

## Eightieth Annual Meeting of the Indian Academy of Sciences\*

The 80th Annual Meeting of the Indian Academy of Sciences was held recently in Chennai. The meeting was attended by 200 Fellows and Associates of the Academy, as well as teachers from several colleges. Thirty scientific presentations were made, including two symposia and two special lectures by the Fellows and Associates of the Academy. Public lectures of general interest were held at the end of each day.

The meeting began with the Inaugural and Presidential address, titled 'Inhibition of bacterial transcription: action of antibiotics', delivered by Dipankar Chatterji (IISc, Bengaluru). He emphasized the dangers humanity will encounter as microbes become increasingly resistant to antibiotics. While this is currently a global problem, it is more serious in India, where antibiotics are dispensed without a registered medical practitioner's prescription off-the-counter and most people do not complete the course. Due to an antibiotic, the infection drops and asymptotically goes to zero, implying that some bacteria can survive and acquire resistance to the drug. Antibiotic resistance has been found to develop in 5–10 years and new drugs have to be developed. For instance, tuberculosis (TB), a bacterial infection, currently the biggest killer in the country, was once believed to have been eradicated. However, a seventh of humans still die due to TB. Rifampicin, the traditional drug for TB, is now rendered ineffective because of bacterial resistance. To come up with more effective antibiotics, it is essential to understand the action of drugs and the mechanisms by which bacteria develop resistance. Resistance is acquired mainly by mutations, whereby the RNA polymerase of the bacteria get modified and lead to reduced affinity of the drug; biofilms, whereby microbes form a layer that cannot be penetrated by drugs, and

defending RNA polymerase through protein–protein interactions.

Chatterji mentioned that we are imbibing antibiotics through foods as well especially meat. This he said is a ticking time bomb, as it will only inhibit the bacteria and not kill them, consequently rendering them more resistant to the drug. He advised against indiscriminate use of antibiotics and non-completion of the course. Work in his laboratory aims to identify these mutations and develop drugs that can overcome the barriers.

### Symposia

To commemorate the International Year of Crystallography (2014), a symposium on 'X-ray crystallography' was held. This year marks the centenary of the beginning of modern X-ray crystallography and its identification as the most powerful tool for structure determination of matter. Max von Laue in 1914, and W. H. Bragg and W. L. Bragg in 1915, were awarded Nobel Prizes in Physics for their pioneering work in this field. The following four talks were part of this symposium.

T. N. Guru Row (IISc, Bengaluru) began the symposium by presenting a stamp released earlier by the Indian Postal Department to commemorate the International Year of Crystallography, to the President and the Academy. In his talk titled 'The nature of a chemical bond involving elements in group 14–17 from experimental charge density studies', he discussed some of the recent advances to study weak intermolecular interactions, highlighting his group's contributions to the understanding of the same.

Dhananjai Pandey (IIT (BHU), Varanasi), in his talk 'Complementary role of X-ray, neutron and electron diffraction in materials research', emphasized the complementary roles of X-ray, neutron and electron diffraction techniques. He gave an overview of the historical and conceptual milestones in crystallography before elaborating on his group's work on two functional materials: PZTs and multiferroics.

Shekhar C. Mande (NCCS, Pune) gave an informative talk on 'Early Indian

contributions to crystallography'. He highlighted the Indian contribution to this field, especially those of Bhagavantham, Kedarweshwar Banerjee and G. N. Ramachandran. Towards the end of his talk, Mande emphasized the need for a synchrotron in India.

T. P. Singh (AIIMS, New Delhi) concluded the symposium with his talk on 'Structural basis for therapeutic applications of innate immunity proteins as protein antibiotics'. The proteins of the innate immune system provide the first line of defence against infecting microbes. These proteins recognize the conserved motifs that are present on the cell walls of microorganisms but absent on human cells. His group has carried out extensive binding studies and determined the structures of several complexes of these proteins.

The India-based Neutrino Observatory (INO) being built in Theni, Madurai, is a state-of-the-art, inter-institutional neutrino detector facility expected to begin soon. In order to garner attention and support of the Indian scientific community towards this grand project, a symposium on the INO was organized.

Amol Dighe (TIFR, Mumbai) introduced the audience to the intriguing world of neutrinos. He described the sources (solar, atmosphere and cosmic), types ( $\nu_e$ ,  $\nu_{\mu}$ ,  $\nu_{\tau}$ ) and their strange property of weak interaction, emphasizing why their detection is difficult. He also mentioned the current open questions in the field such as the mass hierarchy problem, CP violation, etc., and spoke of finding solutions with the new INO for many of the puzzles.

In continuation of Dighe's talk, Vivek Datar (BARC, Mumbai) expounded on the current status and future prospects of neutrino mass measurement.

D. Indumathi (IMSc, Chennai) spoke of the global status of neutrino oscillations and the role of INO in understanding them. She mentioned that the INO is being built to mainly detect the atmospheric neutrinos. Also, the ICAL detector designed for the INO will allow us to resolve the mass hierarchy problem and make sensitive CP phase measurements.

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N. K. Mondal (TIFR, Mumbai) presented an extensive report on the development and current status of INO. He mentioned that 2015 marks 50 years of the first Indian attempt to detect neutrinos in the Kolar Gold Fields. He described the salient features of the INO facility: a huge underground tunnel with a 50 k tonne magnetized iron calorimeter (ICAL detector) and a dark matter laboratory unit. These detectors, he mentioned, are highly sensitive for CP phase measurement and can be used to solve the mass hierarchy problem as well. ICHEP is coming up at Madurai and students are already being trained for the same. He urged the timely implementation of this project, as any further delay will only make us fall behind in the world competition.

### Special lectures

Each day began with a special lecture. The first one was by R. L. Karandikar (CMI, Chennai) on 'Power and limitations of opinion polls'.

How can obtaining opinion of, say, 20,000 voters be sufficient to predict the outcome of an election in a country with over 71 crore voters? Do the opinion polls conducted, say, a month before the elections accurately predict what will happen on voting day? Using simple examples, Karandikar showed that accuracy is determined by sample size and does not depend upon population size: by choosing a large random sample, one can ensure that in most samples (99%), the winner in the sample is also the winner in the constituency. Failure to select a random sample can lead to wrong conclusions, he said. Any prediction based on pre-election polls does not have predictive power as far as final results are concerned because of volatility of opinion and unreliability of responses. Exit polls were devised to correct both these effects, he added. He elaborated on the methods used by his group (multi-stage systematic sampling based on various socio-economic parameters that match profiles obtained from the census data at the state level) and highlighted their track record.

The second special lecture was delivered by Ashok Jhunjhunwala (IIT-M, Chennai) on how decentralized  $24 \times 7$  solar power supply to India can mitigate power-cut problems. All over the country,

AC power is being supplied to houses, while most electronic appliances run on DC. So, conventionally every appliance is fitted with an AC/DC convertor, which leads to power loss. A novel approach of additionally supplying parallel uninterrupted DC to houses from solar panels installed on home rooftops can reduce the demand–supply gap. Jhunjhunwala's team has succeeded in providing decentralized solar-powered systems to his laboratory and to an entire village near Chennai. He urged that we take the first innovative steps to develop such green power and hence set an example to the world. He also added that the use of indigenous electric cars will eventually become inexpensive in future.

### Public lectures

The first public lecture was delivered by Gopalkrishna Gandhi, former Governor of West Bengal. India is a land of diverse cultures, tribes and traditions, and it is almost impossible to find one unifying answer to 'Who owns India?' he said. Gandhi categorized India as North, South, East and West based on the population count. With apt examples he voiced the dominance of North Indians over the South in almost all fields. He mentioned that, however, the North, very much like Hindustani music, has brought the gifts and taxes of emotion, impulse and feeling to the Indian political imagination, while the South, more like Carnatic music, has brought the boons of analysis, reason and cogitation. 'Who owns India', he said, is 'not a rhetorical question, but a self-inquiry by the people about themselves in times when blind acceptance is obscuring thought'. He further emphasized that ownership is not of land or people or culture, but is of thought, the software of human lives. He concluded that ideologies based on cultural antiquity, moral infallibility and political superiority make India self-obsessed, self-advertising and self-certifying. So, such ideologies must not be allowed to root in the broad-minded, deep and assimilative India (for more details, see ref. 1).

The second public lecture was by D. Subbarao, former Governor, RBI, on 'India – mega trends'. Much of our worldview is shaped by our daily experiences and exposure to mass and social media. One needs to step back from daily

experiences and discern the mega trends in order to understand the big, albeit gradual, changes that are going to transform our collective and individual futures. In an information-packed lecture, Subbarao spoke of five mega trends, the evidence for these trends, how they came about and their implications, as well as their challenges.

The first mega trend is the shift in terms of trade towards the rural economy, as evidenced in prices that have shifted in favour of the rural economy, which implies improved lifestyles of the rural sector.

The second mega trend he mentioned was contrarian demographic dynamics. India's increasing demography will now start paying dividends as we will provide labour for the rest of the world. But this can happen only if we create jobs, which leads us to the third mega trend – a manufacturing revolution. The only way of creating employment opportunities is through manufacturing with high productivity. There are many challenges to engineering a manufacturing revolution: skill shortage, government labour policies, lack of infrastructure and insufficient exports.

The fourth mega trend is decentralization. Decentralization has kept India together, where states improve by sharing resources. In the future there may be protests regarding this as richer states may not like poorer ones piggybacking on them.

The fifth mega trend is globalization. Subbarao mentioned that globalization comes with costs and benefits. The benefit is that we integrate with the world. The cost is when we are adversely affected by the global financial crisis. We must maximize the benefits and minimize costs, he added.

### Lectures by Fellows/Associates

#### *Chemistry*

Balaji R. Jagirdar (IISc, Bengaluru) spoke on 'Activation of unreactive chemical bonds in small molecules'. Many small alkane molecules are unreactive due to strong sigma bonds. In order to induce reactivity, these strong sigma bonds must be activated. Towards achieving this challenging goal, he described his group's work on the heterolytic activation of these strong yet

inert sigma bonds, their binding to transition metal centres, their subsequent activation pathways and unusual reactivity patterns relevant to activation and functionalization.

K. V. Adarsh (IISER, Bhopal), in a talk titled 'Ultrafast light-induced effects in amorphous chalcogenide thin films', described his group's studies on chalcogenide glasses, an important class of amorphous semiconductors that exhibit remarkable photo-induced changes. He also proposed a new method to synthesize gold nanoparticles on the surface of amorphous chalcogenides and demonstrated ultrafast all-optical switching.

C. V. Ramana (NCL, Pune) spoke about 'Inspirations from natural products: new catalytic methods by metal complexes'. His group focuses on the development of transition metal-catalysed reactions and their application to the total synthesis of natural products of biological relevance. He described his laboratory's work on the development of new reactions inspired by natural products and on the modular strategies for the synthesis-focused small molecules collection.

The human body is homochiral, while many drugs are chiral. Both enantiomers of the drug must be tested as one could be toxic. Obtaining a single enantiomer in pure form is therefore necessary. For this, chirality must be introduced into a reaction, preferably through catalysts. In his lecture titled 'Controlling stereochemistry at the quaternary center through olefin functionalization and desymmetrization', Santanu Mukherjee (IISc, Bengaluru) described his work on electrophilic halogen-induced heterodifunctionalization of unactivated olefins and desymmetrization of prochiral compounds. With the help of bifunctional catalysts, his team could set stereochemistry at quaternary stereogenic centres with high selectivity.

### Biology

Visceral leishmaniasis, popularly known as kala-azar, is a fatal disease if left undiagnosed and untreated. Nahid Ali (IICB, Kolkata) explained her work on developing easy diagnostic tools for kala-azar and also suggested novel strategies to combat the disease.

In his talk on 'Cold-loving microbes: biodiversity, genes and genomes',

S. Shivaji (L. V. Prasad Eye Institute, Hyderabad) spoke of his team's discovery of 74 new species of bacteria living in extreme cold habitats of the Antarctic, Arctic, Himalaya and stratosphere. He also mentioned that they had successfully identified and extracted the gene that allows these bacteria to live in extreme cold conditions.

B. Gopal (IISc, Bengaluru), in his talk entitled 'Studies on sigma factor/anti-sigma complexes reveal a molecular rationale for *Mycobacterium tuberculosis* persistence', mentioned that *M. tuberculosis*  $\sigma$  factors are regulated by transcriptional, translational and post-translational mechanisms. Studying these regulatory mechanisms is important to understand the expression profile, the latent phase and persistors in *M. tuberculosis*. Information on the conditional expression profile of *M. tuberculosis* could substantially influence TB diagnosis and therapy. Structural studies on  $\sigma$ /anti- $\sigma$  complexes provide a basis to rationalize these observations.

The number of people suffering from diabetes has been climbing rapidly over the years. There is desperate need to quell the spread of this disorder. Nikhil Tandon (AIIMS, New Delhi) researches the possible reasons behind this sudden surge and mines patient data for patterns and clues. In his talk on 'Epidemiology of non-communicable diseases in India – across the life course', he mentioned that four decades of data have revealed unexpected results, such as low-BMI (body mass index) infants are likely to gain fat mass at a later stage and are prone to diabetes, while high-BMI infants are likely to pick up lean mass and grow to be healthy individuals. Studies have also revealed that a good lifestyle in early life can do wonders later in life.

Thomas Pucadyil (IISER, Pune) spoke on 'Membrane fission: analyses using novel assay systems'. Membrane compartments within a cell are constantly changing in shape and composition. Nuclear hydrolysis is said to be the energy provider for membrane compartment creation and consumption. There are various mechanisms to understand the process that is taking place in non-equilibrium conditions within the cell. He spoke about the insights his group had gained particularly from monitoring the dynamics of the dynamin-catalysed membrane fission reaction, which is an extreme membrane remodelling event.

Membrane proteins are vital constituents of the proteome of an organism, and are critical for cell recognition, signalling and homeostasis. Outer membrane proteins of mitochondria and bacteria possess the unique commonality of displaying  $\beta$ -barrel structures. It is therefore of interest to address similarities and differences in the folding pathways of these barrels. R. Mahalakshmi (IISER, Bhopal) spoke on 'Membrane protein folding and stability: Underlying similarities in bacteria and humans'. The findings of her group indicate the key contributions of barrel-micelle interactions and interface aromatics to the scaffold stability of this family of proteins.

The ubiquitin pathway has been implicated in the pathogenesis of several diseases and genetic disorders. M. Subba Reddy (CDFD, Hyderabad) spoke about his work on several new functions mediated by canonical and non-canonical ubiquitination in his talk titled 'Canonical versus non-canonical ubiquitination: control of protein fate'.

### Physics

Abha Misra (IISc, Bengaluru) introduced the nonlinear behaviour of carbon nanotube arrays in her talk titled 'Carbon nanomaterials and engineering applications'. Many properties of these arrays have promising applications in the electronics industries, she said.

While the observations of the cosmic microwave background are largely consistent with the Standard Model of cosmology, there are certain observations that need theories beyond the Standard Model; for instance, the primordial power spectrum which shows deficit of power. Tarun Souradeep (IUCAA, Pune) shared the results of decade-long research that has led his group to develop new formalisms and methods to probe the fundamental assumptions of cosmology.

There are many unanswered questions related to the formation and evolution of galaxies. Looking deep into space reveals the formation of early galaxies. Annapurni Subramaniam (IIA, Bengaluru) emphasized the importance of studying Megallanic cloud interactions, star formation in Megallanic clouds and their implications in understanding many aspects related to galaxy formation. She also spoke of upcoming major projects in astronomy.

Colloidal inorganic nanocrystals are generally capped with organic ligands which are typically insulating in nature and thus not suitable for integration in electronic and opto-electronic devices. Angshuman Nag (IISER, Pune) introduced his group's work on colloidal semiconductor nanocrystals with magneto- and opto-electronic properties, a novel approach to achieve organic-free colloidal nanocrystals that are electronically coupled to each other.

#### Computer science

Infections by pathogens carrying the New Delhi Metallo  $\beta$ -lactamase (NDM-1) are a major concern for public health-care today, especially in the Indian subcontinent, as these pathogens show resistance to all the beta-lactam antibiotics. Molecular mechanism and kinetics of antibiotic resistance by  $\beta$ -lactamases are vital for the development of novel antibiotics and  $\beta$ -lactamase inhibitors. Nisanth N. Nair (IIT, Kanpur), in his talk titled 'Supercomputers against superbugs', discussed the results and details of computer simulations that unravelled the molecular mechanism and kinetics based on free energy surfaces. The findings of his group agree well with those from X-ray crystallography.

Many problems that arise in the real world (such as facility location, routing, scheduling, etc.) are difficult to solve because they would require enormous computational resources to find exact solutions. Naveen Garg (IIT, New Delhi), in his talk titled 'Approximation algorithms for hard optimization problems', discussed algorithms that are quick to compute solutions that are close to the optimum.

#### Earth, planetary and atmospheric sciences

Pradeep P. Mujumdar (IISc, Bengaluru) delivered a talk on 'hydrologic impacts of climate change and quantification of uncertainties'. He explained how several global models of hydrology need to be downscaled in order to be able to predict the impacts of climate change. Specifically, he described the results on the Mahanadi streamflow and the urban floods in Bengaluru.

C. Vineeth (VSSC, Thiruvananthapuram) delivered a talk on the importance of optical remote sensing of the terrestrial upper atmosphere based on airglow radiation. These optical emissions from different regions of the upper atmosphere are perfect tracers of many physical, chemical and dynamical processes prevailing therein.

#### Mathematics

K. Manjunath (IISc, Bengaluru) began his talk titled 'Collisions between random walks' with the simple question Polya had raised on random walks: if there are two random walkers, what is the probability that they will meet? He derived counter-intuitive results for questions related to the collisions between random walkers in lattices of more than two dimensions. Although the results are purely mathematical, they can have deep implications for various areas of science, he said.

Eknath Ghate (TIFR, Mumbai) spoke on 'Number theory via representation theory', in which he introduced the Galois group and its representations. He mentioned how some of Ramanujan's famous congruences can be explained using Galois representations. He also connected the number theoretic problem of understanding the reductions of local modular Galois representations to a representation theoretic problem using the local Langlands correspondence.

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