature relies on chance. Even in the realm of deterministic classical physics, seemingly simple systems have inherent uncertainties. An attempt to predict their behaviour calls upon chaos theory, which tells us that a system is sensitive to initial conditions (basins), and that outcomes (attractors) can be unpredictable. Attractors can be numerous and mutually exclusive, making the system multistable, which finds applications in switches/logic gates. A biological system is inherently noisy, and chance plays a major role in when and which reactions occur. This gives rise to complex behaviour patterns by which a biological system can explore new behaviours, thus allowing evolution. Life originated as a chance event. Ramaswamy concluded by quoting J. Monod that chance is fundamental and unavoidable, but here we are.

Two public lectures were organized as part of the meeting. Geshe Ngawang Samten (Central Institute of Higher Tibetan Studies, Varanasi), began his talk introducing the audience to the philosophy of Buddhism, the basic principle of which lies in transforming the mind by achieving states of tranquility, concentration and the understanding of reality. He discussed how at one point in the 1980s, Buddhism had attracted scientists from

various scientific disciplines, including physics, neuroscience and astronomy, to participate in an interactive discussion on the state of mind, the concept of emptiness, and so on. Buddhist philosophy states that you can train your mind to block out negativity, to accept reality and achieve 'happiness'. Samten spoke on how studies have found that meditation and behavioural changes influence neuroplasticity and epigenetic changes in the neurons. He concluded by stating that apart from paying attention to the 'external material science' which is no doubt important, one must also pay attention to the research of our 'inner world'.

In the second public lecture, Shabana Azmi (actress and activist) spoke on the changing face of women in Hindi cinema. Indian mythology, and hence Hindi cinema, have portrayed women playing a secondary role to men. Women have been stereotyped as the sacrificing mother, wife or sister, or as a complete vamp. In the 1970s, parallel cinema changed this mould and began showing women as complex and real. But it is mainstream cinema that has a larger impact on society, and this change came slowly, with women initially being portrayed as just a female hero or a rebel to be tamed. This has changed and movies by Satyajit Ray and Shyam Bengal showed a lot of sensitivity to women. Film makers should be sensitive enough not to objectify women, and the audience has responsibility in not accepting such portrayals, she added. Drawing from personal anecdotes, she said art should be used to bring about social change by creating a climate of sensitivity.

The special lectures held this year addressed the controversial subject of GM crops and the state of affairs in the fields of information technology and artificial intelligence (AI). Imran Siddiqi (CCMB, Hyderabad), speaking on the topic of transgenics, explained the basics of its molecular biology, describing herbicide tolerance and *Bt* technology. Although not with its merits, the technology has severe drawbacks such as imposing a strong selection for the emergence and spread of resistant weed. Siddiqi illustrated this citing the example of glypho-

sate-resistant weeds and Monsanto's take on it. He spoke about the pitfalls of the field, including private monopolization of the technology that seeks instant profits without rigorous testing and excessive reliance on a single technological solution rather than employing a variety of approaches, which would be more ideal. He emphasized on the point that although farmers in their desperation may be more oriented towards short-term gains, regulatory processes must consider long-term sustainability, including environmental costs that the technology may incur.

A special lecture was delivered at the close of the meeting by Vijay Chandru (IISc, Bengaluru). While tracing the development of AI, he cautioned against the misunderstandings and myths about it. A real intelligence does not break when the problem is changed slightly, and a black box cannot explain why a solution or prediction is good. He added that India had made great strides in AI since 2006; for example, the StrandOmics platform had developed algorithms and databases for the interpretation and reporting of clinical data, and had reduced costs in gene sequencing. NITI Aayog has released a national strategy on AI in five focus areas. The new developments in AI lie in deep learning and large training sets, requiring huge computing power. He called for bodies like the Academy to advice the public and the Government on the challenges and opportunities that lay ahead in AI, intelligence augmentation and intelligence infrastructure.

The meeting also comprised two symposia. The first on 'Materials of Today and Tomorrow', focused on the future of materials lies in green technologies using natural materials, in miniaturization and in hybridization of living and non-living materials. Space and nuclear industries require composites capable of withstanding large temperature fluctuations. In this symposium, chaired by A. K. Ganguly (IIT Delhi), the great strides made in materials science and the challenges that lay ahead were described.

Rapid urbanization of India has increased energy demand. The Government's

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mandate to make all vehicles electric by 2030 and to decrease the country's carbon footprint requires improvements in batteries. To reduce the cost of batteries and improve their energy efficiency, new materials for anodes and cathodes must be developed. Vijayamohan K. Pillai (CERI, Karaikudi) mentioned that the materials of anodes in lithium ion batteries are well controlled and designed. Despite great strides in materials, the cathode and electrolytes are still facing challenges. He said that Indian technologies were being developed for Li-ion batteries, but would see commercial success only much later.

Avesh K. Tyagi (BARC, Mumbai) spoke on the design of new functional materials. He provided examples of his work on the design, structure and methods of materials for energy storage, oxygen storage, ionic conductivity and dielectrics. Another important development is regarding methods for separating nuclear waste for useful applications and for immobilizing radioactive wastes.

New materials are being discovered every day. What makes them good biomaterials is a holistic property known as biocompatibility. Various research groups across India are studying potential biomaterials for tissue engineering, production of implantable devices, etc. Bikramjit Basu (IISc, Bengaluru) spoke about scaffolds that promote osteogenesis in the case of *in vivo* studies using high-throughput *in vivo* data. He defined 'biomaterialomics' as a discipline integrating the use of computational tools with large-scale databases and 'materiome', which involves capturing biological responses of materials by analysing the transcriptome. He outlined the challenges of developing biomaterials in India, majorly focusing on the need for multi-group collaborative studies. He also touched upon the concept of 3D printing of materials that can promote stem-cell differentiation.

The final talk of the symposium dealt with thermoelectric materials, which allow direct conversion between heat and electric energy, and find application in power plants, automobiles and in the new space power generation. Thermoelectric materials must have low thermal conductivity (like glass) and high electric conductivity (like metals), which is a challenge to produce. Kanishka Biswas (JNCASR, Bengaluru) spoke of his group's efforts to produce such materials

using extrinsic methods (by introducing dopants and defects) or intrinsic methods (by changing bonds and lattice properties) to achieve low thermal conductivity at room temperature. He spoke of the materials – TlInTe₂ and AgCuTe – that his group worked on to achieve this by changing phonon modes by intrinsically changing the bonding in these materials. The symposium concluded with a lively interaction between the speakers and members in the audience.

The second symposium titled 'Community Health – A Genomic Perspective' was chaired by Rajiva Raman (BHU, Varanasi). He began by addressing the question of community health and how it is being impacted by the new knowledge accrued from genomic studies. In his introductory note, Raman spoke on expectations raised and challenges posed by researches in the area of genomic medicine and community health.

Alok Bhattacharya (JNU, Delhi) dilated upon the enormous phenotypic and genetic heterogeneity in neuro-muscular disorders. While the molecular basis of disease pathology in a few diseases such as Duchenne muscular dystrophy (DMD) has been well understood, there are many others of which there is no clear understanding about the relationship between genetic changes and disease phenotype. Complexity in studying these diseases is evident from the fact that: (i) mutations in multiple genes can give similar disease pattern, and (ii) different mutations in the same gene can be seen in different diseases. He emphasized that the development of treatment strategies will depend upon clear understanding of the molecular mechanisms of the causal factors. Continually developing treatment strategies such as exon-skipping could become effective in DMD because one of the common mutations can lead to truncation of the protein dystrophin. Bhattacharya informed that a Trust has been established in India which could support enterprising researches on neuro-muscular disorders.

L.V. Prasad Eye Institute, Hyderabad is a leading research centre on eye disorders in India. D. Balasubramanian (former Director of its research wing) presented a brief account of the genomic and environmental risk factors that cause open angle glaucoma, which occurs at a rather high frequency in old persons, but young sufferers have also been observed. He presented work on the genomics of

primary congenital glaucoma (PCG), which shows high presence in southern India. He also showed the possible ancestry of PCG across the world through haplotype analysis of CYP11B1-associated PCG cases, which suggests a common ancestral origin. In addition to *CYP11B1*, which has been globally identified as the candidate gene for PCG, his group has identified *KLHL26* and *TSHZ2* as novel candidate genes for this disease. The speaker also provided evidence of strategies that have succeeded in treating a large number of affected children. This translational approach as developed, should pave the way for more effective treatments of this disorder.

The third talk in the mini-symposium dealt with cervix cancer, which is among the most prevalent cancers in women, especially in the Indian population. B. C. Das (former Director ICMR-ICPO (now ICMR-NICPR), Noida) explained that while lifestyle is a risk factor of this cancer, the major identifiable cause is infection with human papilloma virus (HPV). The strain most virulent in this case is HPV type16. A simple pap-smear test provides easy diagnosis, but the HPV DNA in cervical smear or urine may predict the individual's susceptibility to developing the cancer. Highlighting the role genomics has played in improving our understanding of the disease and its causative agent, Das pointed out that several antidotes in the form of vaccines, etc. are being developed against HPV, including the India-specific chimeric HPV DNA vaccine. He particularly referred to an indigenously developed triple-conjugate drug with curcumin-folic acid and Doxorubicin, as an effective treatment for possible relapse-free survival of cervical cancer patients, the efficacy of which is currently being tested.

The final talk of symposium strayed into possible 'epigenetic' programming of diabetes in early life. Chittranjan Yajnik (KEM, Pune) focused on 'susceptibility to diabetes in Indians' stressing on non-genetic, modifiable susceptibility factors. He pointed out that Indian babies are amongst the smallest in the world, and this increases their risk of diabetes, which is exaggerated if these small babies grow big in later life. Indians are thin but have high body fat percent (thin-fat phenotype), and this, he said, originates during intrauterine development. It is linked to the mother's nutrition: small

size, micronutrient deficiencies and excess physical activity, all of which are common in rural India. Yajnik also highlighted the role of low B12 and high folate levels in pregnant women in programming diabetes. Modulation of the epigenetic programming by improving maternal and infant nutrition would mitigate the risk of diabetes. The symposium drew much interest and inquiry in the audience that led to a spirited and educative discussion.

As customary, the Annual Meeting also witnessed inaugural lectures by newly elected Fellows and Associates. Sanjay Kumar (BHU, Varanasi) spoke on structural transitions in DNA molecule studies using single molecule force spectroscopy. Living systems are often in a state of non-equilibrium and physiological reactions *in vivo* occur in such conditions. Helicase activity on DNA, for instance, involves ATP acting on it in a periodic fashion. Kumar explained the effect of oscillatory forces of this sort on DNA and showed the existence of dynamical transition where DNA can be transformed from the zipped state to an open dynamic state without changing the physiological condition.

In low-dimensional spin systems, quantum fluctuations are important. In many naturally occurring, low-dimensional spin magnetic systems, quantum fluctuations of spin due to interactions cause frustrations. These lead to many interesting physical properties. S. M. Yusuf (BARC, Mumbai), along with his collaborators, used neutron scattering to explore the magnetic properties of such systems. Their experiments were backed by numerical simulations and theoretical work.

Grass is the primary source of nutrition for sangai (*Rucervus eldii eldii*) and hog deer (*Axis porcinus*), both of which are endangered species found inhabiting the Keibul Lamjao National Park of Manipur, India. Swati Tripathi (BSIP, Lucknow) presented results of her study on dung samples, which she analysed for pollen and non-pollen palynomorphs. The samples were found to contain pollen and phyloliths of grass, aquatic and arboreal taxa, consistent with the extant vegetation of the habitat. Tripathi emphasized on the significance of her findings which will be useful in correlating modern pollen and vegetation, which is otherwise challenging considering the difficulty to accomplish the same during seasonal floods that affect the region.

In traditional computer architecture, memory and computing are well separated. In analog neural networks, memory and computing are intertwined. Spintronics is well-suited for these as it is non-volatile and compact, and consumes less energy. Debanjan Bhowmick (IIT Delhi) has simulated spintronic synapse devices using micromagnets and benchmarked them against experiments. He has simulated on-chip learning of different types of neural networks using spintronics, with the goal to fabricate and characterize such spintronic neural networks in order to explore learning paradigms closer to the actual functioning of the human brain.

As the world moves towards increasing use of renewable energies, their storage is becoming paramount in order to prevent wastage and timely release of energy during peak hours. Electrochemical batteries, such as Li-ion batteries, and supercapacitors are efficient and compact, and can be scaled up for use in electric vehicles, but a cost factor is involved. Alternatives with improved efficiency and cost are being considered. Aninda J. Bhattacharya (IISc, Bengaluru) spoke of the advances and challenges in developing Li-F2, metal-chalcogenide, metal-S and even metal-air (which uses atmospheric oxygen) batteries.

Evolutionary biologist Deepa Agashe (NCBS, Bengaluru) spoke on the relevance of microbiomes in the development and evolution of eukaryotic hosts. She works with dragonflies and butterflies and she spoke about her experiments with manipulating the microbiomes in wild populations of these organisms. The insects were shown to harbour distinct bacteria across different stages of their developmental cycle, but most of the species had shared groups of bacteria across each stage of their development. Agashe described how she observed large dietary shifts in butterflies which occur without resorting to reliance on mutualistic bacteria. She also spoke on her research on red flour beetle *Tribolium castaneum*, which was found to acquire distinct microbial communities in new diets, allowing it to adapt to the new diet.

Bhisma K. Patel (IIT Guwahati) spoke about his work on the incorporation of heteroatoms into polycyclic aromatic hydrocarbons to fine-tune their chemical and physical properties. Regiospecific annulations were observed and the emis-

sion properties were studied. It was found that some of the polycyclic heteroaromatics that were synthesized exhibited fluorescence and aggregation-induced emission. Since they are bio-compatible, they can be used as fluorescent bio-probes for cell imaging.

Upscaling Li-ion batteries from use in smart devices to automobiles and power grids requires new materials for the electrodes. Jeevanjyoti Chakraborty (IIT Kharagpur) and his group modelled silicon anodes to study the challenges that lay in upscaling. Silicon anodes, due to heterogeneous diffusion of Li during charging, show differential volume expansion and hence stress. Since they are constrained axially and can grow radially, there is buckling. With these conditions, the group attempted to upscale a cylindrical silicon nanoparticle to the battery level.

CP violations could be the reason for the observed matter and antimatter asymmetry in the universe. CP violations are observed in quarks, but the search for them in leptons is still on going. CP violations could be due to neutrino oscillations. Srubabati Goswami (PRL, Ahmedabad) mentioned that the T2K and VOVA accelerators of Japan and USA respectively, had measured many parameters of neutrino oscillations, but the India-based Neutrino Observatory is expected, in conjunction with T2K and NOVA, to have increased sensitivity to atmospheric neutrinos and measure other parameters, thus answering questions on CP violation.

Suvendra Nath Bhattacharyya (IICB, Kolkata) talked about factors controlling microRNA activities in mammalian cells. He delved into the cellular and extracellular factors and mechanisms involved in the regulation of exosomal export of miRNA as an effective gene expression control strategy. He also connected this to ongoing research on miRNA-exocytosis-mediated control of lipid metabolism in liver. Inter-organelle interaction dynamics via spatio-temporal uncoupling controls miRNA activity in translational repression. Bhattacharyya addressed the role of molecular players that he identified as part of this interaction.

Copy-number variations (CNVs) are genomic structural variations involving duplications and deletions of nucleotide sequences. Nallur Ramachandra (UoM, Mysuru) introduced CNVs as powerful tools for genome analysis. His team has

performed genome-wide genotyping identifying 44,109 CNVs from 1717 genomes across 12 human populations. A large number of CNVs were identified in chromosomes 14, 8, 2 and 15, while lesser number of CNVs were found in chromosomes 13, 20 and 18. The study also allowed tracing the path of human migration.

Due to lateral growth with slope-dependent speeds and relaxation mechanisms, the large-scale behaviour of naturally occurring growth models, such as the ballistic deposition model and corner growth model, has sub-diffusive height fluctuations and non-Gaussian scaling limits. A large class of such models are believed to exhibit universal behaviour in the so-called Kardar–Parisi–Zhang universality class, which is empirically also seen in many real-world phenomena such as mutant bacterial colony formation, in the slow combustion of paper, and in the coffee ring effect. Riddhipratim Basu (ICTS, Bengaluru) described the serious mathematical challenges in rigorous understanding of these models,

particularly beyond the limited class of exactly solvable ones. He also described a new approach combining the exactly solvable inputs together with geometric understanding which is recently being pursued by him and his co-workers, and has yielded some promising results.

Jayanth Vyasnakere (APU, Bengaluru) introduced the field of cold atoms and the necessity of artificial gauge fields. He then showed how a nonabelian gauge field induces a Rashba spin orbit coupling (RSOC) in an interacting system of fermions. He demonstrated that a new kind of Bose–Einstein condensate can be achieved using RSOC. This is made out of a novel kind of bosons, named Rashbons, whose properties are solely governed by RSOC. Finally, he showed, by a calculation of quantum fluctuations, that RSOC can help boost the transition temperature of weak superfluids.

Ergodic hypothesis describes the long-term behaviour of chaotic systems. Using ergodic theory and harmonic analysis, Anish Ghosh (TIFR, Mumbai) estimated

Diophantine exponents of points on affine varieties. This has connections with the theory of automorphic forms and Ramanujan’s conjectures.

Parthasarathi Dastidar (IACS, Kolkatta) spoke about supramolecular gels and coordination polymers, and their potential in crystal engineering. He described about self-assembled fibrillar networks as part of designing supramolecular gels and cited examples of gelation-inducing supramolecular synthons developed by his group using simple organic salts. The applications of these molecules range from containing oil spills to drug delivery and synthesis of non-steroidal anti-inflammatory drugs.

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MEETING REPORT

When science meets art*

In a first of its kind, a one-day workshop on communicating science through Madhubani folk art was organized at Mohali.

The workshop was conducted by Bitasta Das (Indian Institute of Science, Bengaluru) and Pratik Prabhakar (Madhubani artist and Assistant Art Coordinator at Bihar Museum, Madhubani, Bihar). The workshop was open to all students, researchers and scientists at IISER-Mohali.

Today, there is widespread experimentation in using art as a tool for communicating science in the education sector. This workshop was organized with the aim of introducing students, young scientists and researchers in harnessing the synergy of art and science to communicate their research to a non-scientific audience.

The workshop consisted of two sessions. In the first session, Das and Prabhakar spoke about the uniqueness of folk art with emphasis on Madhubani, a traditional and popular folk art form from the

Mithila region of Bihar. The history of Madhubani – its origin, its basic components and contemporary adaptations were some of the topics that were discussed. Prabhakar also showcased his work explaining the many ways in which he has incorporated themes depicting present-day social and societal practices in his paintings, giving them a modern twist.

The second session of the workshop provided participants an opportunity to try their hands at Madhubani painting, with Prabhakar guiding and helping them in conceptualizing and painting science-based themes.

The workshop gathered positive responses from both the participants and the experts. ‘Relating art to science is fantastic. We did not have anything like this before’, said Inayat, a third-year undergraduate student. Neerja Sahasrabudhe (Department of Mathematics) echoed Inayat’s opinion. ‘I thought it was excellent. It’s a great idea to understand science through art. In fact, geometry and topology are very open to interpretation through art’, she said enthusiastically.

Das believes traditional folk art such as Madhubani can help build conversations between the scientific community and the public. ‘Scientists are at one end of the spectrum while the public on the other extreme side’ said Das, reflecting from her own experiences and observations. This workshop was also the first time Prabhakar was interacting with scientists. ‘I am very glad to have been a part of this workshop. I always thought workshops such as these took place abroad. It’s nice to know research institutes like IISER are organizing them too. It’s a wonderful approach,’ he said.

In recent times, both scientists and policy makers in India have been vocal about the need for communicating science amongst the public, to help develop a scientific temperament. Workshops such as these help in bringing fun back into science; a place where scientific ideas can be repacked and presented in creative and engaging ways.

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