

Indian Academy of Sciences, Bengaluru – 28th Mid-Year Meeting

The Mid-Year Meeting of the Indian Academy of Sciences, Bengaluru was held between 30 June and 1 July 2017 at the Indian Institute of Science, Bengaluru. The meeting included a public lecture, 2 special lectures, 12 lectures by Fellows/Associates and a symposium on molecular machines.

The session began with a special lecture by K. Ullas Karanth (Wildlife Conservation Society, Bengaluru) on 'Conservation science at the macro-ecological stage'. With India occupying only 2% of the world's area and unparalleled in its tremendous natural laboratory, Karanth drew the attention of the audience to the immense challenges that the country faces in terms of the 60% of land-dependent poor and growth in economy at 7–8%, putting a lot of pressure on biodiversity. He talked about his initial work with tigers in 1989 that provided important statistics on the animals such as predatory activity, use of space territoriality, etc. Later he switched to numbers to provide the population estimate, survival, recruitment and other difficult parameters using distance sampling and capture–recapture method. Karanth then expanded his study across the whole landscape of 30,000 km² for about 15 years which has led to a massive database on tigers. He started to look at wider landscapes and realized that tigers moved through fragmented landscapes which still have permeability to wildlife. Karanth mentioned that it has become critical how infrastructure projects are put in place. He talked about how macro ecology has become a government monopoly wherein affiliated institutions are given unlimited funds with no review and are also given permits to access protected areas with no expectation of publications or yardsticks for success. For people wanting to study wildlife, entry is barred to the natural laboratories, with access to these laboratories controlled by the management. Karanth provided a tentative solution to this problem – a different Act that governs activities such as wildlife research, film-making, etc. that non-consumptively use these resources. Such stakeholders must not be governed by the Wildlife Protection Act, which is meant to deter criminals. Karanth concluded his address by stating that progress

can take place alongside conservation, if we are intelligent about it.

New Fellows and Associates who were elected recently by the Academy presented their work. The first lecture was by V. Subramanian (CLRI, Chennai) on 'Exploring the changes in structure of α -helical peptides adsorbed on to carbon and boron nitride-based nanomaterial'. He talked about the interaction between α -helical peptides and single-walled carbon nanotubes (CNTs). The observations indicated that interaction of CNTs with α -helical peptides causes helix breakage at regular intervals. He also discussed the length-dependent stability of α -helical peptides upon adsorption to single-walled CNTs. Small globular proteins having smaller helices may be less affected, whereas proteins having longer helices may be considerably disturbed. Salient findings also indicated that structural changes in helical peptides increase with decrease in the curvature of boron nitride-based nanomaterials.

The second lecture was on 'Topological phases of quantum matter' by Sumathi Rao (Harish-Chandra Research Institute, Allahabad). She talked about her work carried on in topological field theories, edge state of the quantum Hall problem, edge structures of integer quantum Hall effect, Weyl semimetals, Josephson effect in Weyl semimetals and Majorana modes. Her current work is now part of a global effort to theoretically understand these topological phases.

Debabrata Dash (BHU, Varanasi) in his talk provided excerpts from his studies that involved photo-thermal ablation of thrombus using NIR-active nanomaterials like gold nanorods. In an experiment, thrombus formation was induced in mice. Gold nanorods were injected into mice to target the fibrin-rich thrombi. NIR laser was applied that led to clot disintegration with the blood flow restored. This is the first application of photo-thermal therapy to combat thrombus. Addition of streptokinase accelerated the photo-thermal disintegration of thrombi even at a significantly lower dose, thus minimizing side effects and adverse complications.

Most DNA replication studies, are focused on model organism *Escherichia coli* and higher eukaryotes. Replicative

mechanisms that allow pathogens to multiply are of additional interest because through replications pathogenic microorganisms which enter the body in microscopic amounts manage to cripple an entire living system with disease. Suman K. Dhar (JNU, New Delhi) focused on research where he studied key regulators involved in DNA replication processes of *Helicobacter pylori* and *Plasmodium falciparum* that could serve as potential targets for therapy in diseases, including gastric ulcer, gastric adenocarcinoma and malaria.

In the domain of non-equilibrium physics, transport is a universal phenomenon. To explain these driven systems like heat conduction and electricity, Arvind Ayyer (IISc, Bengaluru) and his group used two toy models of particles moving along a linear array with different probabilities in different directions. Based on the asymmetric simple exclusion process (ASEP), the steady state problem was solved using Matrix Ansatz, and the current, density, phase diagram, diffusion constant, etc. were calculated. The ASEP was generalized to a model with several species of particles with periodic boundary conditions (applicable to electric fields). Using Matrix Ansatz, the phase diagram was determined, which showed rich phenomena on the boundaries. They found that there is a limiting direction in which particles move after a sufficiently long time. Thus, according to Ayyer a conjecture by Lam on the limiting direction of a random walk in an affine Weyl group was proved by computing correlation functions in the multispecies ASEP.

In his talk on the science of formal safety assurance of embedded electronic systems, Pallab Dasgupta (IIT Kharagpur) mentioned that formal methods are increasingly finding applications in areas that are not limited to computational sciences. He gave examples of systems using formal methods such as pacemakers, atomic reactors, driverless systems in metro trains, train collision avoidance systems, antilock breaking systems in cars and other cyber critical systems that may not be safe, despite all the testing that is carried out. Dasgupta and his team carry out work on verification problems in integrated circuits in

digital signalling, automotive control, avionic software, smart power grids and network access controls.

While researchers dig into the reasons behind the worrisome trend of weakening summer monsoon in the Indian sub-continent, many interesting facts come to light, including greenhouse gases (GHG) and aerosols. This was highlighted in the talk by Raghavan Krishnan (IITM, Pune). He described the development and use of a novel global climate model with high-resolution zooming over South Asia, to understand the decline in rainfall. Discussing the physical mechanisms of the South Asian monsoon response to GHGs and aerosol forcing, Krishnan emphasized upon simulations which suggest that aerosols play a far more important role in reducing monsoon than GHGs. It was further shown that monsoonal weakening under climate change significantly enhances occurrence of localized intense precipitation events compared to global warming response. Krishnan also discussed the role of change in land use and land cover, and rapid warming of the equatorial Indian Ocean in weakening the South Asian monsoon.

Amitava Patra (IACS, Kolkata) discussed the current status of light-harvesting nanomaterials such as semiconducting quantum dots, metal nanoparticles, semiconductor-metal heterostructures, π -conjugated semiconductor nanoparticles, organic-inorganic heterostructures and porphyrin-based nanostructures. The talk sought to understand the fundamental photophysical and energy transfer processes and exciton decay dynamics in the design and development of efficient light-harvesting systems. Patra discussed the impact of size, shape and composition of quantum dots on the light harvesting capacity, and elaborated on the design and development of potential light-harvesting systems based on hybrid π -conjugated semiconductor polymer nanoparticles, and self-assembled structures of π -conjugated polymers.

To determine electron and structure descriptors of sp² hybridized carbon-based catalysts, Ranjith Thapa (SRM University, Chennai) and his group found that the free energy of OH ion is a quantifying parameter to explain the overpotential of oxygen reaction of a material: a volcano plot between Δ GOH and the activity (negative of overpotential) has already been established. This sug-

gests that the descriptor should be chosen such that it varies linearly with Δ GOH, thereby making it possible to screen and identify the optimal active sites. With boron- and nitrogen-doped graphene as model systems, descriptors based on the π -electronic structure were chosen. The occupancy of Pz (π) electrons of C atoms projected density of states of the various active sites of (i) a single nitrogen atom-doped and (ii) a single boron atom-doped graphene. Correlation of Pz-at-EF of the various active sites of nitrogen and boron-doped graphene with Δ GOH was linear. Δ GOH of any site can be computed by knowing its number of relative positions to the dopants. Thus, Pz occupancy and Pz density at Fermi level are electronic descriptors. Experimental findings were well predicted by computational results.

Shiv Atreya (ISI, Bangaluru) in his lecture 'Dense graph limits under respondent-driven sampling', stated that social networks have received a lot of attention and studies have implemented RDS in order to obtain estimates about properties of hard-to-reach populations. The basic idea is to start with a convenience sample of participants, ask them for referrals among their peers and then iterate the process to reconstruct the network. The main purpose of the talk was to establish a theory of RDS on dense graphs in order to understand the graphs produced under various sampling procedures. Atreya showed that limit of a dense graph sequence obtained through a specific respondent-driven sampling procedure, where the sequence of the vertex-sets is ergodic, can be expressed in terms of the original graph limit and a transformation related to the invariant measures of the ergodic sequence.

Visceral leishmaniasis (VL) also known as kala-azar is caused by the parasite *Leishmania donovani*. The disease is accompanied by a chronic dermal sequel known as post-kala-azar dermal leishmaniasis (PKDL). Mitali Chatterjee (IPGMR, Kolkata) in her lecture 'Post-kala-azar dermal leishmaniasis (PKDL) – *in vivo* veritas' talked about factors contributing towards the immunopathogenesis of PKDL. She discussed the results of her studies on the molecular pathogenesis of the disease, drug efficacy and diagnostic approaches involved. The talk stressed on the need to eliminate PKDL, which although not life-threatening, does serve as a potential disease reservoir.

Members of the RecQ helicase family have been shown to play significant roles in carcinogenesis. Sagar Sengupta (NII, New Delhi) in his talk spoke about the involvement of BLM – a member of the RecQ helicase family – in chromatin remodelling and how it recognizes DNA damage and is recruited to the sites of DNA damage following specific ubiquitination events. He discussed the role of this protein in DNA repair process and homologous recombination. Molecular events that control the turnover of BLM during mitosis and genomic instability following deficiency in its turnover were also elaborated upon. Outlining his research on RECQL4, Sengupta explored the role of this mitochondrial helicase in neoplastic transformation.

The public lecture 'C. Subramania Bharati: Nationalism and Creativity' was delivered by A. R. Venkatachalapathy (Madras Institute of Developmental Studies, Chennai). With respect to science, Bharati had endorsed the view that while application of science in agriculture, manufacturing and commerce was needed, scientific enquiry cannot be dismissed. He also strongly subscribed to the belief that India was, historically, always a leader in the fields of knowledge and enquiry. At the same time Bharati had conceded that, during the world war, with industries in the West on the back foot, India needed to capitalize on the opportunity. He had also indicated that IISc, which owed its origin to the munificence of Tata and the Maharaja of Mysore, should not have been headed by an Englishman. He considered that P. C. Ray should have been made the director.

In her special lecture on 'Vaccines and public health in India', Gagandeep Kang (THSTI, Faridabad) talked about the impact of vaccines, the challenges in India, the future of vaccines, and developing the most challenging vaccines and responding to outbreaks.

Impact of vaccines: Providing statistics on the elimination of small pox and polio using ring immunization strategy, Kang gave examples of the measles outbreak in USA, cases of meningococcal disease in New Zealand and elimination of meningitis A in sub-Saharan Africa to show how vaccines or the lack of them can affect disease. She indicated that vaccines not only prevent diseases, but benefit the society as a whole whereby a 10-year gain in life expectancy in a country, translates to one additional percentage

point of annual growth of income per capita.

Challenges in India: Kang mentioned that the scale of the routine immunization programme, and the ability to move beyond child and maternal immunization are two major problems that India faces. In addition, there is huge heterogeneity in performance across States as policy gets decided at the Centre and is implemented by the States. Also we have ended up with a periodic intensification of routine immunization wherein districts in the country are categorized and a quarter of the worst-performing districts are chosen to improve their performance.

Future of vaccines: Though vaccines are inexpensive in the initial stages, they become expensive on entering clinical testing. One way of making use of this is to ensure the vaccines fail early. In such a case the cost is reduced and the probability of success for the vaccines that do go forward is increased. There are also exploratory clinical studies being conducted that can generate or test a early endurance hypothesis in order to provide information that can accelerate discovery or translation.

Outbreaks and global responses: In case of outbreaks and responses what matters is 'just in case' and 'just in time'. CEPI – coalition for epidemic preparedness innovations – intends to stimulate finance and coordinate vaccine development against priority threat, particularly where the big companies are not willing to solve problems of the developing world where such outbreaks occur. CEPI is required because there is a need for an ethical and regulatory framework that can plan appropriately for rapid response and testing. While India has implementation and development challenges, taking on new vaccine development is a huge opportunity for industry and public health.

With the award of Nobel Prize in Chemistry 2016 'for the design and synthesis of molecular machines', nanoscale molecular machines have attracted increased focus. Honouring the discoveries and exploring the multi-disciplinary nature of the subject, the second day of the meeting had a special symposium on molecular machines.

Debashish Chowdhury (IIT Kanpur) indicated that this multidisciplinary enterprise has benefited from the concepts and techniques of several disciplines,

including physics, chemistry, biology, engineering and nano-biotechnology. He gave a 'Physics perspective of the noise and non-equilibrium in nano machine operation'. This was followed by the talk 'Teamwork in molecular motors: a cell biology perspective' by Roop Mallik (TIFR, Mumbai). Tanweer Hussain (IISc, Bengaluru) talked about 'Understanding the principles of design of molecular machines: A structural biology perspective'. Following this, the last talk of the symposium by Pradyut Ghosh (IACS, Kolkata) explored the concept of 'Synthetic small molecules as machines: a chemistry perspective'.

Chowdhury described the mechanics, thermodynamics and kinetics of these molecular machines. In nano machines, gravitation is forgotten, and the viscosity of the liquid, the molecular shocks of the Brownian movement, viscous forces, etc. make up the physical environment. The motors are driven by noise and have random trajectories. Using examples of a motor protein carrying cargo, Chowdhury indicated that such a motor uses Brownian Ratchet, which does not violate the second law of thermodynamics as it operates far from equilibrium where the law is not applicable. In explaining the kinetics of a system driven by random thermal and chemical noise, he said that the system hops from state to state. The probability of finding the system in a state evolves. How the machine operates, i.e. its stochastic kinetics, is modelled as a Markov process. There are multiple pathways, each with multiple intermediate states with distinct transition rates, between the two arbitrary nodes of the directed network of mechano-chemical states. Probabilities were found using graph theory. To find the distribution of time taken for the transition between two given states (a first-passage time), an example of the dwell time (first-passage time) of a ribosome motor was used by the group. They found that the average velocity of a ribosome motor depended on substrate concentration via a generalized Michaelis-Menten equation. With the same example of distribution of dwell times of the ribosome system, they found that one can get the number of nodes and the rates of transitions by the methods of reverse engineering. Traffic-like collective movements of molecular motors on filamentous tracks (such as poly-ribosomes and tran-

scriptional interference) were studied using totally asymmetric exclusion principle.

The second talk of the symposium addressed the concept of molecular machines with 'intra-cellular transport' as the focus. Mallik delved into the force generated by single motor proteins and why it is imperative that many such molecules work in collaboration to drive motion of cargo within the cell. Using dynein as an example, he illustrated how such motor proteins work as part of a larger complex, where a number of them come together to move phagosomes across the cell. The talk also looked at how kinesin motors in hepatocytes, under the influence of insulin, modulate the transport of lipid droplets to the smooth endoplasmic reticulum, where these are processed to be sent out of the cell as very low density lipoproteins.

The biological function and complexity dictate the evolution of the structural design of these molecular machines and deciphering the three-dimensional structures of biological molecular machines has emerged as a crucial area of research in recent years. Hussain emphasized on the structure of ribosomes – one of the most complex molecular machines of living systems. He elucidated the role of structural biology approaches in capturing the action and associated structural changes of the molecular machine in multiple states in the biological process. He also discussed the role of biochemical and mutational studies in understanding the working of molecular machines.

Tracing the history of development of molecular machines, Ghosh focused on synthetic threaded molecules and their applications as molecular machines. The talk charted the journey of Nobel laureates – Sauvage, Stoddart and Feringa and how they succeeded in linking molecules together to design the molecular machines from a tiny lift to microscopic motors and muscles. Ghosh also discussed his work on the development of threaded systems, such as pseudorotaxanes and rotaxanes.

Sushila Rajagopal, Geetha Sugumaran and Savitha Sekhar, Indian Academy of Sciences, Bengaluru; **S. Priya*** (*S. Ramaseshan Fellow*) Current Science Association, Bengaluru.

*e-mail: priya@ias.ac.in