विज्ञान एवं प्रौद्योगिकी विभाग
DEPARTMENT OF
SCIENCE & TECHNOLOGY

Azadi Ka Amrit Mahotsav

The National Academy of Sciences, India

5, Lajpatrai Road, Prayagraj-211002, India

Summary of the Activities, held in the month of October 2023

The National Academy of Sciences, India (NASI), Prayagraj is the first Science Academy of India, established with a mandate- 'Science & Society'. Therefore, right from its inception in 1930, the Academy is striving hard to promote & popularize science & technology, all across the country (through its 22 Chapters now); its Fellows & Members organized/organizing several activities to disseminate scientific know-how and cultivate scientific temperament among the students and general mass.

1. NASI has the two tier structure, i.e. it elects Fellows/Foreign Fellows to recognize the outstanding contributions of the established scientists, on the other hand it also selects bright scientists as Members to enthuse the good work done by them in the realm of Science & Technology; the names of the elected Fellows & Foreign Fellows have been announced (please see **Annex. 1**).

2. The Academy (NASI) celebrated the 130th birth day of its Founder President, Prof. Meghnad Saha on 6th Oct. 2023; and expressing tributes to Prof. Saha, remembered his manifold contributions to the Science in general, and the Academy, in particular (please see the excerpts of the views expressed – **Annex. 2**).

3. A one day workshop on '**From Harappa to Harish Chandra: Our Mathematical Heritage & Legacy**' was organised by the NASI on Oct. 10, 2023 on the eve of the birth centenary of a legendary Mathematician Prof. Harish Chandra (please see the copy of the programme held – **Annex. 3**).

4. Another two days' workshop on **'Science & Technology for Women Empowerment & Rural Development'** was jointly organized by NASI & Pt. Ravishankar Shukla Univ., Raipur on October 13-14, 2023 at Raipur. A brief report is attached herewith as **Annex. 4**.

5. The Academy also actively organized the meetings of Inter Academy Panel for Women in Science; a SWATI Portal (to be activated soon), has been created for easy access of information/data regarding the Women in Science, on a multidimensional web-portal. The IAP has also been reconstituted; and the Presidents of all three National Science Academies have been informed. The reconstituted panel includes distinguished women scientists of India, and the representatives of several departments, including the DST, GoI (please see **Annex. 5**).

6. The Publications of the Academy are also regular; and achieving the desired milestones with good impact factor; also a Special Issue was published by NASI on '**Interface between Biological & Physical Sciences towards *Atma Nirbhar Bharat***' (enclosed herewith –**Annex. 6**).

The NASI-Secretariat also created three Sefie Points as per DST's direction; and a draft ppt (enclosed herewith – **Annex. 7**) was sent to the DST for its kind approval. The **Cleanliness Drive** is on, and reports are being sent to the DST. Several **Programmes for 'Science & Society'** have been conceived by the NASI-Chapters, as per mandate of the NASI.

Annex. 1

The National Academy of Sciences, India (NASI)

Outstanding Research Contributions

of

those who have been recommended

for the

Fellowship & Foreign Fellowship

for the year 2023

Outstanding Research Contributions of those who have been recommended for the Fellowship for the year 2023

ACHARYA, Narottam (b. 1974), PhD, Scientist F, Infectious Disease Biology, Institute of Life Sciences, Bhubaneswar, for his significant contribution in the area of DNA replication in eukaryotes and vaccine development against fungal pathogen *Candida albicans*.

AGARWAL, Vivek (b. 1964), PhD, FASc, FNA, FNAE, Professor, Department of Electrical Engineering, Indian Institute of Technology Bombay, Mumbai, for his contributions to power electronics systems and photo voltaics.

ANILKUMAR, Thapasimuthu Vijayamma (b. 1961), PhD, FNAAS, Scientist G & Head, Division of Experimental Pathology, Sree Chitra Tirunal Institute for Medical Sciences & Technology, Thiruvananthapuram, for pioneering a technology for isolating extracellular matrix of mammalian gall bladder and preparing tissue-graft scaffolds, for human and veterinary regenerative medical applications.

ARVIND (b. 1968), PhD, Professor & Vice Chancellor, Punjabi University, Patiala, for his outstanding works on quantum optics and continuous variable quantum cryptography. He along with his collaborators performed first quantum computing experiment in India. He has designed new protocols for secure quantum communication and has intensively worked on popularisation of science. He also leads the photonics vertical of QuEST, a national program of DST dedicated to quantum science and technology.

ASIF, Mehar Hasan (b. 1973), PhD, Senior Principal Scientist, CSIR-National Botanical Research Institute, Lucknow, for her works on fruit ripening and plant secondary metabolite synthesis using bioinformatics and computational biology. She has extensively worked to identify structural and regulatory genes in Banana, Mango and tomato specifically involved in ripening. She identified various molecular components for secondary metabolic biosynthesis in several medicinal plants, fibre quality and drought responsiveness in cotton and arsenic tolerance in rice.

BAJAJ, Avinash (b. 1980), PhD, Professor, Regional Centre for Biotechnology, Faridabad, for his work on improved delivery of chemotherapeutic drugs and development of small bioactive molecules for combining multidrug resistant bacterial pathogens.

BASU, Anupam (b. 1957), PhD, FNAE, Pro Vice Chancellor, Sister Nivedita University, New Town, West Bengal, for his outstanding contributions in low cost embedded systems, assistive living and natural language processing.

BATRA, Punita (b. 1970), PhD, Professor H, Mathematics, Harish-Chandra Research Institute, Chhatnag Road, Jhunsi, Prayagraj, for her outstanding contribution in the theory of Lie Algebras. She gave complete classification of almost compact real forms on affine Kac –Moody Lie Algebra which have been much cited.

BHAGAVATULA, Lakshmi Vara Prasad (b. 1969), PhD, FASc, Director, Centre for Nano and Soft Matter Sciences (CeNS), Bengaluru, for his major contributions in the field ofsynthesis of metal nanoparticles and their assemblies and applications of soft and nano-materials

BHANDARI, Rashna (b. 1972), PhD, Staff Scientist VII, Centre for DNA Fingerprinting and Diagnostics, Hyderabad, for her significant contribution towards understanding the chemistry and biology of polyphosphates and establishment of the first mouse model to study polyphosphates.

BHASKARAN, Prasad Kumar (b. 1970), PhD, Professor & Head, Department of Ocean Engineering & Naval Architecture, Indian Institute of Technology Kharagpur, Kharagpur, for his significant contributions in the field of costal oceanography specifically regional wave prediction model for North Indian Ocean, tsunami modelling, tropical cyclones induced storm surges and coastal flooding

BISWAS, Debabrata (b. 1974), PhD, Senior Principal Scientist, Molecular Genetics Division, Indian Institute of Chemical Biology, Kolkata, for his contribution on understanding of SEC mediated transcriptional regulation and its implication on mixed lineage Leukemiafusion protein mediate leukemogenesis.

BISWAS, Ranjit (b. 1969), PhD, Senior Professor, SN Bose National Centre for Basic Sciences, Kolkata, for successfully implementing the interplay between experiments, formulation of theory, and computer simulations and making noteworthy contributions in several areas, including deep eutectic solvents and ionic liquids.

CHADA, Raji Reddy (b. 1973), PhD, Chief Scientist & Chair, Department of Organic Synthesis & Process Chemistry, Indian Institute of Chemical Technology, Hyderabad, for his outstanding contributions in organic synthesis towards human healthcare. The methodologies developed by him on the reactive sp-hybridized carbon resulted in diverse molecules having relevance to both fundamental and applied chemistry.

CHANDRA, Poonam (b. 1975), PhD, FASc, Associate Professor, National Centre for Radio Astrophysics, Tata Institute of Fundamental Research, Pune, (currently at National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville VA 23903, USA), for her fundamental contributions in the field of electromagnetic counterparts of gravitational waves. She has contributed to the study of magnetic massive stars and discovered a rare Cyclotron Maser Emission (ECME) in them.

CHATTOPADHYAY, Buddhadeb (b. 1979), PhD, Associate Professor, Centre of Biomedical Research, Lucknow, for seminal contributions towards the development of metal-catalyzed C-H borylation reaction via catalyst engineering to make high-valued N-heterocycles.

CHATTOPADHYAY, Kalyan Kumar (b. 1963), PhD, Professor & Head, Department of Physics, Jadavpur University, Kolkata, for his innovative contributions in the areas of designing novel p-type transparent conducting oxides with band engineering and anionic site doping. His in-depth research on the tunablephotoluminiscence (PL) from functionalized graphene quantum dots explained the origin of the tunable PL emission from such system.

CHATTOPADHYAY, Krishnananda (b. 1970), PhD, Chief Scientist & Head, Structural Biology & Bioinformatics Division, Indian Institute of Chemical Biology, Kolkata, for his significant studies on the early and unexpected events of protein conformation and conformational transition and their implications in model neurogenrative and infectious diseases.

DAS, Amitava (b. 1973), PhD, Senior Principal Scientist, Department of Applied Biology, CSIR-Indian Institute of Chemical Technology, Hyderabad, for his phenomenal work in the area of stem cell biology for regenerative medicines.One of his research findings have led to the development of porous polyethylene glycol polyurethane scaffolds for stem cell delivery for tissue repair.

DATTA, Simanti (b. 1974), PhD, Professor, Centre for Liver Research, School of Digestive & Liver Diseases, Institute of PG Medical Education & Research, Kolkata, for her significant contribution in understanding the Biology of hepatitis B virus and the complex path physiology mechanism. Her work has great potential to be translated into effective therapy for hepatitis B which is still incurable.

DATTA, Sourav (b. 1979), PhD, Associate Professor, Department of Biological Sciences, IISER Bhopal, Bhopal, for his contribution to the understanding of plant-environment interaction. His work focuses on characterization of BBX transcription factors and their role in light signaling. He is also engaged in the characterization of MATE transporters for their role in mediating loco phosphate and aluminium stress tolerance.

DEY, Abhishek (b. 1977), PhD, FASc, Senior Professor, School of Chemical Sciences, Indian Association for the Cultivation of Science, Kolkata, for his seminal contributions towards understanding the reactivity of metallo-enzymes involved in catalyzing chemical transformations which require multiple electrons and protons electrochemically using a combination of synthesis, electrochemistry, spectroscopy and electronic structure calculations.

DUTTA, Sourabh (b. 1967), MD, PhD, FAMS, Professor of Pediatrics, Neonatology Unit, Department of Pediatrics, PGIMER, Chandigarh, for his major contribution to early diagnosis and effective treatment of neonatal sepsis. His focused research on neonatal sepsis has great potential to reduce morbidity and mortality of this disease with major public health significance.

GAUNS, Mangesh Uttam (b. 1970), PhD, Senior Principal Scientist & Head, Biological Oceanography Division, National Institute of Oceanography (NIO), Goa, for his comprehensive study on marine biodiversity and biogeochemistry of the northern Indian Ocean (NIO) which showed how bio-physical coupling changes the food web dynamics and carbon cycling seasonally.

GEORGE, Subi Jacob (b. 1977), PhD, FASc, Professor & Head, NCU & SAMat, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, for his remarkable impact on the understanding of the mechanism of supramolecular polymerization at different scales, and the application of supramolecular organic materials.

GHOSH, Subimal (b. 1979), PhD, Institute Chair Professor, Department of Civil Engineering, Indian Institute of Technology Bombay, Mumbai, for his contributions in hydrometeorology that provide fresh perspective on land-atmosphere interaction in the complex Indian Summer Monsoon System.

GHOSH, Sumit (b. 1980), PhD, Senior Principal Scientist, Plant Biotechnology Division, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow, for his contribution towards novel biosynthetic pathways and discovery of a catalogue of about 20 key enzymes that catalyze crucial reactions in biosynthesis of medically important compounds. Besides, he has provided insights into the molecular basis of the fruit ripening process.

GOGATE, Parag Ratnakar (b. 1975), PhD, FNAE, Professor, Department of Chemical Engineering, Institute of Chemical Technology, Mumbai, for his seminal contribution towards design and scaling stratigies of cavitation reactors**.**

GONGOPADHYAY, Krishnendu (b. 1978), PhD, Professor, Department of Mathematical Sciences, Indian Institute of Science Education and Research Mohali, Sector 81, SAS Nagar, for his notable contribution in the interface between Group Theory and Geometry, dealing with a broad range of issues on the theme, including classification of conjugacy classes, Symmetry groups, classification of isometries etc.

GOPALAN, Jagadeesh (b. 1966), PhD, FASc, FNAE, Professor, Department of Aerospace Engineering, Indian Institute of Science, Bangalore, for his seminal contributions in hypersonics and shock dynamics.

GULATI, Sheffali (b. 1971), MD, FAMS, Professor, Faculty I/C, Centre of Excellence & Advanced Research for Childhood Neuro developmental Disorders, Department of Pediatric, AIIMS, New Delhi, for significantly contributing to the understanding of developmental neurology and epilepsy research in India. The core area of contribution is neuro-muscular disorders.

GUPTE, Neelima (Madhukar) (b. 1956), PhD, Emeritus Professor, Department of Physics, IIT Madras, Chennai, for her significant contributions in the area of Nonlinear Dynamics and Chaos, wherein diverse issues pertaining to congestion in communication networks to multifractality in birdsong were addressed.

JAIN, Deepali (b. 1975), MD, Professor, Department of Pathology, All India Institute of Medical Sciences, New Delhi, for generating novel method of productive biomarker testing in resource constrained settings by containing conventional cytopathology with molecular technique using liquid biopsy specimens. This has led to novel understanding and more procure management of Lung tumors.

JHA, Gopaljee (b. 1980), PhD, Scientist V, National Institute of Plant Genome Research, New Delhi, for contributing to the understanding of molecular mechanism of interaction between rice and sheath blight disease causing fungal pathogen. His work on isolation of rice-associated bacterium that feeds on fungi has received wide appreciation.

JHALA, Yadvendradev V. (b. 1962), PhD, FNA, Former Senior Professor, Wildlife Institute of India, Dehradun; Res. Chandrabhuvan, Darbargarh, Wadhwan City, Gujarat, for designing and supervising the monitoring system of tiger, leopard, and other wildlife species in the Indian subcontinent; particularly ecological studies using satellite telemetry, and conservation genetics which have enhanced our understanding of the behavioural ecology.

KANEKAR, Nissim (b. 1973), PhD, FASc, Professor H, National Centre for Radio Astrophysics, Tata Institute of Fundamental Research, Pune, for his significant contributions to the studies of galaxy evolution and star-forming galaxies during the epoch of galaxy assembly. His careful astronomical investigations have placed the strongest limit on possible secular variation of the fine structure constant and the electron-to-proton mass ratio.

KANUNGO, Suman (b. 1967), PhD, Scientist E, Division of Epidemiology, National Institute of Cholera & Enteric Diseases, Kolkata, for his significant contribution towards estimating disease burden and prevention of enteric infectious diseases, particularly Cholera. His work on Cholera and its vaccine has been truly translational with potential to substantially reduce its related morbidity and mortality.

KAPUGANTI, Jagadis Gupta (b. 1980), PhD, FNAAS, Scientist V, National Institute of Plant Genome Research, New Delhi, for his significant contribution in nitric oxide (NO) biosynthesis and signaling in plants. He has uncovered the role of mitochondria alternative oxidase in NO biosynthesis. In addition, he has investigated the role of this NO pathway in seed germination, plant metabolism and defense pathway.

KAPUR, Manmohan (b. 1975), PhD, Professor, Department of Chemistry, IISER Bhopal, Bhopal, for developing several innovative methodologies for C-H and C-C functionalizations via transitional metal catalysis for site-selective and catalyst-controlled functionalization of pi-deficient N-heterocycles.

KARTHIKEYAN, Ganesan (b. 1970), MD, Professor of Cardiology, Cardiothoracic Sciences Centre, All India Institute of Medical Sciences, New Delhi, for his contribution to the management of rheumatic heart disease and mechanical heart valve thrombosis. His work has impactful management of cardiovascular disease.

KEMPAIAH, Kemparaju (b. 1964), PhD, Professor, Department of Studies in Biochemistry, University of Mysore, Mysuru, for his significant contribution in the area of snake venom pharmacology, platelet and neutrophil biology. He demonstrated that NETosis is the key mechanism of viper bite induced sustained tissue decay which can be alleviated by deoxyribonuclease treatment.

KHARWAR, Ravindra Nath (b. 1967), PhD, Professor, CAS in Botany, Institute of Science, Banaras Hindu University, Varanasi, for significant contributions in the field of structural and functional diversity of microbial endophytes.He evaluated the neem tissues for endophytic microbial suites with a maiden report on actinobacteria. He has reported functionalized antimicrobial, antioxidant and anticancer compounds from fungal endophytes. Prof. Kharwar also utilized the potential of fungal endophytes in plant growth by alleviating the salt and drought stresses.

KURPAD, Anura Viswanath (b. 1959), MD, PhD, FASc, FAMS, FRCP, Professor, Department of Physiology, St. John's Medical College, Bengaluru, for his primary contribution to the field of human mutation using isotopes. This has led to generation of prime evidence towards defining protein and amino acid requirement for human consumption.

LAISHRAM, Rakesh Singh (b. 1979), PhD, Scientist F, Rajiv Gandhi Centre for Biotechnology, Trivandrum, for his significant contribution in our undertaking of eukaryotic post- transcriptional gene regulation. Specially his work has discovered the novel regulatory functions of non-genomical polyadenylation in diverse biological processes.

LUTHRA, Kalpana (b. 1965), PhD, FAMS, Professor, Department of Biochemistry, All India Institute of Medical Sciences, New Delhi, for her studies on correlation of HIV virus in the human host, particularly in the pediatric population. This along with her work in generating broadly neutralizing human monoclonal recombinant antibodies provides new insight into therapeutic antibodies.

MALL, Rajesh Kumar (b. 1965), PhD, Professor, Dean & Head, IESD, Banaras Hindu University, Varanasi, for his seminal contributions in climate science for deciphering climatechange impacts on extreme weather events, crops, water, and human health and framing resilient adaptation strategies.

MANDAL, Bhabani Prasad (b. 1968), PhD, Professor, Department of Physics, Institute of Science, Banaras Hindu University, Varanasi, for his far-reaching contributions in many areas including non-Hermitian but PT symmetric Hamiltonian and Finite Field BRST transformations in Gauge Theories. In addition, he has devoted special efforts to make STEM education accessible to Visually Impaired Students.

MEHRA, Mani (b. 1979), PhD, Professor, Department of Mathematics, Indian Institute of Technology Delhi, Hauz Khas, Delhi, for his impressive contributions in developing wavelet based schemes to solve partial differential equations on topologically complicated domains.

MITRA, Rahul (b. 1966), PhD, FNAE, Professor (HAG), Department of Metallurgical & Materials Engineering, Indian Institute of Technology Kharagpur, Kharagpur, for his seminal contributions towards processing structure property relation in refractory intermetallic alloys**.**

MUKHERJEE, Srabani (b. 1964), PhD, Scientific G, Department of Molecular Endocrinology, National Institute for Research in Reproductive and Child Health, Mumbai, for her immense contribution in understanding the molecular mechanism involved in the pathophysiology of polycystic ovary syndrome (PCOS). She has demonstrated dysregulation on ovarian angiogenesis in women with PCOS.

MUKHERJI, Suparna (b. 1966), PhD, FNAE, Professor, Environmental Science and Engineering Department, IIT Bombay, Mumbai, for her outstanding contributions in water and waste water treatment and environmental microbiology.

MUKHOPADHYAY, Achintya (b. 1968), PhD, Professor, Department of Mechanical Engineering, Jadavpur University, Kolkata, for his outstanding contributions on reactive system design and strategies for early detection and control of failure in gas turbines.

MYLAVARAPU, Sivaram Venkata Satya (b. 1974), PhD, Professor, Regional Centre for Biotechnology, Faridabad, for his contribution towards discovery of novel molecular mechanism that regulates cell division and the intercellular communication in animal cells. His work has been published in the advanced and high impact journal of cell biology.

NANDI, Ashis Kumar (b. 1967), PhD, Professor, School of Life Sciences, Jawaharlal Nehru University, New Delhi, for his significant contributions to the understanding of Immunity Development in Plants. His group identified novel proteins that are epigenetic regulator of infection memory in plants.

NITTALA, Chalapathi Rao Venkata (b. 1969), PhD(Hyd.), PhD(UK), FASc, FNA, Professor, Department of Geology, Institute of Science, Banaras Hindu University, Varanasi, for his original and path breaking fundamental contributions on the petrogenetic and petrophysical aspects of kimberlites, lamproites, lamprophyres, their entrained xenoliths and mafic dykes which enriched understanding of the mantle processes through geological time.

PANDEY, Jitendra (b. 1962), PhD, Professor, Department of Botany, Institute of Science, Banaras Hindu University, Varanasi, for his innovative research contribution on Ganga River Ecology with special reference to ecological response index for simultaneous prediction of eutrophy and metal pollution; river ecosystem resilience index as a tool for river management.

PATRA, Abhijit (b. 1979), PhD, Associate Professor, Department of Chemistry, Indian Institute of Science Education & Research Bhopal, Bhopal, for his seminal contributions at the interface of supramolecular chemistry, polymers, and physical chemistry with significant impact in the area of functional materials.

PENMATSA, Aravind (b. 1982), PhD, Associate Professor, Molecular Biophysics Unit, Indian Institute of Science, Bangalore, has contributed in the area of Pharmacology especially role of secondary active transporter involved in the neurotransmission during multi drug efflux. He has made significant contribution in the area of understanding the neurotransmitter during antibacterial compound movement across lipid membranes and their block to affect neurological disorder.

RAJADURAI, Chandrasekar (b. 1973), PhD, FASc, FRSC, Professor, School of Chemistry, University of Hyderabad. Hyderabad, for his original contributions by developing organic nano/micro scale photonic materials and technology for use as optical-wave guides, optical resonators, nonlinear optical lasers, and optical circuits.

RAKSHIT, Sujay (b. 1970), PhD, FNAAS, Director, ICAR-Indian Institute of Agricultural Biotechnology, Ranchi, for his keen interest and involvement in genetic enhancement of crops like maize, sorghum, millets, rice, pea, and chickpea using both conventional and molecular tools. He has also been involved in the development of several varieties in maize hybrids and a forage sorghum variety.

RAMAMURTHY, P. Chandrashekarapura (b. 1973), PhD, Professor, Department of Materials Engineering, Indian Institute of Science, Bengaluru, for his outstanding contributions towards developing organic photovoltaics, sensors and ultra-thin EMI shivelding coatings.

RAY CHAUDHURI, Shaon (b. 1973), PhD, Professor, Department of Microbiology, Tripura University, Tripura West, for his contribution towards developing various processes of waste water treatment and products through microbial greening with the focus to reduce, reuse and recycle for environmental substances.

RAY, Manas Chandra (b. 1963), PhD, FNAE, Professor (HAG), Department of Mechanical Engineering, Indian Institute of Technology Kharagpur, Kharagpur, for his outstanding contributions in smart composite structures, nanostructure and strain gradient elasticity.

ROY, Dipanjan (b. 1977), PhD, Associate Professor, School of AIDE, IIT Jodhpur, Karwar, Rajasthan, for using cutting edge technologies of brain imaging and mapping to study. The connectivity of different regions of the brain during normal development and life course, as well as in neurodevelopmental disorders.

SAHOO, Bijaya Kumar (b. 1977), PhD, Professor, Physical Research Laboratory, Ahmedabad, for his novel contributions to the atomic physics that has made it possible for reliable calculations of isotope shift constants of atomic systems and for identifying very neutron rich magnetic nuclei. His calculations have set new limits for the chromo electric dipole moment of the combined up- and down-quarks.

SAMANTA, Luna (b. 1970), PhD, Professor, Redox Biology and Proteomics Laboratory, Department of Zoology, School of Life Sciences, Ravenshaw University, Cuttack, for significant contribution to the field of male infertility and contraception, particularly the role of active oxygen metabolism in testicular development, aging and impairment of sperm function.

SARKAR, Jaydeb (b. 1976), PhD, Professor & Head, Statistics-Mathematics Unit, Indian Statistical Institute, 8th Mile, Mysore Road, RVCE Post, Bangalore, for his outstanding contributions in the area

of operating theory, especially on the theme of the Arveson curvature invariant and characterization of invariant subspaces of a magnificent class of operators.

SENGUPTA, Debarka (b. 1983), PhD, Associate Professor, Department of Computational Biology, Indraprastha Institute of Information Technology, New Delhi, for his immense contribution towards single cell genomics for identifications of rare-cell type discovery and integrating it with microfluids and artificial intelligent to detect tumor cells of rare phenotypes from patient blood. His work has revealed unique cancer mutations that bear clinical relevance.

SHARMA, Archana (b. 1964), PhD, FNAE, Director, Outstanding Scientist, Beam Technology Development Group, Bhabha Atomic Research Centre, Mumbai, for her excellent techno scientific progress in the field of electron beam accelerators, plasma, laser, and pulsed power technologies.

SINGH, Divya (b. 1975), PhD, Senior Principal Scientist, Division of Endocrinology, Central Drug Research Institute, Lucknow, for her significant contribution in the understanding of bone formation and fracture-repair process. She has translated her findings and a few of the lead mutations are under the clinical trial.

SINGH, Ravindra Pratap (b. 1964), PhD, Senior Professor & Head, Atomic, Molecular & Optical Physics Division, Physical Research Laboratory, Ahmedabad, for his pioneering contribution on experimental quantum optics and quantum cryptography. His outstanding experimental work includes indigenous realisation of free-space quantum key distribution. He has also contributed enormously in India's national activities in the domain of quantum communication.

SINGHAL, Rekha Satishchandra (b. 1962), PhD, FNA, Professor, Food Engineering and Technology Department, Institute of Chemical Technology, Mumbai, for her pioneering work on the amalgamation of basic and applied sciences in food chemistry. She developed microencapsulation technologies of sensitive food components and fortification of foods with iron and Vitamin B12 and D. She handled many industrial projects and consultancies.

SUNDAR, Durai (b. 1973), PhD, Institute Chair Professor, Department of Biochemical Engineering & Biotechnology, Indian Institute of Technology Delhi, New Delhi, for his contribution to natural product research for discovering biologically active compounds, in designing/analyzing genome engineering tools to develop their ability to quantitate/visualize genome editing outcomes and applications of Artificial Intelligence/Machine Learning in Biomedical Research.

SURESH, KG (b. 1968), PhD, Professor, Department of Physics, IIT Bombay, Mumbai, for his outstanding significant contribution to intermetallic compounds including magnetic, spintronic and topological aspects, with the aim of identifying novel, potential materials for applications such as magnetic refrigerators, sensors and spintronics specifically magnetocaloric materials and multifunctional Heusler alloys. He is well known for his dedicated teaching.

TANDON, Vibha (b. 1968), PhD, Professor, Special Center for Molecular Medicine, Jawaharlal Nehru University, New Delhi, for her significant contributions in the area of medicinal chemistry. One of the molecules from her research group has been identified that exerts radioprotection of the normal cells during radiotherapy of tumor patients derived xenografts.

UPADHYAY, Ranjit Kumar (b. 1967), PhD, Professor (HAG) & Head, Department of Mathematics & Computing, Indian Institute of Technology (Indian School of Mines), Dhanbad, for his outstanding contribution in the field of non-linear differential equations. He proposed a mathematical model on the issue why chaos is rarely observed in natural population. For the first time, he provided the analytic proof for finite time blow-up of L^p norm in ecological models for large initial data.

VERMA, Praveen Kumar (b. 1966), PhD, Professor, School of Life Sciences, Jawaharlal Nehru University, New Delhi, for his outstanding research focusing on interactions between plant and fungal pathogens. His work has been instrumental in elaborating fungal virulence factors and host resistance function.

YADAV, Bal Chandra (b. 1970), PhD, Professor & Head, Department of Physics, Babasaheb Bhimrao Ambedkar University, Lucknow, for his outstanding contribution to the science and technology of sensor using nanomaterials and devices. He has used various oxide materials, conducting polymers and perovskite materials to detect important gases and other parameters.

YADAV, Om Prakash (b. 1963), PhD, FNA, FNAAS, Director, Central Arid Zone Research Institute, Jodhpur, for his work to understand the adaptive mechanism of crops to drought and water limited environments to develop stress-adapted cultivars of pearl millet, maize and peanut. The results led to identification of drought tolerance and disease resistance and release of 11 commercial cultivars.

YADAVA, Devendra Kumar (b. 1966), PhD, FNAAS, Assistant Director General (Seed), Indian Council of Agricultural Research, New Delhi, for highly significant contribution in oilseed brassica breeding and seed distribution system; released 22 varieties and developed generic resources for pathogen resistance, thermo-tolerance and yield. He has developed unique genetic resources by introgressing genes for resistance to Sclerotinea stem rot, Alternaria blight and thermo tolerance through inter-generic somatic hybridization.

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GUPTA, Nivedita (b. 1974), PhD, Scientist F & In-charge, Virology Unit, E&CD Division, Indian Council of Medical Research, V. Ramalingaswami Bhawan, Ansari Nagar, New Delhi, for her significant contribution in viral research and diagnosis to effectively combat epidemics and pandemics of viruses including high risk pathogens like Nipah, Ebola etc. She has worked tirelessly for over the past 7 years to establish a network of 132 virus research and diagnostic laboratories, which has made India self-reliant for timely detection of viral disease outbreaks and diagnostic testing including COVID-19.

KAILASAVADIVOO, Sivan (b. 1957), PhD, FNAE, Former Secretary to GoI, Department of Space & Former Chairman, ISRO, ISRO Headquarters, Antariksh Bhavan, New BEL Road, Bangalore, for being the mission architect for 104 satellites launched in a single mission of PSLV. He led the flight testing of SCRAMJET engine and technology demonstration reusable launch vehicle (RLV-TD). He has established Mission Synthesis and Simulation Facility, Parallel computing facility and hypersonic Wind Tunnel Facility for ISRO's launch vehicle program.

SOMANATH, Sreedhara Panicker (b. 1963), ME, FNAE, Secretary to GoI, Department of Space & Chairman, Indian Space Research Organization, ISRO Headquarters, Antariksh Bhavan, New BEL Road, Bangalore, for his outstanding contribution in the area of space technology especially system engineering of launch vehicle. Under his able leadership ISRO has made a very successful landing on Moon on August 23, 2023, which has written the successful history of India's Moon Mission making the country's entry into the World leaders in space program.

Outstanding Research Contributions of those who have been recommended for the Foreign Fellowship for the year 2023

ATTFIELD, John Paul (b. 1962), DPhil, FNA, FRS, FRSE, FRSC, Chair, Centre for Materials Science at Extreme Conditions, University of Edinburgh, King's Building, Mayfield Rd., Edinburgh, UK, for his seminal contribution in the field of Chemistry-structure-property relationships in inorganic materials, typically transition metal oxides, nitrides of importance for electronic, magnetic and energy properties. He solved controversial 70-year old problem of how electrons order at low temperatures in original magnetic material magnetite. He is a highly decorated chemist, which include Fellow of Royal Society (2014) and Foreign Fellow, Indian National Science Academy (2019).

CHORGHADE, Mukund Shankar (b. 1953), PhD, DSc, FRSC, President & CSO THINQ Phamra/Adjunct Research Professor, Harvard University, 7 Jones Court, Hillsborough, New Jersey, USA, for his manifold contributions in many areas of Development including Process Chemistry, Development, Industrial Chemistry and Good Laboratory Practices. He is currently helping many Indian universities establish key partnerships and faculty- faculty, student exchanges and faculty sabbaticals with the universities in the USA. He is an elected fellow in prestigious academic societies and has demonstrated skills in management of academic collaborations, global development of new chemical entities.

CHOWDARI, B.V.R. (b. 1943), PhD, DLitt(hc), DSc(hc), Senior Executive Director, Nanyanag Technological University, Singapore, is an internationally acclaimed Materials Scientist with over 350 publications, 25000 citations and H-index of 84. He is Fellow of Singapore Academy of Science, the President of Materials Research Society (MRS) of Singapore and President of International Union of Materials Research Society (IUMRS). His recent interests include the development of electrode and electrolyte materials for Energy Storage applications, including Li-ion batteries. He has nurtured and interacted with all thewith all the Solid State Ionics research groups in India; in particular with those

from Varanasi, Roorkee, Delhi, Chennai, Coimbatore, Bengaluru, Kolkata, etc. As the Executive Director of the “National University of Singapore (NUS) – India Research Initiatives” and Senior Executive Director at the Nanyang Technological University where he led the “NTU – India Connect” initiative.

ECKERT, Jurgen (b. 1962), PhD, FNAE, Director, Erich Schmid Institute of Materials Science Leoben, Austria, for his outstanding contributions in non- equilibrium processing, disordered systems, amorphous and Nano structured materials and structure – property correlations.

GHOSH, Sankar (b. 1959), PhD, Professor & Chairman, Dept. of Microbiology & Immunology, Columbia University, College of Physicians & Surgeons, New York, for his seminal work in understanding the regulation of nuclear Factor-Kappa B (NF-Kappa B), a transcription factor that plays a critical role in regulating the expression of a large number of genes involved in the mammalian immune systems. He is an elected member of the National Academy of Sciences USA (2021) and National Academy of Medicine USA (2022).

Founder President Prof. M. N. Saha

Excerpts of the views expressed by the NASI Council Member & Officials on 6th Oct. 2023: In addition to his outstanding research work which led to what is referred to as the *Saha Ionization Equation* (which many feel should have given him the Nobel Prize) and many other very important research papers, Professor Saha made Allahabad University a world class university; he created the Institute of Nuclear Physics at Kolkata; he moved Indian Association for the Cultivation of Science (usually abbreviated as IACS) to a beautiful Jadavpur campus and transformed it to a world class research organization; he created the Central Glass Ceramic Research Institute at Kolkata and was also responsible for the eventual creation of the Positional Astronomy Centre at Kolkata. Professor Saha also established (in Allahabad) what is now known as NASI, the first Science Academy in India. He also played a very important role in the creation of what is now known as INSA (Indian National Science Academy). And, in the year 1935, along with Acharya Prafulla Chandra Ray, Professor Meghnad Saha established *The Indian Science News Association* (ISNA) publishing the journal *Science and Culture* every month. It is indeed amazing that one person could contribute so much to the development of our nation and it is very difficult to imagine what more he would have achieved had he not died at the early age of 63.

The Department of Physics, UoA, Prayagraj, also celebrated his birth day & centenary of the establishment of the department; NASI also took part in the event.

Annex. 3

Celebration of the Birth Centenary of the outstanding Mathematician Prof. Harish- Chandra

To be jointly organized by

The National Academy of Sciences, India (NASI),

Prof. B.L. Sharma Higher Mathematics Trust

&

Other Institutions of Prayagraj

***Theme:* From Harappa to Harish-Chandra: Our Mathematical Heritage and Legacy**

Date: 10/October/2023 **Timing: 10:00 am**

Inaugural Session (10:00am- 11:00am)	
Welcome	**Dr. Niraj Kumar** Executive Secretary, NASI
Brief Introduction	**Professor R. P. Shukla** Head, Department of Mathematics, UoA; Treasurer, B. L. Sharma, Higher Mathematics Trust
Address by the Chief Guest	**Professor Punita Batra** Harish Chandra Research Institute, Prayagraj
Presidential Remarks	**Professor S. S. Khare** Former Pro-Vice Chancellor NEHU, Shillong President, B. L. Sharma, Higher Mathematics Trust
Concluding Remarks	**Professor U. C. Srivastava** National Coordinator of Science Communication Programmes, NASI
Vote of Thanks	**Professor Swapnil Srivastava** Department of Mathematics ECC; Secretary, B. L. Sharma, Higher Mathematics Trust
National Anthem & Tea Break	

Technical Session (11:30am- 01:30am)	
Speaker I	**Prof. Punita Batra** Harish Chandra Research Institute, Prayagraj ***Title:*** *Life Sketch of Prof. Harish- Chandra and his contribution.*
Speaker II	**Prof. S. S. Khare** Former Pro-Vice Chancellor NEHU, Shillong President, B. L. Sharma, Higher Mathematics Trust ***Title:*** *" Indian Mathematics from Indus Valley to Bramhagupta".*
Lunch Break (01:30pm-02:30pm)	
Speaker III	**Prof. Swapnil Srivastava** Department of Mathematics ECC Secretary, B. L. Sharma, Higher Mathematics Trust ***Title:*** *"Contributions of great Indian Mathematicians".*
Interactive Session Above mentioned Speakers with the participants	
Vote of Thanks & Tea	

Conference Report

Organised by

National Academy of Sciences, India

&

Pt. Ravishankar Shukla University, Raipur

(School of Studies in Biotechnology, University Institute of Pharmacy, and Centre for Women's Studies)

Introduction

Women empowerment aims to strengthen women's spiritual, political, social, and economic capacities. Achieving this involves greater representation of women in decision-making, both in scientific and political spheres. Their voices in governance are crucial for driving societal changes. India, in its 75th year of independence, celebrates "Azaadi Ka Amrit Mahotsav" with a mission to empower women for a stronger nation. In an agrarian economy like India, where 54.6% of the workforce is engaged in agriculture, 41.8% of rural women and 35.3% of urban women are part of the workforce. Rural women, numbering around 350 million, are pivotal in driving social, economic, and environmental transformations. Empowering them not only benefits their families but also contribute significantly to the economy.

The Program

Aim is to create a more inclusive, equitable, and empowered society where women play a pivotal role in driving positive change at various levels - from the grassroots to the national stage. Pt. Ravishankar Shukla University, Raipur, organized a Two-Days National Conference on “Science & Technology for Women Empowerment and Rural Development” during 13-14 October 2023. The conference aimed to bring the views of experts, researchers, academia, and students to the forefront, with the purpose of fostering an environment of intellectual growth, collaboration, and innovation. Through the dissemination of research findings and the exchange of ideas, we aspire to contribute towards collective effort of empowering rural women in India and creating a more inclusive and equitable society.

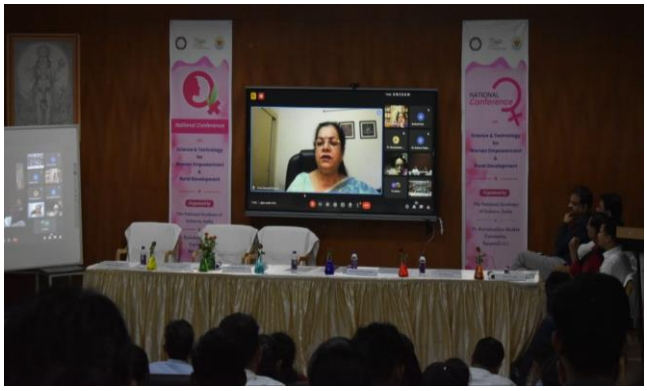
Inaugural Session

The Inaugural Function of the conference was hosted by **Dr Bhanushri Gupta**, Assistant Professor, Centre for Basic Sciences, PRSU, and was began with a Ceremonial Lamp Lighting, followed by the Kulgeet of the University. This function was led by **Prof Keshav Kant Sahu**, Convener of the Conference and Head, School of Studies in Biotechnology, PRSU. Distinguished guests including **Prof Sachchidanand Shukla**, Hon'ble Vice-Chancellor, PRSU; **Mr SS Bajaj**, Director General, Chhattisgarh Council of Science & Technology, Raipur; **Dr Rajendra Dobhal**, Vice-Chancellor, Shree Rama Himalayan University, Dehradun; **Dr Niraj Kumar**, Executive Secretary, NASI, Allahabad; **Prof Paramjit Khurana**, Department of PMB, Delhi University, South Campus; **Dr Pratibha Jolly**, Former Principal, Miranda House, Delhi University; **Dr SJ Dhararwal**, Director, University Institute of Pharmacy, PRSU; **Prof Reeta Venugopal**, Coordinator, Centre for Women's Studies, PRSU; **Padma Bhushan Dr Manju Sharma**, Past President, NASI and Former Secretary to the Govt of India, Department of Biotechnology; **Padma Shri Prof Balram Bhargava**, President, NASI and Chief of the Cardiothoracic Centre of AIIMS, New Delhi; and **Ms Archna Pant**, YWS, NASI, Allahabad. Their warm welcome set the tone of the conference.

Prof Keshav Kant Sahu, Convener of the Conference, delivered a warm welcome address, followed by **Prof Sachchidanand Shukla**, who emphasized the pivotal role of women in science and technology and their progress in the field. **Dr Niraj Kumar** shed light on the initiatives of NASI aimed at addressing challenges faced by women, including programs focused on science communication and education. **Prof Paramjit Khurana** highlighted the various training programs, especially for women from underprivileged backgrounds, and grants aiding schedule tribe women in regions like Uttarakhand and Jharkhand.

Prof Pratibha Jolly delivered a Key-Note address entitled **Rural Women: Science and Technology for an Equal Future**. She eloquently discussed evolving goals in changing times, the mantra of innovation, and how rural India was outpacing its urban counterpart. She emphasized a smart future through participatory action and women's engagement. She also touched upon global challenges and the heightened vulnerability of women during natural disasters.

Mr SS Bajaj Sir spoke passionately about the invaluable contributions of women and their significance in various spheres. **Padma Bhushan Dr Manju Sharma** provided special insights into the endeavors of NASI. The inaugural address of **Padma Shri Prof Balram Bhargava** left an indelible mark, and inspired all the participants. At the last, **Ms Archana Pant** extended a gracious vote of thanks, marking a fitting conclusion of the inaugural function.


Day-1: 13 October 2023

First Technical Session:

The first technical session focused on Women Empowerment was Chaired and Co-Chaired by **Prof Preeti K Suresh** and **Dr Manju Singh** respectively of University Institute of Pharmacy, PRSU. In this session, first Invited Talk was delivered by **Prof SR Joshi** from Department of Biotechnology, North Eastern Hill University, Shillong. Title of the lecture was **Rural Women Empowerment and National Development: Role of Science and Technology in Tribal Society of North-East India**. He highlighted women's involvement in science and technology, discussed DST initiatives for women, and emphasized Northeast perspectives. He also talked about empowerment programs like vermicomposting, mushroom cultivation, and their positive impact on rural communities, along with the benefits of fish farming.

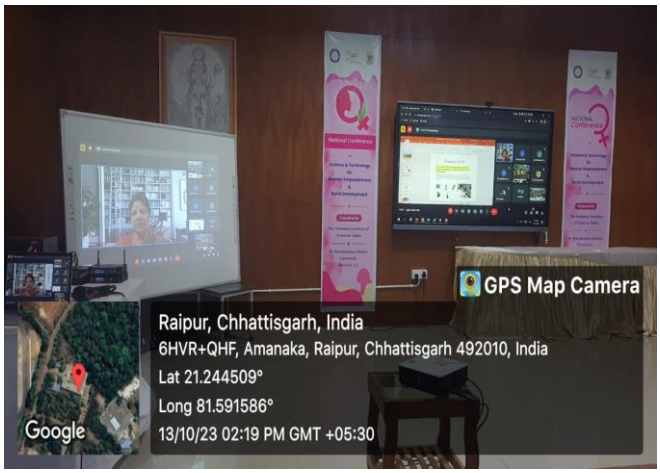
The second Invited Speaker, **Prof Neelam Sangwan** from Central University of Haryana, Mahendergarh, spoke on **Women in STEM: Expanding Horizons**. She discussed the status of women in science and innovation, highlighted notable female Nobel laureates, and emphasized the potential of plant-based natural products in healthcare. **Prof Sangwan** underscored the lifesaving properties of several plant-based products.

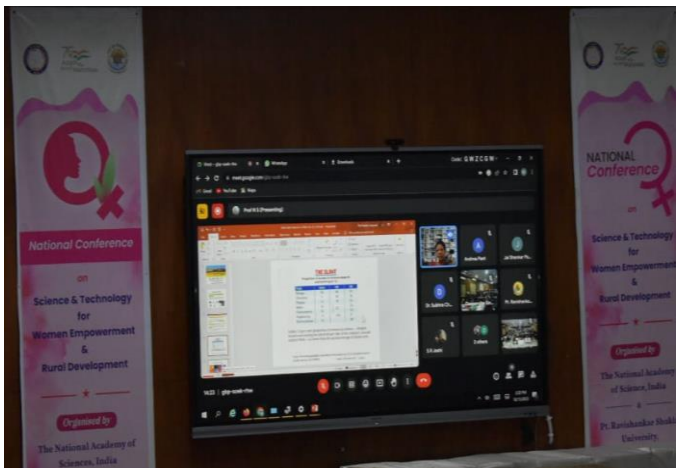
Second Technical Session:

In the second technical session, Prof. Priyamvada Shrivastav, Head, School of Studies in Psychology, PRSU, was present as Chairperson, and Prof. Reeta Venugopal, Director, Centre for Women's Studies, PRSU was present as Co-chairperson. In this session, **Dr N Ranjana,** Director, DSTA, DRDO, New Delhi, served as the first Invited Speaker, who gave a lecture on **"Defence Research & Development: Women Scientists as Harbingers of Change"**. In her lecture, she emphasized that women empowerment is a crucial aim, as it contributes equally to growth and development of the nation. **Dr Ranjana** also discussed about contributions of women in the Chandrayan Mission and their role in driving the economy through advancements in science and technology, which plays a pivotal role in building future of our nation.

Dr Subhra Chakraborty, Director, NIPGR, New Delhi, delivered second Invited Lecture on the topic **"Transforming Lives: Plant Science in Bio-economy"**. She talked solely about empowering women. By spotlighting the accomplishments of eminent women scientists who had received Nobel Prizes, she underscored their substantial contributions to plant science within our nation. This recognition not only celebrated their achievements but also served as an inspiration for aspiring women scientists, furthering the cause of women empowerment in the field of science and beyond.

Thereafter, **Prof Sunil Bhagwat**, Director, IISER, Pune, addressed the vital aspect of rural development through the topic **"Electricity is Regularly Essential for Chilling"**, as third Invited Speaker of this technical session. He emphasized the consistent requirement for electricity, especially in crucial processes such as chilling and pasteurization processes of milk. Additionally, **Prof Bhagwat** explored the potential of solar-based air conditioning systems in India, aligning with the broader goals of rural progress and sustainability.





Poster Presentation:




First day culminated with the exhibition of 34 posters. **Dr Deependra Singh**, Associate Professor, University Institute of Pharmacy, PRSU; **Dr Amber Vyas**, Associate Professor, University Institute of Pharmacy, PRSU; **Dr Vishal Jain**, Associate Professor, University Institute of Pharmacy, PRSU; and **Dr Indrapal Karbhal**, Assistant Professor, School of Studies in Chemistry, PRSU; and **Dr Nagendra Chandrawanshi**, Assistant Professor, School of Studies in Biotechnology were the evaluators of the displayed posters.

The program came to an end with the distribution of certificates to the Chairpersons, Co-chairperons and evaluators. Students were highly benefited from the inspirational lectures of distinguished speakers during the course of the scientific sessions and this served as a vector for their future endeavors.

Day-2: 14 October 2023

The second day of the conference was initiated with the third technical session.

Third Technical Session:

Prof Aditi Poddar, School of Life Sciences, PRSU, and **Prof Ashok Pradhan**, School Studies in Anthropology, PRSU, were served as Chairperson and Co-chairperson respectively of third technical session. Invited speaker **Dr Rajendra Dhobal**, Vice-Chancellor, SRH University, Dehradun, spoke on **"Rural Entrepreneurship- Promotion for Regional Economic Growth"**. He informed about various experiments and programs conducted and successfully completed by him regarding women empowerment, especially in rural areas, and encouraged the students to pursue entrepreneurship.

Fourth Technical Session:

The fourth technical session was Chaired by **Prof KK Ghosh**, School of Studies in Chemistry, PRSU, and Co-chaired by **Prof Arti Parganiha**, School of Life Sciences, PRSU. Invited speaker, **Dr Deepa Khushalani**, Department of Chemistry, Tata Institute of Fundamental Research, Mumbai, gave an overview of **"Soft Skills for a Career in STEM"**. In the lecture, she talked about the importance of soft skills in life. She also stressed how crucial it is for a woman to develop self-confidence and live her own life. The second speaker of the session, **Mr MD Khan**, Senior Consultant, National Institute of Rural Development and Panchayati Raj, Hyderabad, spoke about **"Rural Technology for Women Empowerment and Rural Development"**. He talked about various ongoing schemes of Government of India for women empowerment, and also how thousands of people from different communities are involved in the women's welfare system. He provided facts and gave various successful examples of women entrepreneurs.

Fifth Technical Session (Interactive Session):

This session was an interactive session and was Chaired by **Padma Shri Dr Manju Sharma**, Former President of NASI, and Co-chaired by **Prof Paramjeet Khurana**, Department of PMB, Delhi University, South Campus. In this session, all the Chairpersons and Co-chairpersons like **Dr Preeti K Suresh**, **Pro Rita Venugopal**, **Prof KK Ghosh**, **Dr Manju Singh**, **Prof Arti Parganiha**, *etc*., gave brief remarks about various technical sessions of the conference, and thanked the organizers for conducting this conference.

Sixth Technical Session (Valedictory Function):

The last session of this conference was the Valedictory Function. All the dignitaries from NASI joined this ceremony in online mode through Google Meet. This session was Chaired by **Padma Shri Dr Manju Sharma** Madam. In her concluding remarks she spoke about different technical sessions and congratulated the university for successful organization of the conference, and also spoke about future collaboration. Brief remarks about the conference were given by the convener of the conference **Prof Keshav Kant Sahu** who thanked all the invited speakers and tram NASI for sparing their precious time and their active participation and involvement in the conference. A few of the participants shared their experiences and gave feedback of the conference. At the end, **"Best Poster Presentation Award"** were given to the winners. At the last, vote of thank was extended by **Ms Archana Pant** on behalf of NASI, while **Prof Keshav Kant Sahu** thanked all those persons who were contributed directly and indirectly in the organization of this conference. The conference ended on a fruitful note and lunch was served to all afterwards.

Glimpses of the event:

(Keshav Kant Sahu)
Convener

1.	**Dr. Manju Sharma** Steering Committee (Chair) Former Secretary to the Govt. of India, Department of Biotechnology Former President, NASI Chairperson, NASI New Initiatives
2.	**Prof. Shobhona Sharma** Steering Committee (Incumbent Chair) Chair of INSA 'Women in Science Panel' INSA Honorary Scientist, ICT, Mumbai Former Senior Professor and Chairperson, Department of Biological Sciences, Tata Institute of Fundamental Research, Mumbai
3.	**Prof. Rohini M Godbole** Steering Committee (Senior Member) Centre for High Energy Physics, Indian Institute of Science, Bangalore
4.	**Dr. Renu Swarup** Former Secretary to the Government of India, Department of Biotechnology Ministry of Science & Technology , New Delhi
5.	**Prof. Deepak Dhar** Distinguished Professor, Department of Physics, IISER, Pune
6.	**Prof. Gaiti Hasan** Senior Professor, National Centre for Biological Sciences(NCBS), Bengaluru
7.	**Dr. Madhu Dikshit** THSTI National Chair, Translational Health Science and Technology Institute (THSTI) NCR Biotech Science Cluster, 3rd Milestone, Faridabad – Gurgaon Expressway, Faridabad, Haryana 121001 Former Director, CSIR- Central Drug Research Institute, Lucknow; Former Visiting Professor, Department of Bioscience & Bioengineering, Indian Institute of Technology, Jodhpur
8.	**Dr. Subhra Chakraborty** Director, National Institute of Plant Genome Research New Delhi
9.	**Prof. Gautam I. Menon** Dean (Research) & Professor, Departments of Physics and Biology, Ashoka University (On lien from: The Institute of Mathematical Sciences, Chennai)
10.	**Prof. Somdatta Sinha** Adjunct Professor, Indian Institute of Science Education and Research (IISER) Kolkata, Mohanpur, WB
11.	**Prof. Madhoolika Agrawal** Department of Botany, BHU, Varanasi
12.	**Prof. Ramakrishna Ramaswamy** Visiting Professor, Department of Chemistry IIT-Delhi, New Delhi
13.	**Dr. Shobhana Narasimhan** Professor of Theoretical Sciences Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore
14.	**Dr. Smita Mahale** Former Director, ICMR-NIRRH, Mumbai
15.	**Prof. Shubha Tole** Chair of the Women in Science Panel of the Indian Academy of Sciences
16.	**Dr. Anindita Bhadra** Co-Chair, Global Young Academy (GYA) Associate Dean of International Relations and Outreach, Indian Institute of Science Education and Research (IISER) Kolkata ; Founding Chair and alumnus, Indian National Young Academy of Science (INYAS); Associate Professor, Behaviour and Ecology Lab, Department of Biological Sciences, IISER, Kolkata

17.	**Prof. Latha Rangan** Applied Biodiversity Laboratory (ABL) Department of Biosciences and Bioengineering (BSBE) Indian Institute of Technology (IIT)-Guwahati ,Assam
18.	**Dr. Srubabati Goswami** Professor, Theoretical Physics Division Physical Research Laboratory Navrangpura, Ahmedabad-380009, Gujarat, India
19.	**Prof. Paramjit Khurana** Department of Plant Molecular Biology University of Delhi South Campus, New Delhi
20.	**Prof. LS Shashidhara** Indian Institute of Science Education and Research (IISER), Pune (Currently, on Lien at Ashoka University); Co-Investigator, Pune Knowledge Cluster; President, International Union of Biological Sciences (IUBS)
21.	**Dr. G Taru Sharma** Director, National Institute of Animal Biotechnology (NIAB), Hyderabad Former Director, Center for Advanced Faculty Training in Veterinary Physiology; Physiology & Climatology Division, Coordinator, National Library of Veterinary Sciences, ICAR-IVRI (Deemed University),Izatnagar
22.	**Dr. Sushmita Mitra** Machine Intelligence Unit, Indian Statistical Institute , Kolkata
23.	**Dr. Shilpa Sharma** Additional Professor, Department of Paediatric Surgery, All India Institute of Medical Sciences, New Delhi
24.	**Dr. Namita Gupta** DST Nominee Scientist G, KIRAN DIVISION, Department of Science & Technology New Delhi
25.	**Dr. Alka Sharma** DBT Nominee Adviser, Department of Biotechnology, Govt. of India
26.	**Dr. Hema Rajaram** DAE Nominee Dean (Acad) Life Sciences, BARC, HBNI Head, Cyanobacterial Stress Biology and Biotechnology Section Molecular Biology Division, BARC, Trombay, Mumbai
27.	**Dr. Geeta Vani Rayasam** CSIR Nominee Scientist 'H' Head, CSIR-HRDG, New Delhi
28.	**Dr. Nivedita Gupta** ICMR Nominee Scientist 'F', Division of Epidemiology and Communicable Diseases, ICMR
29.	**Dr. Nigar Shaji** ISRO Nominee Scientist/ Engineer-G,URSC
30.	**Ms. Archna Pant**, Young Woman Scientist, NASI Member Secretary

Annex. 6

Proceedings of the Symposium

on

'Interface between Biological and Physical Sciences towards Atmanirbhar Bharat'

विज्ञान एवं प्रौद्योगिकी मंत्रालय
MINISTRY OF SCIENCE AND TECHNOLOGY
सत्यमेव जयते

THE NATIONAL ACADEMY OF SCIENCES राष्ट्रीय विज्ञान अकादमी ESTD 1930 भारत INDIA

The National Academy of Sciences, India (NASI)

Proceedings (transcribed from the talks of the eminent speakers)

of the Symposium

on

Interface between Biological and Physical Sciences towards '*Atmanirbhar Bharat*'

-Celebrating 75 years of India's independence

(held during the 91st Annual Session of NASI)
December 4 - 6, 2021

The National Academy of Sciences, India (NASI)

5, Lajpatrai Road, Prayagraj-211002, India

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NASI: Brief History, Evolution & Activities

The National Academy of Sciences, India (initially called *The Academy of Sciences of United Provinces of Agra and Oudh*) was founded in the year 1930 with the objectives to provide national forum/opportunities to the Indian scientists for the publication of their research works and exchange of views. The Memorandum of Association was signed by seven distinguished scientists namely Prof. Meghnad Saha, Prof. K.N. Bahl, Prof. D.R. Bhattacharya, Prof. P.C. MacMohan, Prof. A.C. Banerji, Prof. Ch. Wali Mohammad and Prof. N.R. Dhar. Of these, the Academy had the good fortune of having the continued association of Prof. N.R. Dhar until very lately when he expired on December 5, 1986. Apart from being one of the founders of the Academy and taking continued interest in its progress, Prof. Dhar also donated the piece of land on which the Academy building stands today. Since then, the Rules and Regulations of the Academy based on those of the Royal Society of England and the Asiatic Society of Bengal have been revised and updated to meet the emerging challenges. Prof. Meghnad Saha was elected its first President. In the Inaugural address, Prof. Saha Said, "…..But the main function of the Academy should be towards cultural improvement by contribution to human knowledge". Since then, the Academy has crossed many milestones, successfully serving its mandate 'Science & Society'. In its Silver Jubilee Session in 1955, Prof. Saha further emphasized the role of the Academies in developing human scientific resources. Similarly, during the Golden Jubilee Session of the Academy in 1980, Late Shrimati Indira Gandhi, the then Prime Minster of India stressed that the need of hour was to ensure that science does not remain confined to laboratories. The address delivered by His Excellency Sri R. Venkataraman, President of India during the Diamond Jubilee Session (1990-91) was a timely reminder of the vision of late Pt. Jawaharlal Nehru to integrate science with the lives of the people; and the Academy left no stone unturned in pursuing its aim and objectives which was appreciated by His Excellency Dr. APJ Abdul Kalam, President of India, in his address during the Platinum Jubilee Celebrations of the Academy in 2005. Dr. Kalam praised the role of the Academy in boosting the zeal of the budding scientists, who could do better in future with such support and endeavour. The Academy undertakes several 'Science-Society' programmes under the guidance of its President (Presently, Prof. Balram Bhargava), Past Presidents and Fellows. The Past Presidents (who are also very distinguished scientists) like Prof. M.S. Swaminathan, Prof. Manju Sharma, Prof. P.N. Tandon, Prof. Jai Pal Mittal, Prof. V.P. Kamboj, Prof. Ashok Misra, Prof. Asis Datta, Dr. K. Kasturirangan, Prof. Akhilesh K. Tyagi, Prof. Anil Kakodkar, Prof. G. Padmanaban and Prof. Ajoy Ghatak are keenly associated with the Academy and enormously contribute to its development. It is worth mentioning that a few other Past Presidents (unfortunately who are not with us now) as Prof. M.G.K. Menon, Dr. V.P. Sharma, Prof. A.K. Sharma, Dr. T.N. Khoshoo, Prof. U.S. Srivastava, Dr. A.P. Mitra, Dr. S.Z. Qasim and Prof. S.K. Joshi also contributed a lot to the development of Science in general and the Academy in particular, in the recent past. The Academy while starting with 57 ordinary Members and 19 Fellows has now 1944 Members and 1959 Fellows from all parts of the country including 15 Honorary Fellows and 113 Foreign Fellows from various disciplines of Science and Technology. The Academy is financially supported by the Department of Science & Technology, Ministry of Science & Technology, Government of India; and it is also recognized as the Scientific and Industrial Research Organization by the DSIR, Government of India.

NASI envisions the cultivation and promotion of Science & Technology in all its branches through (a) promoting scientific and technological research related to the problems of societal welfare; (b) publication of proceedings, journals, memoirs, transactions and other works as may be considered desirable; (c) organizing meetings and hold discussions on scientific and technological problems; (d) undertaking, through properly constituted committees and bodies, the scientific work(s) of technological or public relevance. (e) co-operating with other organizations in India and abroad, having similar objectives, and to appoint representatives of the Academy to act on national and international bodies; (f) securing and managing funds and endowments for the promotion of science and technology; (g) maintaining a Science Library; (h)

performing all other acts, matters and things that may assist in, conduce to or be necessary for the fulfilment of the above mentioned aims and objectives of the Academy; hence, creating an adequate impact of the Academy all over the country by opening the Chapters of the Academy in other cities/states in the country where reasonable number of Fellows and Members are available. The noteworthy accomplishments with the kind cooperation of its Fellows and Members and financial support of the DST, New Delhi are as follows:

Publications: NASI publishes 'The Proceedings of NASI-Sec. 'A' & 'B', each in IV parts and 'National Academy Science Letters' in VI parts in collaboration with the Springer Nature, every year. More than 1000 papers are received from 50 countries/regions every year.

●National Academy Science Letters has Impact Factor (IF) as 1.2 from Thomson Reuters ● PNASI, Sec. A has Impact Factor (IF) as 1.2 ● The PNASI, Sec. B has Cite Score as 1.7 from Scopus ● Several research papers are published by the NASI-Chairs/Senior Scientists/Honorary Scientists every year. ●In addition, several Books/ Monographs/Book-Chapters with socio-scientific content are published by the NASI.

Science Education/Communication Activities: NASI-HQ and its 22 Local Chapters spread across India are organizing several science education/communication activities in and around their respective regions. More than two dozen Institutes/Laboratories/Educational Institutions (as IITs, NCSM, Medical Colleges, Universities, CBSE, DNA Clubs etc.) are associated with NASI in organizing such programmes. Several students and faculty/teachers have been benefitted from these activities focused on 'Poshan (Nutrition)', 'COVID Appropriate behaviour', 'Entrepreneurship development for *Atmanirbhar Bharat*' (in consonance with the recent national programmes announced by the Hon'ble Prime Minister of India) and so.

Activities under Joint Women in Science (WiS) Panel of three National Science Academies: NASI is heading the joint panel of three National Science Academies (IASc, NASI & INSA) under the leadership of Prof. Manju Sharma, Past President, NASI & Former Secretary to the Govt. of India. A Mega Event on 'Technological empowerment of women' (graced by the then Hon'ble Minister for S & T, Govt. of India and the then Secretary of DST, Govt. of India; Prof. M S Swaminathan, Prof. Anil Kakodkar and about 1000 women scientists) was organized in 2018 after successfully organizing several sensitization programmes in about 17 states of our country for the welfare of women scientists and the rural women by the scientific intervention. The programme is going on with full vigour and NASI looks forward to organize more such national events in future.

Research Projects being undertaken by the NASI-Chairs & Senior Scientists: NASI has undertaken several important research works/projects led by its Distinguished Chairs and the Senior/Hony. Scientists (as Prof. G. Padmanaban, former Director, Indian Institute of Science, Bangalore; Prof. V. M. Katoch, former DG, ICMR; Prof. Ashok Misra, former Director, IIT Bombay, Prof. Amit Ghosh, former Director, CSIR-IMTECH; Prof. Satya Deo, former Vice-Chancellor & Emeritus Scientist, HRI, and many others), aimed towards the development of science in general and the society, in particular. Due to their noteworthy contributions, the NASI has been recognized as SIRO by the DSIR, Ministry of Science & Technology, GoI. The detailed reports have been sent to the DST (as a part of the Annual Reports of NASI); and also available on the website of NASI- www.nasi.nic.in

S&T Entrepreneurship development: ● Training programs for entrepreneurs ● Awareness and Training on Nutrition, Safe drinking water, Health & hygiene etc. included in the spirit of *Swasth Bharat Mission* ● Safe drinking water and pollution abatement, especially for the rural areas and municipal workers. This was included in the spirit of *Swachh Bharat Mission*. 5th Brain Storming on 'Safe Water & Sanitation' was organized at MPCOST Bhopal in Sept. 2019; a large number of scientists, municipal workers, researchers and others attended the brainstorming sessions.

Activities under Scheduled Tribe Sub-Plan Programme: A Mega Event on 'Science & Technology Intervention for the Tribal Welfare' was held at ILS, Bhubaneswar on Feb. 24-25, 2020 in which about 300 participants attended from all across the country representing 22 Tribal Welfare Centres established by NASI. The programme is still going on which would be beneficial for more than 10,000 tribes.

Annual Session/Symposia/Seminars & Scientific Discussions: Every year the Annual Session is organized; also other symposia/seminars are organized on the current scientific topics of societal interest.

The 90th Annual Session of the NASI was organized on WEB (due to COVID-19 pandemic), on February 25-27, 2021 which was attended by more than 300 dignitaries and the participants; a symposium on 'Towards a New Healthcare regime for the Nation' was also held during the session. Several scientific papers were presented in the session.

Fellowship / Membership: To recognize the outstanding scientific contributions of the scientists, NASI awards every year, the prestigious Fellowship/Membership to some of them. More than 100 scientists working in different areas of Science & Technology were selected from all across the country every year. It also awards a few Foreign Fellowships to scientists who are working in different countries and have collaborated with scientists from India.

Science Education Programmes in joint collaboration with National Science Academies: NASI, together with other two Science Academies viz. Indian National Science Academy, New Delhi and Indian Academy of Sciences, Bangalore jointly sponsors the Summer/Winter Research Fellowship under the joint Science Education Panel to provide opportunities to bright UG and PG students and teachers to usefully spend their summer/winter vacations.

Recognition and Awards: NASI recognizes eminent scientists for their contributions in different areas of S&T with conferment of various awards • NASI-Reliance Industries Platinum Jubilee Awards for the application oriented innovations covering both Physical and Biological Sciences to distinguished scientists • NASI Young Scientist Platinum Jubilee Awards to young scientists/researchers in the fields of Biological/Physical/ Chemical Sciences • NASI Senior Scientist Platinum Jubilee Fellowships • Professor M. G. K. Menon Memorial Award • NASI Swarna Jayanti Puruskars for *Best Paper Presentation* to young scientists/researchers during the Annual Sessions • Memorial Lecture Awards to eminent scientists every year • NASI Science and Maths Teacher Awards (by NASI HQ & Chapters) to the best teachers for their contributions.

Major and Unique National Facilities: Apart from the aforementioned activities/accomplishments, the Academy also established two galleries (other than the *Ganga-gallery at Prayagraj*) on the rivers *Brahmaputra and Cauvery at Guwahati* (with the partial support of the Government of Assam) and *Mysuru* respectively (with total support of the Government of Karnataka). This is a unique feature of the Academy. NASI also undertook several projects on water; and scientifically rejuvenated the baolies (step-wells of about 200 years ago) at Bundelkhand area of MP with the scientific support of MPCOST, Bhopal and the BARC, Mumbai. All these facilities have been dedicated to the Nation.

The Academy (NASI) has a well-equipped auditorium of 200 persons capacity, a committee room with all WEB facilities for holding webinars etc., a rich library and a Council Room (Prof. MGK Mennon Hall) for holding meetings.

Important collaborations (national and global) established: a) NASI together with other two Science Academies viz. INSA, New Delhi and IASc, Bangalore, is jointly sponsoring the Summer Research Fellowship under the Joint Science Education Panel; b) Continuing its established collaboration with the Reliance Industries, SCOPUS and Springer for recognizing the talent in scientific research; c) Organized many science communication/popularization activities in collaboration with the Indian Universities/Institutes/CSIR Laboratories/ NCSM and other prestigious institutions.

Symposium on 'Interface between Biological and Physical Sciences towards *Atmanirbhar Bharat*' – *A Prologue*

In the 70 years since **James Watson and Francis Crick** brought Physics and Biology together to unveil the molecular structure of DNA, the boundary between the two disciplines has continued to become increasingly blurred. The outstanding contributions of **G.N. Ramachandran** (a world famous Indian physicist known for creation of the 'Ramachandran plot' for understanding peptide structure) are another such example. He was the first to propose a triple-helical model for the structure of collagen. Other contributors include Nobel laureate **Robert Laughlin** of Stanford University and **Geoffrey West** of the Santa Fe Institute, who are both theoretical physicists with a broad range of biological interests. Several interdisciplinary areas have appeared at the interface between biological and physical sciences. A complex network-based methodology is required to be suggested for analyzing the interrelationships between some of these interdisciplinary areas including Bioinformatics, Computational Biology, Biochemistry, among others. In this post-genomic era, ever more principles from physics have been applied to living systems in an attempt to understand complexity at all levels. Yet, cultural differences still exist between physicists and biologists. It is commonly agreed that the most challenging problems in modern science and engineering involve the concurrent and nonlinear interaction of multiple phenomena, acting on a broad and disparate spectrum of scales in space and time. It is also understood that such phenomena lie at the interface between different disciplines such as physics, chemistry, material science and biology. The multi-scale and multi-level nature of these problems commands a paradigm shift in the way they need to be handled, both conceptually and in terms of the corresponding problem-solving computational tools. Many of the physicists recall collaborations that have yielded long-lasting friendships and significant scientific advances, yet some are more candid about their experiences of working with biologists. An example of this two-way communication is detailed in an entertaining perspective jointly written by biologist **Bonnie Bassler** and physicist **Ned Wingreen** (both at Princeton) who have been collaborating for more than 15 years after randomly bumping into each other at baggage reclaim in an airport in Mexico City on the way to a conference. The perspectives throw up examples of similarly serendipitous meetings, such as the one described by physicist **Herbert Levine** from Rice University who was reading a biology book to learn more about a micro-organism he was studying when he realized that the book's author was actually based in the building next to his. They have now been collaborating for almost two decades.

However, **Athene Donald** from the University of Cambridge is one of a number of scientists who believes that these encounters should not be left to chance; and more needs to be done to bring physics and biology closer together. So, it seems a lot of work still needs to be done on the part of researchers as well as their universities and institutions to ensure that biological physics continues to flourish and scientific advancements on the scale of that of Watson and Crick are repeated.

Realizing this as the need of hour, the Academy (NASI), working for **the betterment of the Society with Science** (as per its mandate), thought to organize a symposium on '**Interface between Biological and Physical Sciences towards *Atmanirbhar Bharat*'** so that the young Indian researchers be enthused to take up the challenging path of such reunion of different disciplines of science & technology for fruitful exciting results leading to the growth of science in general; and our nation, in particular.

The Convener of the symposium, **Prof. Manju Sharma**, Past President, NASI, and former Secretary to the GoI, along with the Co-Convener **Prof. Ashok Misra**, former Director, IIT Bombay & Chair Professor, Indian Institute of Science, Bangalore developed a compact programme incorporating almost all the essential points for discussion; and eminent scientists/technocrats/entrepreneurs having experience of working in different areas of Physical & Biological Sciences gave their kind consent to make it a fruitful brainstorming. **Prof. Ajoy Ghatak**, Former President, NASI took keen interest to ensure the involvement of the expertise from all relevant areas directly concerned with the aim & objective of this symposium.

Brief Proceedings

(*Transcribed from the talks of the eminent speakers*)

Inaugural Session

Welcome & Genesis of the Symposium

Prof. Manju Sharma

I extend a very warm and cordial welcome to all the distinguished speakers, participants, Past Presidents, Council members, Fellows and Members of NASI and others.

Every year, the NASI, the oldest Science Academy established in 1930 by Prof. Meghnad Saha, one of the most eminent scientists of this country, organizes one symposium during its Annual Session, on a subject relating to excellence in science and its applications and benefits to the country. This is as per the mandate of NASI, i.e. Science & Society.

Today, on the occasion of the *Foundation Day* of the Academy, we'll have a 'Foundation Day Lecture' by Prof. Balram Bhargava, DG, ICMR & Secretary, DHR, Govt. of India.

The present symposium on 'Interface between Biological and Physical Sciences towards *Atmanirbhar Bharat'*, through its speakers, will bring out the great importance of interdisciplinary science, cutting across various areas- Physics, Chemistry, Engineering Sciences, Biology, Medical Sciences etc. The importance of Mega projects, particularly, the Inter-disciplinary, Multi-Institutional projects has been globally recognized now in all areas such as Agriculture, Space, Atomic Energy, Biotech etc. Today, scientists prefer large projects instead of being confined to small one; and by bringing together a large number of scientists from all the disciplines, the results are outstanding. We are aware that modern Biotechnology and Biology depends to a great extent on advances in instrumentation. In fact, both the product and technology development are dependent on the areas such as Engineering, Sciences etc. The advanced instrumentation is responsible for most of the discoveries and helping Medical Science having spectacular advancements to move very fast.

We have very eminent speakers, viz. Prof. R Chidambaram, Prof. G Padmanaban, Dr. Mohapatra, Prof. Balram Bhargava and many others to talk on the subjects relevant to *Atmanirbhar Bharat* as reflected from the titles. While discussing the interdisciplinary areas, we would also mention about the new products and technologies coming in the country.

During COVID-19 Pandemic, India has shown its strength in Science, whether it is vaccine availability or other requirements for handling the pandemic and we have moved towards self-sufficiency in this case; not only this, we have also started exporting the vaccine. The efforts of Govt. of India involving the scientific community, health officials and others have been appreciated globally and we have been able to manage the situation to a large extent.

There are very eminent Scientists in the Biological Sciences section starting with Dr. Mohapatra, DG, ICAR; Prof. Akhilesh Tyagi and others. The sessions on Agriculture, Medical Sciences and Entrepreneurship Development comprise the key areas to be focused/ discussed along with the Foundation day Lecture by Prof. Balram Bhargava. The interdisciplinary sciences including physical and biological sciences coming together will help the nation to move towards self-sufficiency.

Theme Address- 1
Interdisciplinary Research: Physical Sciences & Biological Sciences

Prof. R Chidambaram

Traditionally, the natural sciences have been divided into two branches, viz. the physical sciences and biological sciences. Today, an increasing number of scientists are addressing problems lying at the intersection of two. We now have Biophysics which means study of Biological Systems as Physical Systems. Biological crystallography is a good example. There are many interdisciplinary research areas which have become independent disciplines in their own right, like cybernetics, biochemistry and biomedical engineering. Then, we have mathematics present in every discipline; and biological science is not excluded. Biomathematics is the use of mathematical models to help understand phenomenon in many areas of biology including physiology, immunology and evolution. Computational biology includes bioinformatics and is the science of using biological data to develop algorithms or models in order to understand biological systems and relationships; computational biology was nucleated with the advent of DNA sequencing and supported by availability of supercomputers and high-speed networks like Indian National Knowledge Network (NKN). For example, one can create specialized grids (brain imaging grids) for people working in the same area e.g. vascular dementia, Alzheimer disease and neurodegenerative disorders as managed by NBRC. If people want to share their research information or data, they can do it. The techniques used or the approach adopted by the biologist for solving the biological problem is of physical nature and the Nobel Prize is conferred in chemistry; for example, Venki Ramakrishnan an India born British-American structural biologist shared the 2009 Nobel Prize in Chemistry with Thomas A. Steitz and Ada E. Yonath for “studies of the structure and function of the ribosome”. Many problems of Physics and Chemistry are Biological problems. The important area in Biology relates to drug design. Computer-aided drug designing utilizing in silico methods has shown promise for the novel drugs development in cost efficient way in the past few years.

The various computational approaches viz. molecular dynamic studies, ligand locking (crystallography is a useful technique in identifying druggable targets) and quantitative structure function relationship have been utilized in each phase of drug discovery cycle. The physical techniques are now being used at bio molecular and cellular level including atomic force microscopy, theoretical and computational biophysics, time-resolved electron microscopy, biophotonics, X-Ray and neutron scattering; and the biological problems relate to nucleic acid, proteins, complexes and membranes. Some of the problems are targeted therapeutics, i.e. the science of delivering drugs where they are needed in the body at the right time, in the right place (like in cancer) and at the right dose. This requires developing a computer replica of the organ. All this requires skills to work at the life science/ physical science interface. The radiopharmaceuticals can be used to study the functioning of different organs of the body such as heart, brain, lungs and for detection of tumour, determination of hormones etc. Radiations from radioisotopes can also be used for treatment of cancer by teletherapy and brachytherapy. Chemical Engineering & Biotechnology play important role and include engineering of biological process, metabolic and tissue engineering. Catalysts play an important role in chemical reactions. Biocatalysts are used to manufacture specialty enzymes and also employed in the production of pharmaceuticals/ intermediates (antibiotics and statins) and food ingredients (sweeteners & nutraceuticals).Biomedical engineering is the application of the principles and problem solving techniques of engineering to biology and medicine. A Centre for Biomedical Engineering was established in 1971 in the IIT, Delhi as a joint venture with AIIMS, Delhi. In 2001 (its golden jubilee year), the School of Medical Science &

Technology (SMST) was started at IIT, Kharagpur with the objective to provide a platform of interdisciplinary teaching and research in diverse areas of medical science and technology.

The Retro-engineering of brain tumours for personalized medicine requires computational (clinical image data, multi-omic data, AI based continuous learning model) and biological analysis (live cell imaging, flow cytometry, protein arrays) to study the tissues and finally get the functional assays i.e. patient-derived glioblastoma spheroids. There are many examples/instances, where engineering and biology are getting together in medicine and of course for human good. Indian Medical devices market is expected to rise to US$50 billion in 2025. Today, 70-80 % demand is met by imports. In view of this, the Government's new policy is encouraging both FDI and indigenous manufacture. The Medical Device design is clearly interdisciplinary. The need is biological and the device is based on physical sciences. There are very good groups, both in national labs like BARC,CSIR-CSIO,DRDO and universities (IIT B; Prof. B Ravi, Biomedical Engineering and Technological Innovation Centre with 14 partner institutes; and IITM; Prof. Mohanasankar Sivaprakasam, Healthcare Technologies Centre in IITM Research Park etc.) developing indigenous medical devices. Prof. Mohanasankar Sivaprakasam has done tremendous work towards successful technology translation and taking/ transferring the innovation to the industry/ start-ups. The examples include mobile eye surgical unit (closely related to Sankara Nethralaya, a missionary institution for ophthalmic care headquartered in Chennai) related to wireless remote patient monitor 5000 plus devices since August, 2020 release, endoscopy imaging system, image guided spine surgery system etc. The good thing is that all these technologies/devices are being designed in India so that the cost is the fraction of the total imported cost; also, the Indian doctors are accepting them for use. All these reveal successful technology translation and the social impacts of the innovation. Cybernetics deals with communication and control systems in living organisms, machines and organizations; and the outcomes of actions are taken as inputs for further action. It's a precursor to fields such as AI, cognitive science, complexity science and robotics; and has actually evolved into the field of artificial neural networks which are like a massively parallel, distributed processor made up of simple processing units (artificial neurons).

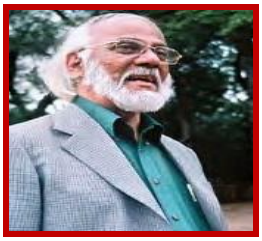
Concluding remarks: Most of the exciting problems in Science and Technology today are multi-disciplinary. Design of nuclear power plants, Space Launched Vehicles or Advanced fighter aircraft in mission oriented agencies are examples of multi-disciplinary technology projects. The borders between science disciplines are continuously getting fuzzy. For example, Density-Functional Theory (DFT) is very popular for the first principal energy calculations in solid state physics; and the scientists in solid state physics and high pressure physics groups in BARC use it routinely now. DFT is equally popular for calculations in quantum chemistry. The border between theoretical chemistry and theoretical condensed matter physics is nearly absent; and very often both handle biological problems. There is a talk of reducing the man-machine divide; and there are people who are scared of long term developments in the AI fields and want international regulation of AI.

Prof. Stephen Hawking once told to BBC correspondence, "…. the development of full artificial intelligence could spell the end of the human race". I do not agree.

Sir Roger Penrose and some other leading scientists argue that humans will always be smarter than computers and computer algorithms or any other cybernetic machines that they create. I agree. Prof. Dror while reviewing the book on Srinivasa Ramanujan, 'The man who knew Infinity', says, "No enhancement of human intelligence opens a door to becoming a Ramanujan; and no algorithm is likely to produce robots with the abilities of Ramanujan".

Theme Address- 2

Covid-19: Meeting Ground for all sciences



Prof. G Padmanaban

I'll take a few specific examples from COVID-19. We know it's a tragedy, basically. Lives and livelihoods have been lost; this is something unheard of, a challenge from a tiny virus. There are few examples where we find that the scientists from multiple disciplines have come together to contribute one way or other. If we consider the Medical Sciences for example, the things have become very prominent in certain areas, which the general public or even the scientists were not much aware of. For example, public health, clinical diagnosis, prevention, therapy, infrastructure and instrumentation have become topics of discussion. Wearing masks, personal hygiene, social distancing, quarantine, mental health, RT-PCR, molecular epidemiology, medicinal chemistry, vaccines, diagnostics, which we were not very familiar with, have now become household words. Molecular Epidemiology has been greatly supported by genome sequencing. DNA sequencing has become so popular and is being recommended by the government as a priority. So, some dramatic changes have taken place on the ground and the scientists from various disciplines viz. Molecular Epidemiology, Medicinal Chemistry, Physics, Biology, Computational Biology, Engineering, Diagnostics, Vaccines- all have come together. The time scale for research has changed. The Vaccine which used to take fifteen years to develop, took two years. So, the expectation of the government as well as the public is very different now. We didn't know many aspects of regulatory sciences viz. the ECGR, the drug controller, the clinical trials etc.

Molecular epidemiology: We all know that the virus, especially RNA virus keeps on mutating. SARS 2 virus is expected to undergo one to two mutations per month. A review in the 'Nature' says that at the end of the pandemic, we'll have millions of sequences. All the mutations were identified; and it became necessary to classify them. So, the WHO came into the picture and classified the mutants as variants of concern, variants of interest and also variants of high consequence and defined them accordingly. 'Variant of Interest' is indicative of the potential and, it can become more transmissible. The classification was possible because of genome sequencing, which became the subject of widespread interest. All the mutations of virus are observed in the spike protein. SARS-CoV-2 genetic lineages in the United States are routinely monitored through epidemiological investigations, virus genetic sequence-based surveillance, and laboratory studies. The US government SARS-CoV-2 Interagency Group (SIG) added a new class of SARS-CoV-2 variants designated as Variants Being Monitored. This class includes variants with substitutions of concern, including previously designated Variants of Interest (VOIs) or Variants of Concern (VOCs), that are no longer detected or are circulating at very low levels in the United States, and as such, do not pose a significant or imminent risk to public health in the United States. The latest variant which has come up and affecting people is 'Omicron'. As per available sequence data, Omicron is characterised by 30 amino acid changes (15 in the receptor binding domain), three small deletions and one small insertion in the spike protein compared to the original virus (A67V, Δ69-70, T95I, G142D, Δ143-145, Δ211, L212I, ins214EPE, G339D, S371L, S373P, S375F, K417N, N440K, G446S, S477N, T478K, E484A, Q493K, G496S, Q498R, N501Y, Y505H, T547K, D614G, H655Y, N679K, P681H, N764K, D796Y, N856K, Q954H, N969K, L981F). This is the highest number of mutations yet seen, many of which are at antibody binding sites and may reduce the effectiveness of neutralizing antibodies. Some mutations have been associated with increased transmissibility in previous variants. Molecular Phylogenetics is another area. Virus Sequencing and Data Analysis were done in many laboratories using different softwares /tools viz. PangoLIN, Nextstrain for assigning; and reports were published in reputed journals and lodged in

GISAID ((Global Initiative on Sharing Avian Influenza Data INSACOG (Indian SARS-CoV-2 Genomics Sequencing Consortium) was first established in 2020 and came into existence few months later. Millions of samples have already been sequenced globally and many institutions in India have been involved in the task of sequencing. A Phylogenetic tree (a branching diagram or a tree showing the evolutionary relationships among various biological species) can be based on sequence analysis performed on DNA or RNA strings, geography (related to another virus) and origin. All such trees could be constructed with different perspectives; the tree may have different clades.

Drugs for COVID 19: There is actually no drug, specific for this virus. Examples of some drugs used: Remdesevir (FDA approved), Dexamethasone etc. Then, there is anti-inflammatory therapy, immune-based therapy including convalescent serum. Some monoclonal antibody medications are also available. These include sotrovimab, a combination of 'bamlanivimab' and 'etesevimab'; and a combination of two antibodies called 'casirivimab' and 'imdevimab' and also certain chemistry-based drugs (being studied or even used) that have uncertain effectiveness. Ivermectin is a parasitic drug. Hydroxychloroquine and chloroquine, anti-malarial drugs are also being used to prevent COVID-19. Since we don't have a drug, it's important to study the biology of this virus and the structure of proteins very carefully. We need to know the mechanism of action of these drugs. There is a latest Pfizer drug viz. PAXLOVID™ which is an investigational SARS-CoV-2 protease inhibitor antiviral therapy, specifically designed to be administered orally so that it can be prescribed at the first sign of infection or at first awareness of an exposure, potentially helping patients avoid severe illness which can lead to hospitalization and death. PF-07321332 is designed to block the activity of the SARS-CoV-2-3CL protease, an enzyme that the coronavirus needs to replicate. Co-administration with a low dose of ritonavir helps slow the metabolism, or breakdown of PF-07321332 in order for it to remain active in the body for longer periods of time at higher concentrations to help combat the virus. There is reduced risk of hospitalization or death by 89% in interim analysis of phase 2/3 clinical trial.

Vaccines: So, from sequencing to phylogenetics to drug discovery, another important area to be highlighted is vaccine. There is an unprecedented interest in vaccines. There is a separate committee which looks into Vaccine platforms. These include: Recombinant Spike Protein, Receptor Binding Domain, DNA vaccine, mRNA vaccine (self-amplifying and non-Self amplifying), Vector-based (Adeno, Measles, Rabies etc.), all against the spike protein target. Inactivated Virus is yet another vaccine candidate. Now different companies have opted for various delivery systems, including Nasal Delivery. There are several challenges involved in case of vaccines, e.g. manufacturing, distribution and storage. Engineers have designed flasks to maintain 2-8^{o}C for the vaccine filled syringes, providing last mile connectivity. There are strategies even to use power from cell phone towers and for Designing vials to maintain temperature. It is also important to know for how many variants the vaccine would be effective and it would become necessary to tweak the vaccine.

Molecular Diagnostic Tests: RT-PCR has now become a household word. COVID-19 tests are available that can test for current infection or past infection. A viral test tells you if you have a current infection. Two types of viral tests can be used: nucleic acid amplification tests (NAATs) and antigen tests. An antibody test (also known as a serology test) might tell you if you had a past infection. Antibody tests should not be used to diagnose a current infection. Chemists have gone into the Fray. A rapid breath test that is reportedly capable of detecting COVID-19 within 60 seconds is currently under trial .VOCs (volatile organic compounds) are consistently produced by various biochemical reactions in human cells. Different diseases cause specific changes to the compounds, resulting in detectable changes in a person's breath profile. As such, VOCs can be measured as markers for diseases like COVID-19. The test is conducted by having an individual blow into a disposable mouthpiece connected to a high-precision breath sampler. This is, then, fed into a mass spectrometer for measurement. Finally, the result is produced after special software analyses of the VOC profile.

Medical Devices: What is a Pulse Oximeter? A Pulse Oximeter measures how much oxygen is in someone's blood. It is a small device that clips onto a finger, or another part of the body. They are used often in hospitals and clinics and can be bought to use at home. A normal level of oxygen is usually 95% or higher. Oximeters

work by the principles of spectrophotometry: the relative absorption of red (absorbed by deoxygenated blood) and infrared (absorbed by oxygenated blood) light of the systolic component of the absorption waveform correlates to arterial blood oxygen saturation. Indian Institute of Science (IISc), Bangalore has developed a 'Make in India' high-performance oxygen concentrator (95% oxygen concentration at 1 liter per minute available within 3 minutes of the start of operation and, more importantly, 90% oxygen at 5 liter per minute). Doctors and hospitals have reviewed its performance and found it equivalent or better than imported units that are in short supply in these trying times.

New age Thermometers: Thermal imaging systems and non-contact infrared thermometers (which are non-contact temperature assessment devices) may be used to measure a person's temperature. An elevated temperature is one way to identify a person who may have a COVID-19 infection, although an infected person may be contagious without an elevated temperature or other easily detectable symptoms.

Chest Scans: Along with laboratory testing, chest CT scans may be helpful to diagnose COVID-19 in individuals with a high clinical suspicion of infection.

Two types of scans have similar uses, but they produce images in different ways. A CT scan uses X-rays, whereas an MRI scan uses strong magnetic fields and radio waves. CT scans are more common and less expensive, but MRI scans produce more detailed images. In those patients who had CT scan, the changes were comparable to MRI. The results showed that in case CT is not available; it is advisable to conduct a chest MRI for patients with suspected or confirmed COVID-19. Considering that T2WI (T2 weighted image (T2WI) is one of the basic pulse sequences on MRI. The sequence weighting highlights differences on the T2 relaxation time of tissues) is a fluid-sensitive sequence, if imaging for the lung infiltration is required, the abbreviated MRI protocol consisting of T2 and T1 WI can be recommended. BIRAC has supported development of Lightweight, Ultra-fast, World's first fully mobile Generation Magnetic Resonance Imaging (MRI) scanner. This is a low liquid helium, full body, high field human MRI scanner that can be mounted on a truck and taken to the remotest parts of the country • The Scanner is very cost-effective and will result in a 3-4 X increase in Return on Investment (ROI). Lightweight and compact, this scanner can be installed on any floor of a hospital. This is a only example in India to develop such cryogenics for large scale superconducting magnets that can be used in MRI scanners.

Indian companies responded efficiently to the Covid-19 pandemic by fast-tracking innovation, revamping assembly lines and expediting manufacturing of everything from N95 masks and Personal Protective Equipment (PPE) to diagnostic kits and ventilators in record time. Remarkably, from producing almost no ventilators domestically, India indigenously manufactured and managed 60,000 ventilators in just three months. Personal Protective Equipment (PPE) refers to protective clothing, helmets, gloves, face shields, goggles, respirators or other equipment designed to protect the wearer from injury or the spread of infection or illness. The Face Masks may not sound Hi-Tech; but, are still considered the most effective way to protect oneself from the virus and should not be underestimated. Virus spreads as respiratory droplets, 5-10 mμ (potential for aerosols as well). Even a cloth mask properly worn would help prevention and spread. Barrier face coverings: As described in ASTM F3502-21, a barrier face covering is a product worn on the face, specifically covering at least the wearer's nose and mouth with the primary purpose of providing source control and to provide a degree of particulate filtration to reduce the amount of inhaled particulate matter.

Surgical masks: A mask intended for medical purposes that covers the user's nose and mouth and provides a physical barrier to fluids and particulate materials. Surgical masks are Class II medical devices. These masks meet certain fluid barrier protection standards and flammability requirements (that is, Class I or Class II, per 16 CFR 1610.4). Surgical masks are also tested for particulate and bacterial filtration efficiencies and biocompatibility and are considered Personal Protective Equipment (PPE). While surgical masks may be effective in blocking splashes and large-particle droplets, they do not provide a reliable level of protection from aerosolized particles because of the loose fit between the surface of the mask and the face. Surgical masks are not respiratory protective devices, such as respirators. The air purifying respirators (known as respirators)

including Filtering Face-piece Respirators (FFRs) such as N95s and surgical N95s, filter at least 95 percent of airborne particles.

These are the PPEs that tightly fit the face and provide certain filtration efficiency levels to help reduce wearer exposure to pathogenic particles in a health care setting. They provide a higher level of protection against viruses and bacteria when properly fit-tested.

Concluding remarks: The tiny virus has posed a huge challenge and scientists from various disciplines have contributed to tackle the pandemic. The time lines for applications have shrunk beyond imagination. But, we should accept that it is a tragedy affecting lives and livelihoods. Hopefully, the lessons learnt will help mankind to face pandemics in future. There are several disciplines which came together whether it is the drug discovery, vaccines, diagnostics or the extensive research including the lineages, phylogenetics etc. and a huge amount of interaction has taken place; but, it still poses a lot of challenges. I think we need to respect nature.

Presidential Address
Why study of light is so important

Prof. Ajoy Ghatak

Today, December 4th, 2021 is the Foundation day of our Academy which is the oldest Science Academy in India. I would like to express my deep sense of appreciation to Professor Manju Sharma and Professor Ashok Misra for having organized extremely important deliberations by inviting a galaxy of speakers in this symposium. I also greatly appreciate the efforts of the Sectional Presidents Professor Anirban Pathak and Professor Rohit Srivastava for organizing a very nice program on the third day of the event on Physical and Biological Sciences; and of course, I greatly appreciate the tremendous efforts made by everyone at NASI Headquarters.

I would like to briefly mention why the study of light is so important. UNESCO declared the year 2015 as the International Year of Light and Light based Technologies. One thousand years back, in 1015, Alhazan wrote 'Kitab al Manazir' which is the first book on Optics. In proclaiming 2015 as the International Year of Light, the United Nations recognized that "Applications of light science and technology are vital for existing and future advances in medicine, energy, information and communications, fiber optics, agriculture, mining, astronomy, architecture, archaeology etc...." . So, the study of light is extremely important not only in Physical Sciences, but also in Engineering and Medical Sciences. Then, few years back, UNESCO declared May 16th as the International Day of Light; this is because the first successful operation of the laser was done by Theodore Maiman, an engineer and physicist in California, on May 16, 1960. Maiman demonstrated the first working of laser which revolutionized medical science, engineering and many other areas. The 1964 Nobel Prize was awarded to Townes, Basov and Prokhorov for the construction of oscillators and amplifiers based on the maser-laser principle. Many feel that Maiman should have also received the Nobel Prize for constructing the first laser.

Discovery of the laser has led to tremendous benefits to society in communications, healthcare and many other areas. One of the main properties of the laser beam is the fact that whereas the light coming from an ordinary bulb propagates in all possible directions, the light coming from a laser is very directional. Because the laser beam is directional, it can be focused by an ordinary lens to a very small area, the radius of which is of the order of microns; 1 micron is a millionth of a meter. Therefore, a laser beam falling on the lens of your eye can get focused to a very small area, producing extremely high intensities. So, a few milliwatt laser can produce an intensity of few MW/m^2.

Using focused laser beams, extremely important devices have been created. There is a big laboratory at RRCAT at Indore developing lasers for industrial purposes. The theme of the symposium, i.e. 'The Interface between Biological & Physical Sciences towards *Atmanirbhar Bharat*' is very much relevant to many important applications of the laser particularly in health care, communications etc. Focused laser beams can cause retinal burns, but they are also extensively used to cure retinal detachment. In December 1961, a hospital in the US used a laser on a human patient for the first time destroying a retinal tumor. This was the first time a laser was used for medical treatments. Laser therapy uses focused beams of light to treat damaged areas on the body; and can also improve the appearance of scars.

Powerful laser beams can create temperatures which can result in generation of fusion power. Laser physicists at the Lawrence Livermore National Laboratory have used a large number of laser beams delivering more than 500 trillion watts of peak power to the target librating fusion energy.

Laser pulses propagating through millions of kilometers of optical fibers connect us across the oceans and have revolutionized communications. Today, we can connect each other from far off places; this has been possible because of semiconductor lasers and optical fibers. In an optical fiber, light guidance takes place because of total internal reflection of light. In 1930, Heinrich Lamm, a medical student in Munich, first assembled a bundle of transparent fibers to form what is known as a coherent bundle; a coherent bundle consists of aligned optical fibers which could be used for imaging and viewing inside the human body. Heinrich Lamm used the fiber bundle to transmit an image. Narinder Singh Kapany also played an important role in image transmission using coherent bundles. Plastic fibres are used to transport light from the roof to the inside of the room. It is a great technology for a country like India which has lot of sunlight. People in Europe are using this technology to bring sunlight into their homes. Unfortunately, plastic optical fibres are not made in India.

Because the light beam has a very high frequency, it is capable of transmitting a tremendous amount of information. Telephone calls have now become almost free. This could be possible because of low loss optical fibers and semi-conductor lasers. Half of the 2009 Nobel Prize in Physics was awarded to Charles Kao for ground breaking achievements concerning the transmission of light in fibers for optical communication.

Today, during the COVID crisis, we have used internet to teach in distant places. 30% of our population is still below the poverty line which is a staggering 400 million people. How to remove the poverty? It is only through education, science and technology that we can find a solution. We can use the internet to educate people in remote areas.

We have to invest more on research in the general area of photonics which has applications not only in communications but also in health care and education.

Award of Honour to the COVID-19 Frontline Warriors

Remarks by the Convener **Prof. Manju Sharma**

The NASI Council considered a proposal to felicitate the medical people or scientists who have contributed towards prevention, control, management and research towards handling the COVID situation; so the Council decided to institute two awards for the same. We started 'Jagrukta Abhiyan'; and organized several webinars addressed by very distinguished scientists. NASI has been actively involved in spreading awareness for this cause. While the expert committee was discussing about the selection of awards to those who have enormously contributed towards the COVID pandemic management, it was felt by the committee that one single person who has really contributed to this task by communicating the message of importance of vaccines, scientific research and also about the vaccine hesitancy to different strata of the society is **Prof. G Padmanaban**; and therefore, the committee unanimously decided to honour and felicitate him during the Annual Session. So, on this occasion, we feel proud to announce the name of **Prof. G Padmanaban.** He has contributed so much to the field of biotechnology; and for many things we got the guidance from Prof. Padmanaban.

During the times of the pandemic, **Dr. Neeraj Nishchal** attended thousands of patients and worked 24X7 in the AIIMS, Delhi. He has done a monumental work in managing the pandemic. He not only looked after the patients, but also helped and advised the state government when the pandemic was on its peak. So, NASI has selected him for his monumental contributions. We are all thankful to him for his excellent patient care.

Dr. Pragya Dhruv Yadav is the Head of maximum testing facility at NIV, Pune. Dr. Balram Bhargava has strongly recommended her candidature. She has worked round the clock at NIV; and was the person who was involved in every aspect of COVID, both at the state and sector level. I'm very proud that the young lady has worked for this cause and NASI congratulates her.

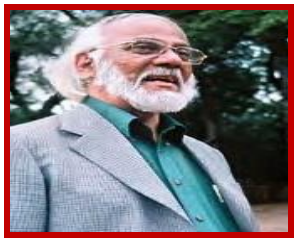
Dr. Neeraj Nischal

It was only because of the kind encouragement, you people gave me time and again. This has motivated me to put forward my best in these trying times. This could not have been possible without the team that I had including the healthcare workers who stood behind me in these challenging situation. Thanks for considering me for this award.

Dr. Pragya Dhruv Yadav

I would like to congratulate NASI on the auspicious occasion of its Foundation Day and I'm fortunate to be here in this august gathering of the intellectuals. Prior to COVID, India had many challenges; and as a head of maximum containment facility state in India, we have been working on Nipha virus, Zika virus and many other challenging viruses. During the time of pandemic, we served our facilities to the entire country and screened each and every sample. We trained different laboratories on biosafety and biorisk management; and it was a challenge to have everything on time including the testing, detection/diagnosis. We were the first to sequence few genomes from India. Prof. Balram Bhargava, the DG, ICMR was the source of motivation for us. I thank everybody in my team as well as the Director, NIV, Pune to stand behind us in challenging times.

Felicitation



Prof. G Padmanaban

It's indeed a great honour and privilege for me to be recognized by NASI. I was the member of the committee which elected these two awardees. The committee strongly felt that Prof. (Mrs.) Manju Sharma has made enormous contribution and driven the entire activity related to COVID awareness at NASI. I am very much thankful to NASI for the recognition what I have done.

Vote of Thanks

Dr. Niraj Kumar

We are very much grateful to our Hon'ble President Prof. Ajoy Ghatak for his continuous guidance, encouragement and very valuable support for organizing the 91st Annual Session and the symposium.

The whole pogramme of the symposium was chalked out by Prof. (Mrs.) Manju Sharma and Prof. Ashok Misra, the Past Presidents of NASI; and both worked together to make this programme very much beneficial, scientifically rich and in such a coherent way that the interface could be utilized by the researchers in the best possible manner. So, we are very much grateful to both of them.

The Thematic Addresses given by the eminent speakers Prof. R Chidambaram and Prof. G Padmanaban were excellent and carrying the theme of the symposium. We also express our gratitude to both the learned speakers and the world famous scientists.

The Presidential Address was unique in the sense that it encompassed the main guiding principles which led to all certain advancements and innovations in science and technology.

In the end, the felicitation and prestigious awards to the COVID-19 warriors was also a good occasion that we organized.

With this, I thank everybody, all our Past Presidents, Council Members, the Fellows and Members as well as the other distinguished guests for joining the Inaugural Session.

Session 1: Agriculture and Allied Areas

Chairman

Prof. Manju Sharma

Co-Chair

Prof. S K Barik

Prof. Manju Sharma

We are going to start the first session. I request the Co-Chair Prof. S K Barik to please join. We have the first lecture by Dr. T Mohapatra. He has been one of the most dynamic Secretary of the Department of Agricultural Research and Education and the Director General of Indian Council of Agricultural Research. During his tenure, we have seen the phenomenal growth of Agricultural Science as well as agricultural production and all other aspects. Dr. Mohapatra has more than 170 research papers in both national and international journals. He is the fellow of all the three National Science Academies and the National Academy of Agricultural Sciences. He has received several prestigious awards viz. *INSA Young Scientist Award* and *Platinum Jubilee Award* to name a few. So, we are very happy and grateful to Dr. Mohapatra for very kindly agreeing to deliver the first/opening lecture of this session.

Mainstreaming Smart Agriculture for *Atmanirbhar Bharat*

Dr. T Mohapatra

Agriculture has been growing well. More than 4% growth in one of the recent years fixes a kind of technology that is driving the growth. The agricultural policies and the schemes are providing the impetus and catalyzing this growth; and moreover, the farmers' efforts are bringing in a much needed push to this entire growth. The rural economy has been resilient to both the waves of pandemic; the GDP accounts for 20% contribution from agriculture sector. But, the entire economy was badly hit because of COVID. India is exporting because it is agricultural surplus nation and the amount of export is increasing. Despite COVID, it has touched more than 41 billion US dollars. The import is mostly at the same level as in previous two to three years. So, we have more than 19 billion plus additional earnings from export, if we take into account, the import. This reflects that we are not only feeding 1.3 billion plus population, but also exporting. Though we are importing for instance, some edible oil and amount of pulses during pulse revolution period, we are able to produce additional 6-9 million pulses. That's the kind of recent developments and the government's support in the form of minimum support price increase. All this contributing to the technology covering more areas under food grains; and pulses production is increasing very significantly.

Similarly, the food grains are in surplus after feeding more than 80 crores of population of the country for more than six months; and therefore, providing free rations during the COVID times could be possible because we had surplus. We are improving in not only the cereals and animal products, but also the processed food products, floriculture, fresh fruits vegetables in terms of export. Disruptive technology driven agriculture growth in recent years is to be self-sufficient, and also for export in case of sugarcane. Before COVID, we were reducing poverty at the rate of more than 2.5% per year which is very very significant.

Poverty reduction means agriculture development, because agriculture and rural settings go hand in hand. If we talk of rural development and poverty elevation, agriculture plays the most vital role. Agricultural growth was enabling poverty reduction. The covid period has put a break. We'll on our course, meet the target i.e. SDG by 2030; and are hopeful keeping in view the pace, we are actually moving. India ranks among the top two producers in several agricultural products and per hectare rural per capita income is growing and rural poverty is declining. Poverty still remains and we have lot more to do. **Our Hon'ble Prime Minister has also emphasized on speed, scale and spectrum to transform India and agri-food system for ensuring food and nutrition security in our country.** We still have many challenges like improper use of irrigation and fertilizers, increase in rain fall, intense and frequent heat waves requiring inputs, climate change, soil, water getting degraded and plant and pest diseases devastating the whole production system in the country with regard to rain falls, temperature, drought events. Frequency of extreme events like drought, floods, cyclone and hail storm is increasing with climate changes which have an impact on different crops, cropping systems and also animal and fisheries system.

What we are actually trying to manage now, is by employing *Smart Agriculture* practices. The agriculture has to be sustainable and the technology should have measurable impacts. The target has to be attainable in terms of product quality as well as quantity; and we have to do it with fair amount of responsibility, all at farm level to trace what is happening.

So, digital agriculture platforms are being deployed in the entire agri-food value chain before production to post-production and consumption stages. How do we actually mainstream the base and use Physical Sciences effectively so that we address the concerns and impacts of climate change. We can do yield mapping and use GPS based applications effectively and go for understanding what is happening with

regard to soil and water and manage accordingly. In the process, we can have efficient production system, quality produced and then delivered at the door steps of the consumers with adequate profit to the farmers.

Use of IoTs, robotics, drones, big data, sensors and AIs are being mainstreamed in Smart Agriculture platforms in order to enable agriculture to be very precise as well as to make agriculture a precision agriculture platform; and we call it smart farming which is recognized globally. We need sensing technologies, software applications, communication systems, telematics and also other hardware and software systems to make agriculture smart. We also need Climate Smart Agriculture to predict the future situation for enhancing productivity, quality, improve nutrition outcome and have resilient production system at various stages to address the effect of climate change so that we can have efficient production system, quality produced and delivered for increasing agriculture productivity and incomes, adapting and building resilience to climate change; and also reducing greenhouse gas emissions.

We have various agencies/infrastructures viz. NSSO, MoWR, AIRAWAT, MoSPI, DAC IMD, DoS etc. working. We have decision support system in place and more are being worked out based on data which is being generated; and we are using large scale remote sensing, out-rooms, census, data to have decision support system and use AI as well as all information system available to predict what should/ can be done, go for irrigation scheduling, appropriate time of sowing/harvesting, application of agrochemicals and other agronomic practices. So, all these kind of information tools/technologies are being utilized at this stage, more a kind of at pilot level going for prediction as support system. We are using our own system existing in the form of KVKs and also mobile communications viz. *World Wide Web* being mainstreamed and used. A large number of youngsters from IITs are using smart agriculture tools to have productive, efficient, smart agriculture system in the country. The various parameters have been integrated into this system and we are communicating to the farmers using audio, video image and text.

Sensors/sensor technology being used for reducing time satellite, planes at different levels of operation. Different levels of sensing taking place enabling real time data generation and guiding precision agriculture. The plants haven been taken to imaging system; non-destructive high-throughput Phenomics including all kinds of imaging sensors viz. visuals etc. All the sensors have been utilized and climate is also monitored and controlled enabling precision agriculture; and huge amount of data is generated in the process. The remote sensing technology is effectively being used to understand the soil parameters, the crop growth conditions and how the yield is being impacted, rainfall etc. are being monitored in detailed. The use of satellite to collect data for monitoring what is happening at country level and to predict soil moisture changes (which is happening) to execute crop planning is a crucial issue in our country. The ICAR Initiatives include:

- Crop biophysical parameters for crop health monitoring.
- UAV based remote sensing can be utilized to understand the irrigation required.
- Airborne imaging for soil fertility assessment.
- Composite soil fertility mapping for site specific nutrient management using customized fertilizer
- Real time monitoring of rice residue burning events and the negative impacts & biotic stress monitoring through sensing techniques. Monitoring of wheat yellow rust through hyperspectral remote sensing.
- Drone-based applications in agriculture accessible to even farmers, use of spray pesticides nano urea being sprayed using drones.
- Precision aquaculture for achieving good aquaculture practices through improving water quality, GIS based diagnosis of diseases of fishes, biosecurity and nutrition.
- Precision dairy farming for monitoring animal/livestock health and performance to improve productivity.

- Digital tools are being effectively utilized to analyze/understand the future of agriculture; there is possibility of area expansion in agriculture and revolutionize the flow from lab to land for communicating with the farmers.
- ICAR knowledge-based precision parameters have been utilized by collaborating various institutions.
- 151 climatically vulnerable districts of the country have been identified by ICAR, based on drought salinity putting technologies to address the climate change impacts and in the process make agriculture sustainable, profitable, less risk prone so that the small and marginal farmers continue doing agriculture.
- Small farm mechanization is another area to address the requirements of small farmers.

Concluding Remarks (*Measures to strengthen Agriculture Sector under Atmanirbhar Bharat*): "Agriculture cannot flourish unless there is investment; and there are opportunities in the post-harvest space to address the issues and concerns. That's the reason why the Central Government has taken the recent steps viz. setting of one lac crore agri-infrastructure funds for farm-gate infrastructure which is a huge one. So, the youngsters have been encouraged to actually go for entrepreneurship; and then, the farm gate infrastructure to be created for increasing the value addition and the returns on the money the farmer spends. There are various other Government schemes, viz. Herbal Cultivation, *Pradhan Mantri Matsya Sampada Yojana*, Animal Husbandry Infrastructure Development, Extension of Operation Greens, Infrastructure Development for Bee Keeping, Agriculture marketing reforms, provisions and investments for making our country *Atmanirbhar Bharat*. It is what is actually emphasized that the farmers are able to actually carry out their work with the help of new tools and technologies and become more and more self-reliant and everything is delivered at their door steps. That is one way of looking at *Atmanirbhar Bharat*. The other way is providing adequate infrastructure and investments so that all kind of existing gaps in agriculture and post-production scenarios could be addressed. This is a holistic approach for smart agriculture and post-production operations so that the food and nutrition security is ensured and we have sustainable agri-food system in this country for the times to come. These are few examples of application of Physical Science and its integration with Biological Science; also, the Government policy and support to enable agriculture to make our country '*Atmanirbhar*', self-sustainable and self-reliant".

Remarks by the Chair: The lecture has brought out so well, the importance of agriculture which also needs tremendous intervention of science and technology; especially the Physical Sciences are contributing towards agriculture for increasing the productivity, resilience and all other related aspects.

Diversifying Crop genomes

Prof. Akhilesh K Tyagi

Agriculture is important for achieving United Nations sustainability development goals like no poverty, zero hunger, good health and wellbeing, affordable and clean energy, climate action, life below water and life on land. These are seven of the 17 goals which cannot be achieved without the intervention of agriculture sector. One of the important interventions that has been made in this sector is represented by genetic improvement the crop plants. We are all aware of the 'Green Revolution' which tripled the food grain production during 1965-1995 in India. India is producing about 315 million tons of food grains, but in another thirty years we need to produce about 150 million tons more; and we hope that interventions at different levels will be able to achieve it and India will not only remain '*Atmanirbhar*' in food production, but also be a major exporter of the agriculture products. In addition to this requirement, we also have to face the environmental degradation and social disruption which is going on and creating very unwanted situations like urban slums; and the farming is getting neglected. This also needs to be taken care of to sustain the agricultural production and achieve the desired targets. In this, the Genomics could help in a significant way. 'Genomics' includes all the components like compiling the genomic sequences of organisms, establishing location of all genes and regulatory elements, establishing function of all genes and regulatory elements, identifying superior alleles, and deploying knowledge to agriculture, health and ecosystem.

There are two ways, in general, for sequencing whole genomes. One is the classical way in which we do the mapping first and align the fragments of DNA with the chromosome, so we go by *Map and sequencing*. Another way is *Whole genome shotgun sequence* wherein we break the whole DNA of the cell into small pieces, sequence them; and assemble with the computation power. We applied the first method in India for sequencing the rice genome, which has about 400 million bases, as a part of an international consortium. We all know that the rice is a pillar of Indian food security. Prof. (Mrs.) Manju Sharma, the then Secretary of DBT, gave this responsibility to us and allowed building a team including Dr. Nagendra Singh, Professor Jitendra Khurana, Dr. Trilochan Mohapatra and other distinguished scientists from the University of Delhi, South Campus and ICAR-NRCPB for execution of the work in the year 2000. The work was also appreciated by the then Prime Minister of India, Sri Atal Bihari Bajpayee Ji. In his letter he wrote, "It is a matter of great pride for India that its scientists have contributed to this international effort". The team/delegation led by Prof. (Mrs.) Manju Sharma was present during the commemoration event organized for the release of the sequence of rice genome in Japan. The first step that was performed scientifically was a genetically anchored BAC-based physical map of rice genome in which Dr. Mohapatra played an important role. In this case, the genome of rice was broken into small fragments, grown in the bacteria as bacterial artificial chromosomes; and then genetically anchored with the help of genetic markers on the twelve chromosomes of rice. Sequencing was done and rice genome sequence assembled as a "Gold Reference Genome". About 60% of the genome of rice was found to be duplicated. This duplication was estimated to have happened about sixty million years ago. This was also the time when dinosaurs disappeared. So, probably the environmental changes were responsible for duplication of the genome of the progenitor. In addition, India continued to work not only on rice, but also produced the sequence of tomato genome as a part of an international effort and also of the wheat genome in due course. Several Institutions including South Campus of Delhi University, ICAR-NRCPB, Punjab Agriculture University and also NIPGR have been part of these efforts. The scenario changed with next generation sequencing; and several of the genomes have been sequenced by Indian scientists

themselves. Among them, the first effort was made in chickpea in which the genomes were sequenced for *desi, wild* and *kabuli* varieties. In addition, pigeon pea, finger millet, pearl millet, tulsi, neem, mango, dark jute and some more genomes were sequenced by Indian scientists themselves. This way, the technology has not only been learnt, but also absorbed by several institutions and the spread of this technology in different laboratories in India was achieved. Worldwide, there are more than 400 plant genome sequences available; and this work is going on ultimately into the formulation of the project called 'Earth Biogenome Project'. In this project, it is planned to sequence in next ten years about 1.5 million eukaryotes present on the earth and this is expected to revolutionize our understanding of biology and evolution, help conserve, protect and restore biodiversity and create new benefits to the society for human welfare. The most powerful technology as of today is genome editing; and deployment of genome editing requires that we have the genome sequence information so that it could provide help to the bioeconomy. This is the idea of 'Earth Biogenome Project' and I hope India would also be able to participate in such a globally important project in the area of genome sequencing.

In the rice genome, we were able to find several genes which are common not only among the plants, but are also common with animals. The remaining halves were specific to specific taxa of the plants. From that step onward, we went into functional genomics and first attempted to know the expression profile of over 30,000 genes that we found in case of rice. We were able to do a microarray chip analysis by which the expression profile of these genes could be worked out. By analyzing these expression profiles, it was possible to identify, for example, the genes which will specifically express in the panicle of rice or the genes which will specifically express in the seed of rice and nowhere else. This followed the idea that if a gene is expressing at one stage, it should have the relevance for creation of that stage; and that became the starting point. In addition, we annotated the genome of rice continuously. There have been four versions of this; and we identified several new genes. We continued with the four version of whole genome annotation, because as information accumulates, the genomes need to be annotated and new versions should be brought out. We also worked on the gene families for transcription factors, epigenomic regulators and regulatory networks in order to find out the relationship of these genes with their expression profile; and also undertook the development of expression atlas for biological processes like water-deficit response, hormone response and reproduction in case of rice. This led to the next step in the process and we were able to find out regulatory sequences by hooking different sequences from differentially expressing genes with reporter genes. Therefore, the knowledge was gained on why some genes express in one stage and not in another. This knowledge was then used to produce male sterility which forms the basis of hybrid vigour in case of rice and other crops. We hooked an anther-specific promoter to a gene called *argE* (coding for L-ornithinase) which converts the acetylated form of the herbicide phosphinothricin into non-acetylated form which kills the pollen grains. It was observed that the control plants got the normal pollen grains while in the transgenics, the pollen grains were killed and the plant became sterile. This could be used for the production of hybrid vigour in case of rice and is a technological advantage to the breeders as well as the farmers. We also identified genes causing the male sterility in rice which included a basic helix-loop-helix transcription factor encoding gene responsible for anther dehiscence and tapetum-related pollen viability.

Then, we moved from the regulatory factors to co-activators. Co-activators communicate between the transcription factors and transcription machinery of the plant. When we down-regulated one gene of co-activator, called Mediator, such as the Mediator14_1 gene, we found that the architecture of the plant is affected and the plant became dwarf. This also affected the lateral root branching which could be restored by application of the hormone, auxin, externally. We also found reduction in the branching of the panicle and pollen sterility and there was a resultant decrease in the seed set. Thus, one gene was found affecting the vegetative as well as the reproductive stages. With further protein level work, we were able to establish a model in which the same protein, which is the Mediator14_1 in this case, interacts with three different regulators to establish the development of anther, seed or lateral organs. Thus, we learnt that how three different regulators communicate through one component with the transcription machinery and are

important for formation of different organs of rice. We were also able to improve the seed size by knocking down one of the genes called the *Grain Width* 2 (*OsGW2*) *gene.*

The stress response of rice was monitored because rice needs lots of water and paucity of water results in water-deficit stress. An amount of about 3,300 litres of water is required for the production of one kilogram of rice! The idea was to look into the genes which will be induced in the stress condition; and we found a novel gene family of zinc finger proteins which are induced in cold, water-deficit, mechanical wounding, submergence and also in heavy metal conditions. These genes were transferred into rice. It was observed that if there is a normal wild type plant and we give a stress, then the number of grains it is able to produce will go down drastically. But, the transgenic lines are able to produce a significant amount of seeds. So, our efforts at identification of genes responsible for stress tolerance were also successful.

In reverse genetics, we know the gene and try to find out the phenotype influenced by it. But, there are examples where phenotype was known but the gene controlling that was not known (earlier). Such genes were ultimately found and genetically marked. These were transferred to other varieties of rice to improve them and similar approach was used in other crops. It has been found that variable phenotypes are available for several traits in case of rice, be it the root size, panicle size or seed weight. But, the question arises, "What causes this variability?". To answer this, we looked at seed-related traits; and by doing Genome-wide Association Study (GWAS) and marker-assisted genetic analysis, we were able to find 13 new genes and also 10 genes which were already known to be significantly associated with the grain traits (grain length, grain width and grain weight) in case of rice. Such discovery of new genes will affect the genomics-assisted breeding for grain in rice.

There is another dimension which brings out the concept of the Pan-Genome in crop genomics. A pan-genome includes common and genotype-specific genes and refers to the full complement of genes of a biological clade, such as a species. This can be partitioned into a set of core genes that are shared by all individuals and a set of dispensable genes that are partially shared or are individual-specific/ variety-specific. It has been found by using sequence of 3,000 genomes in rice that about 25% of genes are specific to varieties and not common among the varieties. This tells us that we need to make use of this information to improve rice, because many of the useful genes are present in case of a variety which may not be in our hand but may be in stock. So, we developed a chip (by analyzing these genomes together) which is 80,000 marker-based pan-genome chip and made use of it for doing Genome-wide Analysis Study (GWAS). A total of 42 gene loci affecting the grain length, grain width, grain length-to-grain width ratio and grain weight were found, out of which 34 are present in common genome of all the varieties. But, we were able to find 8 gene loci which were variety-specific; and that again shows the strength of analyzing pan-genome, a very important area. The gene for submergence tolerance and gene for phosphate utilization in rice, which have already been deployed, are also pan-genome type genes, because these were not present in all varieties, but only in some varieties. Thus, pan-genome analyses are necessary and rewarding.

Besides, the work going on in our laboratory and in collaboration, several other laboratories of ICAR, CSIR and DBT have been working on rice to improve it. It is exemplified by Pusa Basmati 1718 which has been improved by utilizing the technology of genomics and pyramiding some of the Bacterial Blight (BB) genes viz. *xa13* and *Xa21*. Not only the genes for bacterial blight, but also the blast resistance and salinity tolerance genes could be introduced into basmati rice by utilizing the strength of genomics. In another effort, flood, drought and salt tolerance genes are being brought together by Indian scientists by using the knowledge of genomics. Also, an effort is being made to mine new genes in several of Indian institutions. This is also being performed by a group of IARI and other institutions (led by Dr. A K Singh) which is prospecting Indian rice landraces for several of the biotic and abiotic stresses and other traits like grain quality. This will form a very sound base for the breeders who will be able to do speed breeding and bring new varieties in the hands of farmers. This has been done in case of maize also by producing nutritionally rich (in provitamin A as well as desirable amino acid) variety by genomics-assisted breeding. In South Campus of the University of Delhi, Prof. Pental's group has been working on mustard for a long time; and they have also taken the approach of

genomics to develop markers and found the genes related to glucosinolate content, low erucic acid and white rust resistance; and their efforts have been successful in bringing several genes together. We also sequenced chickpea genomes. The chickpea genomes have been used to find out such genes which will improve its quality and also the quantity; and one of such genes has been the ABC transporter gene. By doing the targeted genomics-assisted breeding for introducing a haplotype of a gene into a different variety, it has been possible to produce a variety having 20% more yield, 13% more productivity and 15% more protein content. The genomics is not only supporting rice, but it is spreading and this will be an area representing boundary/restriction-less efforts. We face some regulatory issues with the GM technology, but the interrogation of genes through genomics efforts would not have any of these restrictions; and therefore, would be able to reach in the hands of the farmers very fast.

Still, we are left with several important questions, like, "*Which genes are responsible for form, function, and sustainability of crops?"* ; and the answer lies definitely in efforts in genomics area. So far, only the function of about 5,000 genes is known, but rice has got more than 30,000 genes. Therefore, more efforts would be required in this direction. Another question is, "*What is the spectrum of allele variability and its association with superior traits?"* Here, I would like to say that for a breeder, it is not a gene, but an allele of a gene which is important and a breeder would like to introduce better allele to generate an improved variety. Lastly, the superior genes/alleles need to be combined to increase the diversity of varieties to provide the sustainable solutions in the area of Food Science and Agriculture.

The work in our lab is supported by DBT and SERB. I remain thankful to several researchers in my lab and collaborators for the work presented.

Animal-human interface: Biotechnological interventions for conserving each other

Dr. Subeer S Majumdar

It's our duty to conserve both human and animals. We all know the major infectious disease outbreak, viz. the Nipah, SARS. The disease is not only going from animal to animal or animal to only human; but also going from human to human. The humans are also passing the disease to animal, known as reverse zoonosis and animal to animal. So, it's a cycle which needs to be understood well for surveillance and also stop it from increasing. Factors increasing zoonotic emergence include zoonotic influenza salmonellosis, west Nile virus, plague, emerging coronaviruses, rabies, brucellosis, Lyme disease etc.

The factors increasing zoonosis emergence (diseases transmitted from animals to humans) include deforestation and other land use changes, intensified agriculture, illegal and poorly regulated wildlife trade, antimicrobial resistance, intensified agriculture and livestock production and climate change.

As per ILRI study, the greatest burden of zoonotic disease falls on one billion poor livestock keepers causing 2.3 billion human illnesses and 1.7 million human deaths per year; and also infects more than one in seven livestock every year. Human beings are dying in India because of poor upkeep of animals and lack of knowledge. The main disease in India effecting us include rabies, leptospirosis, brucellosis, anthrax, tuberculosis, pandemic flu, helminthes, arboviruses, plague, food borne and other diseases viz. HIV-AIDS, Ebola, Nipah, SARS, MERS, COVID-19, Swine flu, Avian flu. Sometimes, we find bovine tuberculosis in wild, bovine tuberculosis in the livestock as well as in human beings; and very often, avian tuberculosis also occurring at the same time. So, it's very difficult to make out the source of transmission. The most commonly reported source of *M. bovis* infection in people is the consumption of unpasteurized dairy products, such as milk or cheese which should not be consumed.

Brucellosis: According to WHO factsheet, although, half a million cases are reported annually, the true incident is always 10-25 times higher (undetected) than the reported number of cases, especially, in a country like India, where detection is very difficult and costly. Various kinds of brucellosis affect human being. Infertility and resident fever of no cause is a major issue with human beings also. Diagnostics is always a dilemma for doctor. Serological tests used in the diagnosis of Human Brucellosis include Serum Agglutination Test (SAT), 2 Mercaptoethanol, Coombs Test, Microplate Agglutination Test, ELISA Test and Rose Bengal Test.

Doctors usually confirm a diagnosis of Brucellosis by testing blood or bone marrow for the brucella bacteria or by testing blood for antibodies to the bacteria. To help detect complications of brucellosis, the doctor may order additional tests including X-Rays which can reveal changes in the bones and joints.

Most of the brucella detection kit is from the LPS-the upper surface of brucella to perform the test. So, while performing a test, if an animal is vaccinated, it's not known whether the result of antibodies is because of the vaccination or because of the resident brucella infection.

We have started dissecting the brucella and go into intracellular proteins, one of them being BM5 which is produced and comes out in the blood. If there is antibody for BM5, then one cannot guarantee that there is disease resident. So, one has to differentiate between vaccinated from non-vaccinated animal who is really suffering. We have performed ELISA and LFA (Lateral Flow Assays) which have been patented and given to industry for detection of anti-BM5 antibody in the host serum. We are using the same using Graphene-based Biosensors which are modern biosensors; and very sensitive as well as cost effective. Detecting disease early prevents the spread to others. On the same line, ICAR-IVRI developed a novel Brucella Abortus

S19 Vaccine for brucellosis prevention in the dairy sector with the help of Department of Biotechnology which facilitated the transfer of technology, in which a gene was knocked out from Brucella Abortus S19 strain. During the rainy season, there is a huge flood followed by long exposure to stagnant water and spread of hemorrhagic fever. In addition to that there is SARS, MERS, Avian Influenza and other diseases. Influenza is spread all over the world including Asian countries and gave trouble to whole world. Japanese encephalitis virus is another virus causing harm.

So, what we need is the use of modern bio sensors (physical and biological sciences should come together) to detect the presence of infection. Very recently, electro active reduced graphene oxide is made. Dynamic mechanical deformation and bending studies illustrated the resilience and compliance of the flexible electrodes against extreme mechanical deformations. Our biosensors are meant to be used for detecting human diseases and animal diseases. Label free detection of SARS-CoV-2 Spike S1 antigen triggered by electro active gold nanoparticles.

Establishment of DBT Centre for one health at NIAB to address AMR, Zoonotic and Transboundary Diseases (TADs) in India to initiate and strengthen surveillance systems of zoonotic diseases through existing and newer diagnostics; to have platforms for generating indigenous resources for developing detection kits, vaccines, animal models of diseases. Dig out pathways leading to AMR in Indian subcontinent and tracking points for interventions to mitigate AMR and aftermath.

The scope of application lies in understanding the pervasiveness of specific animal pathogens, their threat to animal health, their zoonotic potential and threat to human health as well as for the incursion and/ or reappearance of animal disease across India; and initiating a one health programme with the ultimate objective of establishing inter-sectoral collaborations among veterinary, medical, agricultural, environmental, wild life, meteorological and other areas to detect, prevent and control zoonoses and TADs (Transboundary Animal Diseases), especially in N-E. The network to be harmonized and synthesized with state and district levels involving local vets and doctors. There are 12 Centres including 6 veterinary and 5 medical in other states of the country; 7 Centres including 4 veterinary, 2 medical in N-E states; one Wildlife Centre-nationwide; 8 disease investigation units-one in each N-E state. We have established Project Coordination and Monitoring Unit. The objectives are:

- to establish a network of laboratories at centralized and field levels
- to estimate prevalence and burden of select disease through serological and other methods
- to detect pathogens where needed by serological (antigen) or molecular tests
- to model data (of surveillance) for disease forecasting and assess the risk, using Artificial Intelligence Tools
- to generate tools and reagents for detecting and treating (therapy part) emerging zoonotic diseases

The Medical Centers which are participating include AIIMS, Delhi, AIIMS, Jodhpur, ICMR-RMRC, Gorakhpur, ICMR-RMRC, Dibrugarh, Nazareth Hospital, Shillong, Gandhi Medical Hospital, Hyderabad, MGR Medical Univ., Chennai; and the Veterinary Universities/Centers covering 6 zones of India include Assam Agriculture University (North-East), TANUVAS, Chennai; IVRI, Bareilly; MAFSU, Nagpur; GADVASU, Ludhiana and NIAB, Hyderabad and coordinate with the Medical Centres also.

So, if the patients come to hospitals with the zoonotic disease, our veterinaries can help to identify that and if doctors get zoonotic disease; also communicate with the veterinarians nearby and see/ ensure whether there is spread of disease in the animals or not. So, with this novel plan, if we are successful in achieving 35 percent, we'll be happy to bring the veterinarians, medical doctors, and wildlife and healthcare takers on one platform and this could be a great achievement.

The major diseases include Bacterial (Brucellosis, Tuberculosis), Rickettsial (Q fever, Scrub Typhus), Viral (CCHF, JE), Parasitic (Cryptosporidiosis, Cysticercosis) and Food borne (Listeriosis, Salmonellosis) diseases.

Actually, the whole project is not about curing the diseases, but also about bringing people together, changing their frame work, understand the problem and reality and make changes at global level to resolve the issues; hence, developing/making the centres working forever.

The expected outcomes would be the understanding of the pervasiveness of the select zoonotic and transboundary pathogens; and their threat to animal and human health.
Its' extremely important to understand and take care of Environment, Soil health and Pollution to make a good cycle, because these affect human and animal health.
Now, we have questions to answer:

1. Should India come out with its own list of select organisms and zoonotic pathogens?
   -Yes, because of these reasons:

- Environment influences the genotypic, phenotypic and pathogenic behavior;
- Human behavior and cultural practices;
- Animal diversity and the balance between wildlife and domestic animals.

2. If so, what needs to be done?
   -Identifying pathogens

- That move between the three domains and gain pathogenicity as they jump;
- Against which effective therapeutics and prophylactics are not available;
- Those with emerging potential to harm the human and animals, and derail country's economy;
- Develop integrative strategies to tackle the threat.

For one and good health (for all), we need to create human resource apart from policy, regulation and funding structure. Students are the change agents who could be the future leaders in health.
Though, the problem is big and ground is vast, the human beings need to collate all their knowledge including Biology, Machinery and Artificial Intelligence for detection, prevention and curtailing health effects of zoonotic and reverse zoonotic diseases inclusive of equal importance to human and animal health. Taking doctors, veterinarians, environmentalists, plant/soil health scientists together on one platform is the need of the day. We'll work for each other as per motto of NIAB; and the motto of NIAB is 'Animal health for Human welfare'.

Remarks by the Co-Chair: I thank Dr. Majumdar for giving details of zoonotics; and the programme that NIAB has been spearheading.

Trend in Farm Mechanization for Atmanirbhar Bharat

Dr. C R Mehta

As we all know, around 45 percent of our work force is engaged in agriculture. However, it contributes to only 18% of GDP of our country. Recently (2020-21), even the horticulture production (330 million tons) has surpassed the food grain production (309 million tons).

If we see the Indian agriculture, 86% of land holding is below 2 hectare. Another issue is the shortage of agricultural labour triggering the mechanization drive. The labour is migrating from rural/farm area to urban area to work in service sector, construction sites and industry. Hence, reducing the availability of labour in rural area to work in agriculture; and recently, it has gone down to around 45% of total work force engaged in Indian Agriculture System. The factors contributing to shortage of labour include shift to service sector for better working condition, increased urbanization and migration of villagers in search of greater opportunities as well as rise of rural entrepreneurs who are looking to set up the business of their own. Shortage of labour in the Agriculture sector will drive need for mechanization and will call for machines with minimal human intervention.

As the farm power availability is increasing, food grain productivity is also increasing and so is the cropping intensity showing a direct link between the food grain productivity and farm power availability which helps in completing different farm operations on time.

Rice and wheat are the two major food grain crops which are mechanized. The mechanization level of cash crops such as cotton and sugarcane is very low. Overall mechanization level is only around 35% for sugarcane crop. Overall mechanization of different crops in our country is around 47% right now which also highlights the need for enhancing mechanization of different farm operations. There are number of challenges with respect to mechanization including small and fragmented land holding which limit the use of high capacity farm machinery. Other challenges are that we have spatial and temporal variation in the cropping systems throughout the country, low farm mechanization in horticulture crops, animal husbandry and fisheries as well as hill agriculture which highlights the need for mechanization of these sectors, low farm power availability that includes drudgery of workers, high cost of operations and low profitability. The increased participation of women farmers due to migration of male workers from rural to urban areas highlights the importance of developing gender-neutral tools and equipments to be operated by male as well as female workers.

India is having diverse agro-climatic zones and soil terrains; and different kinds of machines/equipments are being used in Indian agriculture. In Indian agriculture, animal-operated equipments, light weight and power tiller and tractor operated equipment/implements viz. blade harrow, rotavator, rotavator in puddling, laser land leveller etc. are being used for land preparation. Recently, we have developed the controlled level puddling system for wet land leveling and have potential for export to other countries; and licensed it to one manufacturer. For sowing and planting also, we have manually as well as animal-operated equipments having relevance, particularly to hill areas where we cannot take tractors. In addition to that we have crop specific planters as well as multi-crop planters (inclined plate planter, raised bed planter, seed spice planter etc.); and now we are moving towards using pneumatic planters for saving seeds, because the cost of seeds is increasing day by day. In India, some of the farm machinery manufactures have started manufacturing pneumatic planters having potential for export from India and are even exporting some of the equipments to other countries also. Considering the irrigation and fertigation operations, we have developed good

number of equipments viz. automatic irrigation system, pressure compensated variable rate drippers. We have different kinds of planters which are being used for planting purpose viz. vegetable transplanter, sugarcane multi-purpose equipment, automatic potato planter, turmeric rhizome planter etc. For rice transplanting, we have paddy drum seeder, and four-row, six-row and eight-row transplanters. The self-propelled rice transplanters are being imported from the nearby countries. For intercultural operation, we have twin wheel hoe, self-propelled weeder, SRI power weeder, three-row rotary weeder, etc. There are some plant protection equipment viz. animal drawn sprayers, self-propelled sprayer, tractor-operated horizontal boom sprayer, aero blast sprayer, air assisted sprayer, recently developed sensor based sprayer etc.

For harvesting also, we have manually operated serrated sickle, self-propelled vertical conveyor reaper, self-propelled reaper binder etc. Presently, some companies are importing reaper binders from European countries. India has started manufacturing self-propelled and tractor-operated reaper binders. We have different threshers including crop specific threshers, multi crop threshers, crop specific threshers for paddy, maize, groundnut etc. and are being exported to other countries from India. We also have 'combine harvesters' for rice and wheat crop harvesting. We have developed machinery for management of paddy straw viz. Happy seeder, strip-till drill (also called smart seeder), super seeder and roto drill; all having potential for export, because other countries/neighboring countries like China, Nepal and Pakistan are facing the problem of burning of paddy straw in their fields. Now-a-days, we are moving towards developing the smart machinery to reduce the cost of cultivation and also customizing of farm equipment. In future, we expect to have autonomous vehicle. We have developed Light Sensor based SPAD (Soil Plant Analyzer Development) meter at our institute for measurement of chlorophyll content of the leaves for recommendation of fertilizers to be applied to a particular crop. Now, the government is putting lot of thrust on use of drones in agriculture for remote monitoring and analysis of fields and crops, for crop health scouting and spraying of pesticides and bio-fertilizers on crops. Government of India has approved PLI scheme for indigenous drone manufacturing in India by assembling its different components. As regards the tractor manufacturing, we are independent and exporting tractors to other countries. Around 92,000 tractors have been exported in the year 2019. The export-import trade of agro machinery has been increased from US$ 611 million (2008) to US$ 1301 million (2017) which is almost double in nearly ten years. So, the export import trend is increasing and export has a major role also. Presently, we are exporting machinery to some of the countries viz. USA, Bangladesh, Nepal, Sri Lanka and Turkey. If we see the export-import trend (global) of agriculture machinery, 62% of the machinery is exported by the European Union countries, 18.9% by Asia and 18.7% by USA. China has a major share among import destination nations. Considering the global trend of sale of total machinery, we have 31% share of tractors, and 69% of agricultural machinery revealing that we are moving from 'tractorization' to 'mechanization' as more tractors are being sold for agriculture and non-agriculture purpose. India is having export potential of agriculture/farm machinery viz. tractors, laser guided land leveller, seed drills and planters, power weeder for rice crop, sprinker and drip irrigation systems, self-propelled hydraulic platform, self-propelled reapers and combine harvesters. Some of the machinery is being imported in our country, but having potential for 'Make in India' viz. power tillers, small engines, knapsack sprayers, sugarcane harvesters etc. Recently developed equipments in India include sugarcane bud-chip settling planter, high clearance multi-purpose vehicle, check basin former, tractor operated nursery seeder, etc.

Government of India has taken some initiatives for *Atmanirbhar Bharat* which include restrictions on import of power tillers up to 10% (51% production growth of indigenous industry), enhancement of import duty from 2.5 to 7.5% on rotary tillers, simplification of rules for testing of machines and equipments, agriculture infrastructure fund (financial support to FPOs, SHGs, cooperative societies etc.) for post-harvest management infrastructure, preference to make in India products in public procurement. So, there is a way forward for *Atmanirbhar Bharat* where the Government has provided support to grass level innovations including restrictions on import in a phased manner, enhance manufacturing capacity, design of multi-

purpose equipments, promoting CHCs, industry-engineering college interface, MSME-Agri machinery industry interaction for enhancing/promoting the agricultural machinery.

Conclusion:

- High capacity machinery to be used on custom hiring and for contractual field operations.
- Ergonomic and safety aspects to be considered in design of farm tools, equipments and machinery.
- Appropriate technologies for mechanization of horticulture and hill agriculture are required.

  Further, we also need:
- Whole crop mechanization of rice, sugarcane, cotton and potato crops.
- Farm machinery management.
- Precision agriculture for enhanced input use efficiency and reducing the drudgery of workers especially, the female worker.
- 'Make in India' of imported agricultural machinery needs to be promoted.
- Farmers need support from government and private sector at initial stage to adopt electro-mechanical technologies.

Remarks by the Chair: It's very eye-opener to know about the agriculture machinery and how much the agricultural machinery can contribute to our export which is a very important part of modern agriculture. In fact, the whole session has given a complete picture of modernization of the Agriculture Sector, how it has moved forward, how digitization is taking place starting with the crop productivity to final product. In every area, we have used modern science inputs. It's very challenging considering that Agriculture is the backbone of our economy. I am very happy that the Academy got this particular session organized; and we have had the best of the speakers in all the diverse areas of agriculture, namely plant biotech, agriculture, animal and lastly, the mechanized farm operations. I warmly thank all the speakers for their excellent presentations.

Inaugural Address

Dr. Kiran Majumdar Shaw

It is indeed a great honour for me to deliver an *Inaugural Address* on the occasion of the 91st Annual Session and Symposium of the National Academy of Sciences, India which is the oldest science Academy of the country. For the last nine decades, NASI has been steadfastly delivering on its commitment of developing the scientific temper in the country. Since the time of its founding in 1930, under the visionary leadership of Prof. Meghnad Saha, the Academy has been cultivating and promoting Science & Technology through cutting edge research, publication of scientific works, organizing dialogues and discussions on scientific and technological matters, cooperating with international organizations of scientific research; and securing and managing funds and endowments for the creation of scientific knowledge in the country. In doing so, the Academy has been fulfilling one of the fundamental duties mandated in the constitution of India which states, "It shall be the duty of every citizen of India to develop the scientific temper, humanism, the spirit of enquiry and reform".

It is important to note that the founding fathers of our great country wanted a spirit of enquiry and scientific temper as a foundational aspect of our society.

I believe Science and Scientific temper are imperative, if better lives are to be assured to a billion plus people in a country, constrained by resources and at a time when the world is reeling under the devastating impact of the COVD-19 pandemic. Our scientists have done a stellar job throughout this devastating viral outbreak. They have worked overtime to come up with innovative solutions across a range of biomedical fields. From mathematical models to mass production of masks and personal protective equipments, diagnostic kits to treatment of modalities and vaccines to ventilators. US President Biden's Chief Medical Advisor, Anthony Fauci has actually lauded the Indian scientific community's contribution. He said, "India's contribution to the global scientific knowledge is well known to all with strong government support and a vibrant bio-pharma sector. This knowledge is already yielding solutions to COVID-19 prevention and cure. India, we can proudly say, has delivered 71 million doses of COVID-19 vaccines to over 95 countries till Nov 2021; and since exports have resumed, we'll continue to do this yeoman service to the world. India has become the world's second largest manufacturer of PPE kits from an actual shortage to manufacturing two lac PPE kits and two lac N-95 masks per day. India took less than a year to accomplish its '*Atmanirbhar*' vision to manufacture these very essential medical products. Though, we have achieved so much on the scientific front; sadly, large parts of our society continue to be in science denial mode. Vaccine hesitancy and the tendency to believe in fake cures with no scientific bases and the refusal to trust scientific data-all these are hampering our efforts to fight the deadly virus. We must remember that scientific research does not take place in a vacuum. It can only happen with society's blessings. It can only happen, if we, as a society can develop the right scientific temper. It is the interaction between science and society that ensures that knowledge is exchanged, tested and refined in order to respond to the societal needs and global challenges. Scientists work tirelessly at the forefront of knowledge to discover more. Driven by curiosity of unknown and unexplored, they apply knowledge to new realms; thereby adding knowledge to knowledge base. And in doing so, they help us live longer, healthier and more enriching lives. The scientific method is a remarkable tool for creating verifiable information, always expanding the boundaries of our knowledge and challenging a pre-conceived notion of what reality is. Look at the world's most innovative economies viz. Switzerland, Sweden, Israel, US, UK and

Republic of Korea; all are in the top percentile of Global Innovation Index 2021 rankings. What makes these countries innovation leaders? Some of the factors that make these economies innovative include the culture of questioning, scientific temper, the ability to take risk and the willingness to think out of the box. To be truly innovative, a country needs a critical mass of people who are true innovators. What is a definition of true innovator? A true innovator is one, who sees what everyone else sees, but thinks of, what no one else thinks. Take, for example, the 2005 Nobel Prize winners for Medicine viz. Robin Warren and Barry Marshal. Everyone had thought that the cause of gastritis inflammation and stomach ulceration is excessive acid secretion and irregularities in diet and life style. But, it was Warren and Marshal who postulated that a causative agent was in fact, a bacterium, called Helicobactor pylori (H. pylori). They were ridiculed, but they stuck to their guns. They could see and think beyond what others saw and thought. Similarly, Francis Crick who was originally a physicist did not limit himself to his chosen field of research. The scientific temper drove him to collaborate with James Watson in deciphering the structure of DNA, thus opening the whole new area of Genetics. Their discovery herald in Biotechnology, wherein the living systems could be made to produce any desired products, by artificially introducing the genes responsible for doing so, all because they had cracked the genetic code. Percy Spencer, one of the world leading experts in RADAR Technology discovered the microwave oven, when his curiosity was parked on seeing that the candy bar he had in his pocket melted when he was standing in front of active RADAR set. Today, we can't even imagine a modern kitchen without a microwave oven. These innovators put epitomize action. A parachute only works when it is open. The mind is also like that; it works only when it is open. The pandemic has reestablished the need for nation to develop a scientific temper, to cut across the traditional boundaries of knowledge, and stretch across various disciplines. While ancient India was clearly a leader in disciplines like mathematics, physics, astronomy and life sciences, today's India has too, a considerable scientific achievements to its credit. Not only our country has attained global leadership in information technology and in pharmaceutical and biotechnology sectors, but we also have made significant progress in space research. ISRO is developing heavy lift launchers, human space flight projects, reusable launched vehicles, semi-cryogenic engines (single and two stages) to operate vehicles, development and use of composite materials for space applications etc. Just as the three Nobel Prizes for Chemistry, Physics and Medicine have promoted the spirit of enquiry at global level, I must also mention that Infosys Science Prize has done the same in India. This annual recognition for outstanding achievements in India in engineering, computer science, humanity, life sciences and mathematical sciences as well as physical sciences and social sciences, not only creates a remarkable individuals, but they inspire and encourage others in the society at large. The Infosys science prize 2021 has recognized some incredible scientists including Dr. Chandra Sekhar Nair, a fellow of Biotech entrepreneur, who was awarded prize in engineering and computer science for its development and large scale deployment of indigenously developed TrueNat diagnostics which is a point of testing platform for PCR Test based Medical diagnostics. Dr. Nair's work has enabled rapid testing for millions of COVID-19 and TB cases both in India and across the world. Prof. Mahesh Shankaran was awarded prize in Life Sciences for his pioneering work on ecology of tropical abana ecosystems. His contributions to highlighting the biodiversity of important Indian ecosystems such as the Western Ghats have been recognized. Dr. Neeraj Kayal of Micro soft Research Lab, Bengaluru also got the prize in Mathematical sciences for his outstanding contributions to computational complexity. The winners are felicitated by Prof. Gagandeep Kang, a renowned virologist, who also has won the Infosys Prize for life sciences in 2016 for her contributions to understanding the natural history of the Rotavirus and other infectious diseases. In 2019, she became the first Indian woman, to be elected as a fellow of the Royal society. Despite a large scientific talent pool, and some quality institutions of higher learning and research, they remain a cause for concern. The quality of science education in a vast majority of our institutions is sub optimal. In many of these inadequately staffed and financially strapped departments that offer outdated syllabi, learning by road is unfortunately the norm. This is true, especially of undergraduate colleges which are crucible for science and where the spirit of enquiry must be nurtured. Many of the institutions have overcrowded class rooms and poorly equipped laboratories where

experiments are rarely conducted. In addition, we do not have enough quality teaching or research staff. Partly owing to flight of talent to more supportive and lucrative and academic and research environments abroad; and partly owing to the fact that many brilliant students do not consider a career in science as an attractive option. We have to change it. We have to bring in a very strong research culture in our research institutions, colleges, schools and in our hospitals. I think our clinical institutions must focus on translational research in a much bigger way. We keep focusing on clinical practice; we keep celebrating how dedicated and devoted our doctors are to patient care. But, unless we start harnessing their experience and their wisdom for clinical research, I think we'll lose a huge opportunity. I know well, Dr. Manju Sharma has basically sacrificed a huge research opportunity a decade ago, when clinical trials were banned in the country; and that was actually a very dark phase for research in our country. It took a long time to revive that culture and spirit of clinically investigating any new hypothesis, treatment or concept. The negative impact it has made on translational research is something we are still struggling to overcome. We have to build credibility. Unless we start embracing the spirit of enquiry, the spirit of research and experimentation and the spirit of innovation, I don't think we'll do justice to our talent and our education. In the capital intensive and empirical body of knowledge (that is science), it goes without saying that the lack of state of the art laboratory equipment can have a disastrous effect on the quality of research conducted, whether it is academic institutions or private research centres. Besides, with very little mutual interaction or cooperation, there is disconcerting disconnect between our academia and industry as they pull in different directions. I have always been trying to see how we can bring this industry-academia connect. It has been a struggle. Both parts of the equation believe that they don't need to connect. Each of them believes they are going to work in a certain way; and this is not going to work and help us with scientific temper. There has to be a mutual trust, mutual collaboration and mutual innovation as a focus, if we are to progress. Even in the biotechnology industry which has shown a great promise in India by growing from a little known science to a major economic enabler in a just a few decades, research has mainly focused on an imitative rather than the innovative where opportunity has to be addressed with most strategic direction. We need to shift our focus to discovery led innovation. To attain global leadership in biotechnology, this is a must. This observation can be logically extended to other areas of scientific research and other realms as well. It is true that we have the knowledge and the skill base to be ranked on power with the world's greatest scientific powers. However, we lack the requisites of all persuasive scientific temper that is essential to transfer into a science and technology power house. To rank among the world's scientific elites, we must first and foremost encourage the scientific community to create a market of intellectuals. Entrepreneurial scientists are crucial components in the march towards scientific superiority, as is evident from the success of the United States as a leading scientific power. In today's knowledge-driven economy, innovation is the primary driver of progress to generate intellectual wealth and create social good. India will need to take several key measures. We must create intellectual wealth without which you will not be recognized as an intellectual leader or a thought leader. For innovation to be recognized and respected, I think we have to create intellectual wealth. The scientists must be encouraged to be able to create patterns to be inventors and to basically create that intellectual wealth that they could be recognized for; of course, through their institutions, because technology transfer from institution to industry is going to be a very important part for creating this intellectual wealth like it has been done in other parts of the world. We need to take several steps to create the ecosystem. One is to fund ideas from lab to market. Funding is a critical factor to decide the course of science. For innovation to flourish, ideas must be funded and taken to market. Without capital, even the most transformative ideas can die before they can take flight. At the research level to able to reap the dividends of the time consuming and capital intensive research, we must attract moneys from venture capitalists, angel investors, cooperate social responsibility and with incentives which are linked to the funding that can come forward. Until we create a funding, financing ecosystem, innovation in India will continue to be a far-fetched dream. India needs a virtual cycle where academia generates ideas, especially those based on science and technology which is incubated to proof of concept of Government's sponsored

seeds and incubation funding; and then, taken to the market through business intervention. This is the virtual cycle we need to create. Right now, I think we have started seeing ideas being incubated from scientific laboratories, research institutions and academic centres through government sponsored funding. BIRAC has done an outstanding job of incubating these ideas to a proof of concept; but, what has let us down is the business translation act by venture funding. For some reason, venture funding is a very risky, because nothing is certain in our area of science and technology. Everything is based on hypothesis and one has to take that risk; and believing that the hypothesis could be a reality, you have to fund that hypothesis and that's what we need to educate our venture capitalists to do. They are very spoiled by today's easy technology to market journey of the IT sector. One may develop a digital idea and take it to the market instantly whether it fails or succeeds. When it comes to the field like biotechnology and others, validation of the hypothesis takes a long time to translate into success or failure. They are not willing to take the risk along with the entrepreneur. Ease of accessing market, i.e. primary and secondary and be able to raise capital with greater flexibility for innovation, compelling opportunity to take innovative ideas to global markets. I have been doing it and I wish many entrepreneurs could do the same. India will also need to forge academic research and teaching programmes between institutions of higher learning and national programmes. Besides, the academic institutions must be encouraged to coordinate to share their resources and skills. Better allocation of resources can improve the quality of science education in our schools, colleges and our universities. Opportunities for India to move up to value chain needs to be in coherence with entire ecosystem of innovation that brings together the academic and research institutions, big industries, startups and entrepreneurs. A well rounded nation's eco system can be the ideal catalyst for India's emergence as science and technology leader. While it is important to focus on higher education, it must be understood that the culture of science can be built only when we start from the grass roots. It is encouraging to note that the contributions of public and private initiatives towards this end, the vision of science and technology constituted by Karnataka government is significantly promoting science education in the state. We must take risks; and be more tolerant of failures. The government must support the startups and businesses that think locally, but have a potential to make an enormous global impact. When you look at the new variant viz. the Omicron variant, it is actually the genomic surveillance that we actually have to identify such a new variant. I think, Genomics is very important, when it comes to diagnosing the diseases, understanding the disease and gene regulation. So, genomics offers many opportunities. Then, we have quantum biology, a moonshot area to invest in. Cell and gene therapy is also emerging a hot area we should be investing in. Virology is a hot field because of pandemic and we must continue to invest in virology in a big way. India is a vast country in terms of its ethnicity, demography and various aspects of its geological terrain. We can have very big reservoirs of knowledge built on research and innovation can happen. Immuno-Onchology is also an area fostering a lot of opportunities and applying basic research to various aspects of diagnosis and treatment. The government should support the innovations by undercutting the risks through various forms of incentives and basically start creating an infrastructure and multi-lateral and multi-disciplinary collaborations.

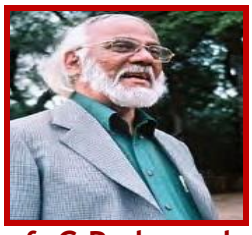
Conclusion: Science gifted the world and its living standard over the past two century and it can do so again. For a country haunted by hunger, poverty and disease, the benefits of scientific research must go right down and should be made affordable for the common man. India has actually demonstrated its leadership, when it comes to affordable innovation; and that has to be a very strong mantra in everything. We have to focus on making it affordable and accessible to the lowest denominator of our country. Making affordable itself requires innovation and to make it accessible requires another set of innovation. So making affordable is a very strong *mantra* we should be practicing. We, therefore, need science to be reached to common man, sustainable for a long term economic development. Science and innovation can offer scalable and affordable solutions to pursue. When we talk of creating a healthcare model, it might work in the small regions of the country. The big question is how do we scale it up? How do we make sure that small idea that works in a small setting can work in a big, scalable model. The government is aware of the need of an inclusive

approach. The Science, Technology & Innovation policy of 2020 states that in order for India to march ahead on a sustainable development pathway towards achieving an *Atmanirbhar Bharat*, a greater emphasis may be needed on developing traditional knowledge systems, indigenous technologies and encouraging grass root innovations. With these objectives, India will not merely lead in science and technology, but also in human development. It is by developing a scientific temper, investing in breakthrough ideas and embracing in inclusive model of growth, that India will be able to unleash the power of innovation to ensure a better life for its billion plus citizens. In doing so, you will be able to garner a large share of global value chain and combine both 'Make in India' and 'Innovate in India' to deliver our aspiration for an *Atmanirbhar Bharat.* Someone who is very invested in scientific ecosystem in the country, I do believe, despite the devastation, we have seen from COVID-19, the small glimmer of hope that I see is, that it has ignited the flame of science and technology, invention and innovation and forcibly brought us into the global research eco system. Scientists from various research institutions viz. NII etc. have been contributing to find solutions for CIVID-19. This has kindled a new kind of life into science and technology in India and we should not lose this opportunity in India. I know, as an industry, we have also requested government to come up with research linked incentives; and one of those aspects is to encourage the incentives under industry academia linkage. That is something we must aim for. If we can really build that link or bridge and if we can actually get bold ideas coming out of our academic research labs and translate them into income opportunities through a business partnership; that is where our country will catapult itself into a strong leadership position in science and technology.

Remarks by Prof. (Mrs.) Manju Sharma: A very outstanding, inspiring and encouraging lecture. The last part that was mentioned, i.e. the link between academia and industry has been talked for so many years; and we really need to strengthen it. Unless we consciously make an effort, I think the things will be still slow. If we want to attain leadership in science and technology, we need to develop an intellectual capital in the country and also focus on innovations, discovery driven research and industry. There are many such platforms where industry and scientific institutions are together and that will make a very strong '*Atmanirbhar*' India.

Session 2: Medical Biotechnology and Healthcare

Chairman



Prof. G Padmanaban

Co-Chair

Dr. Sanjeev Sinha

Prof. G Padmanaban:

It's great pleasure introducing Prof. Balaram, the first speaker of this session. He has been a major contributor to the evaluation of factors influencing the folding and conformations of designed peptides, and has investigated structural elements playing a key role in the formation of secondary structural motifs such as helices, beta turns, and sheets.

He is the recipient of the third highest Indian civilian honour of 'Padma Bhushan' (2014) as well as the TWAS Prize (1994). He has been conferred the **2021** R. Bruce Merrifield Award by the American Peptide Society.

He has authored more than 400 research papers; and also has been the editor of the journal, Current Science; and is a fellow of the Indian National Science Academy.

Protein Sequence Variation by Random Mutation and Natural Selection: The Case of the SARS CoV-2 Spike Protein

Prof. P Balaram

A paper written by John Maynard Smith in 1917 shows natural selection and concept of a protein space. He said, “The new functions will evolve when a certain sequence is capable of imparting a function”. The sequence space of Maynard Smith who won the Nobel Prize for her work of test tube evaluation of bacteria, where she compared protein universe and Jorge Luis Borges enormous number of protein sequences. The characteristics of proteins include 1) Folding into precise three-dimensional structures (binding non-covalent interaction); 2) Oligomerization (protein-protein); 3) Specific ligand recognition, e.g. Receptors, Antibodies (binding) and Enzymes which are little more complicated in terms of binding and doing further chemistry. The SARS-CoV-2 spike protein has 1273 residues and has three functions-it binds to the receptors (ACE-2), having proteolytic cleavage at a specific site as a prelude to infection. After that Membrane fusion and virus internalization happen. All these events require the intimate participation of spike protein. In trying to understand the Amino Acid diversity along with amino acid change, the use called Shannon-Wiener Index for representing this diversity, well known to ecologists. All the mutations are accumulated in different positions in the coronavirus spike protein.

Today, we are worried about the zoonotic transfer. But a great deal of coronaviruses is known to veterinarians for long period of time. For sequence diversity, we aligned the sequences and look at the conserved and variable regions. Coronaviruses bind the cellular receptors. Mammalian aminopeptidase N (APN) plays multifunctional roles in many physiological processes, including peptide metabolism, cell motility and adhesion and coronavirus entry. Considering human amino peptides, we find that it binds many coronaviruses including a couple of human coronaviruses, feline, canine, porcine coronaviruses at different points. There is one human coronavirus oc43 which does not bind. So, we have been exposed to coronavirus for a long time; about 30% of common cold is due to coronaviruses. Virology has now become the most popular subject in India after the pandemic unlike the previous years.

D614G has become the most prevalent form in the global pandemic.

There is evolution of variants during the course of pandemic. NCBI use data-Doubling time-Several mutations of data i.e. Alpha 10.99 days; Delta 11.47 days. Sometimes the mutations do not seem to affect the receptors bindings, because the residues pointing away from the receptors.

Most viral vaccines are based on inducing neutralizing antibodies (*NAbs*) against the virus envelop or spike glycoproteins. Sometimes they stabilize the pre-fusion conformation. All the virus vaccines are not only original spike proteins, but they are engineered sequences. The article entitled “Medical Science, Infectious Disease and the Unity of Humankind” written by Joshua Lederberg (JAMA 1988,260, 684-685) states, “Human intelligence, culture and Technology have left all other plant and animal species out of the competition. We also may legislate human behavior. But, we have too many illusions that we can by writ, govern the remaining vital kingdoms, the microbes that remain our competitors of last resort for dominion of the planet. The bacteria and viruses know nothing of national sovereignties. In that natural evolutionary competition, there is no guarantee that we will find ourselves the survivor”. “Many defense mechanisms, inherent in our evolved biologic capabilities, thus mitigate the pandemic viral threat. Mitigation also, is built into the evolution of virus: it is a pyrrhic victory for a virus to eradicate its host! This may have happened historically, but then both the vanquished host and the victorious parasite will have disappeared. Even the death of the single infected individual is relatively disadvantageous, in the long run to the virus compared

with a sustained infection that leaves a carrier free to spread the virus to as many contact as possible. From the perspective of the virus, the ideal would be a nearly symptomless infection in which the host is oblivious of providing shelter and nourishment for the indefinite propagation of the virus' genes".

"At evolutionary equilibrium we would continue to share the planet with our internal and external parasites, paying some tribute, perhaps sometimes deriving from them some protection against more violent aggression. The terms of that equilibrium are unwelcome; present knowledge does not offer much hope that we can eradicate the competition. Meanwhile, our parasites and we must share, in the dues, payable in a currency of discomfort and precariousness of life. No theory lets us calculate the details; we can hardly be sure that such equilibrium for earth even includes the human species even as we contrive to eliminate some of the others. Our propensity for technological sophistication harnessed to intraspecies completion adds a further dimension of hazard".

"As one species, we share a common vulnerability to these scourges. No matter, how selfish our motives, we can no longer be indifferent to the suffering of others. The microbe that felled one child in a distance continent yesterday can reach yours today and seed a global pandemic tomorrow. Never send to know for whom the bell tolls; it tolls for thee". So, viruses are going to be around and continue to mutate.

Study of Breast Cancer Metabolism by MRI and MR Spectroscopy

Prof. N R Jagannathan

Breast Cancer Metabolism can be studied by MRI and MR Spectroscopy, which is based on the principles of NMR (nuclear magnetic resonance), an analytical tool invented by the Physicists and later used by Chemists and then the Biologists. When it came into the realm of the medicine, it revolutionized the field of radiology. In cancer, the cells proliferate rapidly and for its growth convert the nutrients into energy and biomass essential for cell proliferation. They use a variety of nutrients including glucose, glutamine, fatty acids and amino acids. Glucose supplies energy in form of ATP and carbon for biomass. Some cancer cells use glutamine as an oxidative substrate for energy; and as a source of carbon and nitrogen for biomass. Extracellular fatty acids are used to generate lipids for cell membranes, and are oxidized in mitochondria to produce energy. Amino acids are used to produce macromolecules like proteins and nucleotides.

The technique for in-vivo assessment of metabolism by a non-invasive physical technique includes NMR/MRI/MRS, which revolutionized the field of medicine; and an effective tool acting as an interface between Biological and Physical Sciences. NMR technique was developed in 1940s (by physicists) which was later used by chemists; and with discovery of 2D and 3D NMR, the biologists started using it. Later in 1980s, the use of NMR in medicine was realized when MRI was developed. MRI is a technique that uses the all the fields of science and engineering expertise like physics, chemistry, engineering, technology, computer specialists and others; and is a culmination of science, technology and engineering which basically gives MRI.

MR imaging provides anatomical information and has a superior soft tissue contrast, with multi planner capability. It provides functional information through fMRI (functional MRI), MRA (MR angiography), PWI (perfusion-weighted imaging), and DWI (diffusion-weighted imaging). MR Spectroscopy (MRS) provides the metabolic information, physiology and metabolism, efficacy of drugs, dynamics, pharmacokinetics and monitoring treatment. Role of in-vivo MR in clinical medicine includes diagnosis of tumors, differentiation of malignant and benign lesions; identifying small lesions for early detection and recurrence; and finally the study of physiology and metabolism.

The question is “Can we use In-vivo MR to monitor metabolism induced morphological changes?” Malignant transformation leads to changes in the structural features which lead to morphological changes and microenvironment. These can be studied using routine MRI (T1, T2, and PD), dynamic contrast MRI (DCEMRI), diffusion MRI (DWI) and MR Elastography. Another major aspect of malignancy is that it leads to changes in biochemical and metabolic alterations that can be investigated by MRS.

Further, cancer progression leads to high metabolic demand for oxygen and nutrients which are generally achieved by angiogenesis; this will lead to abnormal vasculature permeability further leading to hypoxia in tumour microenvironment. Hence, perfusion characteristics also change. These can be monitored by DCEMRI in which the patient is given a contrast material which is then monitored and images are taken as the function of time when the patient is being infused with the contrast. So, one can measure the extracellular volume ratio, volume transfer coefficient and such kinetic parameters.

Moreover, the malignant transformation not only leads to rapid proliferation, but also to morphological changes which actually disrupt the cell-architecture and microstructure. This is reflected in tumour size, cell density and loss of membrane integrity as well; and also changes the fluid properties. So, the complete malignant transformation can be monitored by measuring a parameter called the Apparent Diffusion

Coefficient (ADC) measured using Diffusion MRI (DWI) and it provides information on micro environmental and microstructural changes. The ADC value is lower in tumour compared to normal and contralateral unaffected breast due to high cellularity.

Another important aspect of patient management is use the technique of MRI to monitor the therapy induced metabolic changes. Can diffusion MRI give useful clinical information? The answer is, yes, and the diffusion coefficient (ADC) will reflect such changes. Also, DWI can be used for preoperative assessment of residual disease. Data of DWI on 40 patients showed that ADC of the tissues adjacent to tumor showed presence of cancer cells up to 15 mm of distance from the tumor margin. Hence it is concluded that it would be better to remove normal looking tissues up to 2 cm from the tumor margin, so that there will not be any viable cancer cells. Our study showed that DWI is a completely safe method to estimate the viable cancer cells in pre-operative patients which would be highly useful for the surgeon while doing breast conservative surgery.

As discussed earlier, malignant transformation also leads to the biochemical/ metabolic alterations such as water, lipid composition and lipase activity, choline, kinase activity and membrane biosynthesis. These can easily be monitored by in-vivo MR Spectroscopy (MRS). One can determine various biomarkers like water-to-fat ratio and total choline (tCho) by proton (1H) MRS. Additionally, the energy status of tumor tissues can be monitored by measuring various phosphate metabolites by 31P MRS.

Further, lipid metabolism also changes in breast cancer that can be monitored by 1H MRS. To asses this, we performed the experiment on 68 malignant, 35 benign and 30 healthy volunteers. It was found that in case of malignant tumors the fat fraction was lower compared to benign lesions and normal breast tissues. We also estimated the fat fraction as a function of several hormonal statuses.

It is known that during the menstrual period, the woman undergoes several hormonal changes leading to changes in the tumor metabolism which can be easily be monitored by 1H MR spectroscopy. In addition to water and fat in breast, we also can detect Choline peak (when water and fat peaks are suppressed), which can be used as biomarker. The hypothesis of observing Cho in malignant breast tumors is based on the fact that the excess of Choline (Cho) levels in tumors activates the enzyme Choline kinase (CK), which catalyses the conversion of Cho into Phospholipase C (PC) in the presence of ATP; thus, increasing the total PC pool. Increased levels of PC do not affect CT (Cytidylyltransferase) which catalyzes the conversion of PC INTO CDP-Cho; thus, maintaining the increased pool of PC. Due to increased membrane synthesis in rapidly dividing tumor cells, the presence of choline in cells/tissues was observed in most of the malignant tumors.

We also attempted to find out the metabolic differences in various breast tissues between the malignant, benign and normal tissues by quantitative MRS. We developed a method to determine the concentration of Cho by 2 methods namely, (i) a semi-quantitative method by determining the signal to noise ratio (SNR); and (ii) absolute quantitation. We observed the choline in lactating breast also; and attempted to assess the metabolic differences between malignant and lactating breast tissues using DWI and MR Spectroscopy. Combination of two or three MR methodologies (multi parametric MR approach) provided a better picture on the metabolism and were able figure out the metabolic differences that exist between breast cancer patients and the lactating breast cancer patients.

We also carried out a pilot study using MR Spectroscopy and ELISA to find out the association between enhanced choline and its relation between tCho metabolism and the Wnt pathway in breast cancer. Also, Cyclin D1 (an important regulator of cell cycle progression*)* encodes cell regulatory protein that is expressed at high level during the G1 (Gap 1) phase of the cell cycle. *The beta-catenin (*β-catenin) is an important component of Wnt signaling pathway; and is involved in diverse cellular processes including cell adhesion, growth, differentiation and transcription of Wnt responsive genes. It translocates to the nucleus where it binds to T-cell factors and activates the transcription of a number of genes including Cyclin D1. A comparison was made between the cytosolic and nuclear β-catenin and Cyclin D1 expressions with tCho (total choline) concentration from the same patient. It was observed that the Cytosoloic and Nuclear fraction of β-catenin in malignant cells were quite different while in case of benign lesions*,* the Cytosoloic

fraction it was the same; while differences were observed in case of Nuclear fraction. The tCho was high in case of malignant tissue as compared to benign one. So, we compared the choline which we determined from the MR Spectroscopy with the actual metabolism happening in the cancer cell.

Finally, the effect of metabolism/ metabolic changes induced due to therapy can also monitored by MRS. We also studied the effect of therapy and the drug induced metabolism by simultaneous monitoring of microstructure & environment by MRI and MRS. Also, the metabolic changes occurring in liver during the administration of chemo drugs in liver was monitored using 19F MRS.

Finally, there are programs under 'Make in India-Indian MRI Mission', wherein indigenous manufacture of MRI in India has been initiated. Two programmes viz. the one initiated by 'MeitY', Government of India involves five institutions viz. SAMMER, Mumbai, CDAC, TVM & Kolkata, IUAC, Delhi and Dyanand Sagar and the work is in late stages of bringing out an MRI scanner that is completely manufactured in India. The second venture is by a privative company 'Voxelgrid' which is involved in producing Light weight, Ultra-Fast, Next Generation MRI Scanners from India and a porto-type has already been demonstrated. India, is slowly inching towards self-sufficiency in various medical devices under 'Make in India' programme; and soon we'll be able to have an MRI scanner which is cost-effective having all the functions.

Remarks by the Chair: Thanks for an informative lecture highlighting the potential of MRI, its various applications for the diagnosis of cancer, in particular, the breast cancer.

Self-reliance in healthcare: from the experiences @ CSIR-CCMB

Dr. Rakesh K Mishra

I am going to talk about how we got motivated and catalyzed to self-reliance in many things in past couple of years. Although, the pandemic caused lots of sufferings, but this also gave many positive things which I would share from my experiences in the fight against the COVID. So, the self-reliance is not just limited to the COVID, it is beyond that. The Pandemic has been the testing times for the healthcare system; huge economic, social and psychological impact which is still continuing and we are waiting for the pandemic to get over. But, there has been implication that increasing scope of healthcare domain is going to be the driver of economy and job creation. The new healthcare era is coming with precision, personalized medicine, prevention, nutrition and one health for all. To fulfill these aspects, we need to have self-reliance; otherwise, this will be a dream for us. Now, the question arises, in the time of the pandemic when a new infection arrives (natural and enemy intended), what do we need to do immediately? The answer lies in 1) Detection and diagnosis which is accessible, feasible and high throughput); 2) Controlling the spread by technical means as well as behavioural and governmental interventions; 3) Many other issues related with working, adopting a new normal, access to information distribution/policy and ideas.

CSIR-CCMB played multiple roles and made efforts in fight against COVID-19. As we all know, CCMB is a CSIR laboratory with a mandate 'to carry out research in basic biology'. Most of our contribution is of our students who stayed back during the nationwide lockdown and continued to fight against the pandemic. We played multiple roles as a testing center for testing the samples, training center for training, validation center for testing kits and national repository for virus and patient samples. We cultured the virus in laboratory to enable testing and screening of drugs, testing and validation of devices. We developed the diagnostic methods, protocols, SOPs, understanding the biology of virus and genome dynamics of virus; and there were many such activities in which we were involved. So, we have innovated and indigenized the things. The conventional testing for SARS-CoV-2 is done and the swab is collected in Viral Transport Media (VTM) in the lab, packed and transported to testing centre, further unpacked and catalogued; and then RNA Isolation, RT-PCR and reporting are done. So, the students/volunteers adopted the Dry-Swab based SARS-Cov-2 screening to save VTM for swab collection which was transported. There was no risk of leakage, no RNA isolation was required; and we directly did RT-PCR and reporting. This led to many advantages instantly such as 50% less time, 40% less cost and 3-4 fold higher throughputs. The Dry swab technology/ know-how was recognized by ICMR and we handed over the technology to several companies viz. Meril Diagnostics, Vapi, Gujrat; Capital Health, Hyderabad; Indra Chemicals, Chennai; BioSmart, Mumbai; SpiceHealth, Delhi with Apollo Hospital as co-producer of the kit using this technology which would be marketed soon.

Another activity that we performed was NGS based COVID 19 Diagnostics-Strategy funded by CSIR. This includes steps viz. sample collection, RNA Isolation (3 hours), RT PCR with sample specific bar coding (1 hour), pooled cDNA amplification (1.5-2 hours). The samples are pooled together and transferred to NGS library (6-8 hours) with another bar coding; and the results are obtained within 48 hours. The important thing is that the testing of 50,000 samples could be done in one go and the cost may be as low as Rs. 200/- per test. So, this is a very good method for screening/testing large samples in institutional based laboratory in a short time.

We also performed the repurposing testing of various Anti-COVID Drugs at CCMB with several institutions and companies in collaborations as well as service mode including DRDO, CSIR-IICT, CSIR-NBRI, CSIR-CDRI,

CSIR-IIM, CSIR-NCL, CSIR-IGIB, CSIR-IHBT, Aryavaidyashala, AVRA labs, SRISTI. So far we have tested 60 drugs in service mode and 93 drugs in collaborations. There are different labels of commercialization; viz. the first anti-viral/anti-COVID was tested with DRDO and released for use by the Defence and Health Minsters as the Science and Defence Ministries were involved in this task.

We have a major contribution towards antibody therapy for which we are working in partnership with *Vins Bioproducts Ltd. (which is Hyderabad-based company) to obtain an antibody product* VINCOV-19, as a therapeutic option after immunization of horses with inactivated SARS-CoV-2 virus in combination with adjuvants*. It has passed the Phase 1 trial and Phase 2 trial is going on which will be completed soon for getting the emergency approval of this antibody product. So, we are going to be in much better position to handle when patients need hospitalization.*

Genome surveillance is an activity in which CCMB is also involved from the beginning and CCMB has been known for its genomics infrastructure. We have developed tools for a large SARS-CoV-2 sequence analysis which are real time deflections for sequences deposited from India and other places. Around 75,000 sequences were deposited a couple of weeks back and documented; the type of variant (which variant is going on) was assessed. Apart from the genomic surveillance, we did a couple of other surveillance such as the Sewage surveillance (after collecting sewage water from the sewage treatment plant/ wastewater and detect the presence of virus). Hyderabad was the main centre for doing this surveillance, but we have performed this task in 10-11 other cities as well in collaboration with IICT and NEERI having expertise in sample handling network for collecting these samples. This gave the correct estimation of the number of cases and variants. The method of sample collection and processing involves sample collection site, samples in bottles containing disinfectant, transported to COVID-19 testing lab, stored at 4 degree C till further processing, coarse filtration, filtration, concentration, RNA isolation, RT-PCR, Infection estimation. Using this method we could infer that how much sample and concentration is required; and now in a position to say how much population is infected and carried out this process in a very large scale in Bangalore and Hyderabad. We also monitored the trend of infection in Prayagraj (Allahabad) based on wastewater surveillance; and analyzed the actual number of cases reported. We have done extensive analysis involving hourly collection; and then, daily, weekly and monthly monitoring basis and monitored the lakes of Hyderabad, viz., Hussain sagar, Nizam Talab, *Pedda Cheruvu* having the drainage system and the lakes viz. Pothuraju Lake and Edulabad Lake without having the drainage system. We performed surveillance of major cities of Andhra Pradesh with the support of the Government of Andhra Pradesh. So, we learnt a few lessons from this whole exercise involving research and innovation which could be summarized as follows:

- Sewage surveillance gives a qualitative as well as quantitative estimate of the number of people infected in that population.
- Can be used as a reliable and unbiased surveillance measure to understand the progression of COVID-19 even when mass scale testing for individuals is not possible.
- An indispensable tool for early and easier detection of future COVID-19 or other outbreaks as soon as the person starts developing the symptoms.
- Means to ascertain the efficacy of the steps taken; especially in lockdown conditions to check whether people are following the protocols or not.
- Along with SARS-CoV-2, several infectious agents and biomarkers associated with diseases can be detected in wastewater surveillance.
- Wastewater surveillance can help in understanding the antimicrobial resistance emerging in microorganisms.

We are setting up extensive systems in Bangalore and Hyderabad to measure all the infectious agents, particularly the microbiologists who can tell which part of the antibiotic is going to be effective.

The other activity included the Air Surveillance for predicting the presence of virus in the air for which we designed some methods and cheaper tools for doing the air sampling in Chandigarh and Hyderabad; and

the data were pooled for obtaining the results. The sampling was done at COVID wards, COVID ICUs, PPE undressing rooms, OP corridors, Nurse Stations, Non-COVID wards, Mortuaries, General Wards, Apartments/ homes.

What we learnt is as follows:

- SARS-Cov-2 is detected in air in certain conditions and mask works.
- The chance of picking up SARS-Cov-2 in air depends on number of COVID positive cases in the room, their symptomatic status and the duration of exposure.
- The strategy of segregating hospital areas into COVID-care and non COVID-care can help in controlling the spread in the hospitals.
- Analysis of the air samples collected from houses of COVID-19 individuals suggest that if the patient is immediately isolated after being tested positive, cross infection to other family members can be prevented.
- In closed, less ventilated rooms, virus can stay longer in the air.
- Virus can stay in air in place like toilets for more than two hours.

Based on these observations and innovations, we shared the advisories to the government and other organizations which could be extended to other public places also to measure the level of infection to take the decisions further.

Another important aspect which is very well discussed about this virus is that most of the pandemic infections are zoonotic in origin (Zoonotic transmission). Zoonoses are the infections transmitted from animals to humans; and also become transmissible from human to human. Current pandemic is thought to have come from a wildlife food market in China's Wuhan city with likely origin from bat-borne virus. Pathogens that cause outbreaks in humans evolve in reservoir hosts like rodents, bats, and small mammals. There is greater risk involved from zoonotic transmissions as humans come into greater conflict with their environment. We have been procuring the protocols/SOPs for Zoo animals showing symptoms and also monitoring the Zoos all across the country with the support of Central Zoo Authorities for testing the animals. Across the world, around 58 mammals were examined out of which 13 species are found to be susceptible and 7 of them can transmit. We carried an experiment based on the models involving genome data and protein structure of SARS-CoV-2. It was observed that large number of animals have potential to transmit the SARS-CoV-2; the virus can go from animal to human, emerge as new variant(s) and could become problematic for us. So, it is essential that we take a note of this for stopping this pandemic as well as the future pandemics by taking a few measures like stopping the wildlife trade as well as the wildlife consumption (if you destroy the habitats, the animals will come near you) and destroying nature to stop the pandemics in future. It may sound different, but the human race must accept that this planet belongs to all creatures. Indigenization and Self-Sufficiency are very essential for the kit supplies for diagnostics, medical devices. Now, there are new generation of drugs and vaccines including Antibody therapeutics, Biotherapeutics, RNA therapeutics and mRNA vaccines. So, indigenization in this case is very important, otherwise these all will be unaffordable; and in this process (indigenization), we also need to set self-sufficiency. The areas like Precision and Personalized Medicine, Genomics and Genome editing (disease, food and environment) require one hundred percent self-sufficiency. The COVID-19 test requires the components such as Enzymes, DNA polymerase, Reverse transcriptase, primers, probes fluorescent primers, dNTPs as well as the sophisticated handling equipments. So, to indigenize this completely, we executed a project. The objectives included: 1) Sourcing suppliers of components; 2) Quality assurance of the components along with the industry standards; 3) Develop SOPs for testing each component individually and in combination; 4) Capacity assessment; 5) To deliver validated kit and readiness to deliver 0.5 million tests per month; 6) Identifying partners for manufacturing and marketing. So, we identified the standards and indigenous partners. The benchmarked reagents and chemicals were procured such as Promega, Thermofisher Scientific, HiMedia, Sigma, IDT, Takara, NEB, Eurofins. We also identified the Indigenous Reagents/ Chemical Manufacturers such as Sapala Organics, Sisco Research Laboratories,

BioArtis, BioServe Biotechnologies Pvt. Ltd., Avra Life Sciences, Huwel Lifesciences, Richcore Lifesciences, Sahagene, IICT etc. for producing an indigenized kit which comprised the Indigenous COVID-19 Test reagents i.e. Raw materials (reagents, primers, probes, enzymes), Consumables (tips, microfuge tubes, screwcapped tubes), Packaging (kit box with adapter, labels, protocol leaflet), Misc. (power, wastages) and cost Rs.68/- per kit. We have identified a company viz. Nexogen with GMP facility for packaging the kits; and two more companies such as Vintar and AIbot which are interested in marketing the kits with 0.5 million RXN per month.

Conclusion: To conclude, I would say that self-sufficiency in manufacturing and supply of research material is very much required in any kind of pandemic-like situations in future. It is equally important for research and innovation, in general; and will serve as a great catalyst. As scientists, we must also know about spending of significant time and the proper utilization of funds to import the things. For indigenization, we have all the ingredients. All we require is building capacity having quality measures and acceptability (to ensure institutions for accepting the reagents); and we can make difference in a big way.

Remote Patient Monitoring and Telementoring using Telehealth Technology in improving patient outcomes

Prof. R K Dhiman

I'll be talking about the management of chronic hepatitis 'C' as public health problem. The applications of medical biotechnology in health include:

- The discoveries in molecular biology, genomics, cellular and tissue engineering, new drug discovery and delivery techniques and bio imaging hold the promise of improving healthcare by enhancing diagnostic capabilities and by expanding therapeutic options
- Onset of COVID-19 pandemic has brought in convergence of all fields of science & technology, in particular the biological, medical and physical sciences
- Significant contribution of biotechnology in recent times include Digital Medicine/ Digital Health/Cyber Medicine which has converged Physical sciences as Information Technology, Telecommunications, Biosensors, Virtual/Augmented/ Mixed reality with health science and has shown the impact in remote patient care, capacity development when several countries worldwide had instituted shut down and had no physical access to services
- Information science & technology-EMR, Big data Analytics, Machine learning and Augmented Artificial intelligence
- Communication Technology-Wired, Wireless, Sitcom
- Medical biosensors and Internet of Things (IOTs)
- Medical Internet-Health portal for citizen health data storage, access to information, interaction with care providers and seekers
- Telehealth Technology applications for care delivery, remote patient monitoring (Tele-ICU, chronic disease management, emergency medicine, health professional/ system capacity development through tele-monitoring etc.)

Burden of Hepatitis C in Punjab-Prevalence is 3.6%. More than ten lac (10, 00,000) people are Antibody (HCV) Positive; and the viramic population is 80% of the total antibody population. Considering the demography of Punjab, there are 22 districts, 22 district hospitals, 41 sub-divisional hospitals, 150 Community Health Centres, and three Government Medical Colleges.

It's so important to treat the Hepatitis C patients. Once the infection is developed, 70 % of the patients develop Hepatitis C; and over 20-25 years, 30% of them develop the Cirrhosis and thereafter, develop complications in the form of ascites and intestinal bleed called hepatocellular carcinoma (HCC) and end stage liver disease (ESLD). So, the patient needs to be treated at the earlier stage to avoid further/ severe complications. Several such patients (virus positive) have been treated in Punjab under MMPHCRF (Mukhya Mantri Punjab Hepatitis C Relief Fund) model. We made three SOPs under the treatment:

- The goal of the Punjab Model is HCV elimination by 2030 using primary care providers and remote treatment monitoring.
- Reduction of all cause mortality and liver related deaths, risk of developing hepatocellular carcinoma and risk of developing end-stage liver disease and need for liver transplantation.
- Thus, eliminating Hepatitis-C from Punjab would help save thousands of lives.

Hepatitis C workshops were conducted with four hours pre-defined course, wherein around 120 medical specialists/ primary care physicians were trained from 25 centres. Then, we had ECHO programme

(through which we could connect to all), for which PGIMER, Chandigarh was the hub including 25 centres (spokes), the district hospital and three medical colleges; also formed WhatsApp group for discussion and problem solving; the syllabus included the case (the difficult ones) discussions and didactic lectures; these ECHO programmes were conducted once a week.

The capacity building programme included training of district epidemiologists (help medical specialists), pharmacists and data entry operators for the data management, monitoring and evaluation. Initially, we started 25 centres in Punjab (including district hospital, Government colleges, sub district hospitals, ART and OST centres) in 2016 which gradually enhanced to 34 in 2019 and in 2021 for effective outreach of treatment to patients and providing facilities to all places to do micro-elimination.

The laboratory testing of HCV was a challenge. For example, if we are doing HCV antibody testing with ELISA, and those who are found positive then, we perform Quantitative HCV RNA testing also; and in few hepatitis C patients who have liver cirrhosis or advanced disease, we need to do Genotyping otherwise it is optional. For determining the response to HCV treatment, we used to give this therapy either for 3 or 6 months. At the end of the therapy, we have to do HCV RNA. If it is negative, then we do SVR (Sustained Virological Response), 12 weeks after the completion of treatment. If it is positive, that means it is very unlikely to have a relapse in future.

Cirrhosis is present in 15% of the cases, so genotyping is important. The treatment is different for different genotypes (Type 1&3; and Type 4).

We also have to do APRI (AST Platelet Ratio Index) and FIB-4 for diagnosis of cirrhosis; because cirrhosis patients have different treatment. As per the CASCADE report (June 2016-May 2021), around 2, 00,000 patients were screened, out of which 127,921 were found to be antibody positive. Then, RNA was done with or without genotype depending upon whether the cirrhosis was present or not. The treatment was initiated in around 95,884 patients; and 93% were found to have cleared the virus and achieved the viral sustained response which was actually the achievement. Around 56,073 patients were cured, 4,288 failed and 438 deaths were reported. There were several challenges; and we also learnt several lessons. We had capacity building programme initially starting/running in 25 centres; now extended to 67 centres involving primary care physicians, pharmacists and data entry operators. It was also felt that there is a need of repeated capacity building among medical and paramedical staff in management. Earlier, we had only PGI as a hub with spokes at around 67 centres. Before the launch of the programme, PGI was the only centre for treating around 1,000-1,500 patients in a year. After the launch of this programme 4,500-5,000 patients were treated at each centre. So, by the end of the year, we treated around 44,000 patients. We were doing molecular testing also (involving biotechnology) to treat such patients. Primary Care Patients (PCP), Data-entry operators and pharmacists are front runners while hepatologists and gastroenterologists deal with special situations such as the Treatment Experienced (TE) patients who have not responded, decompensated cirrhosis, children etc. The micro elimination programme particularly for the children was also started. The only difference was that we had categorized children under 35 and over 35 kg of weight. For the children under 35 kg of weight, half the dose was administered whereas those over 35 kg of weight category were given the full dose; and over 97% of them sustaining viral response were observed. This was further applied in the patients who inject the drugs (the IV Drug users). We have treated approx. 3,500 patients. Although, the dropout rate was higher as compared to the general patients, but the response rate was equally good. It was observed that decentralized care for chronic hepatitis C, for persons who inject drugs using all generic direct acting antivirals is feasible, safe and effective. As of now, we have treated 2, 00,000 patients out of 8, 00,000 desired patients (25%) since 2016. The main challenge that we faced was molecular testing including RNA and genotyping. The current testing approach is cumbersome and not ideal for high volume screening. There are different tests evolving viz. the POCT (Point of Care Testing) and RDT (Rapid Diagnostic Test). The RDT requires special equipment and trained personnel whereas the POCT is rapid and no special equipment or electricity is required, easy to perform and no cold chain required. These

provide immediate linkage to the care; the RNA and the antibody test can be performed (on the same day) to start the treatment the same day depending on the availability of the tests. There are challenges ahead which include the management of Treatment Experienced Patients (those who have failed) because of the presence of drugs viz. NS5A associated with the substitutions in the RNA virus. So, we are looking forward to the resistance-associated presence. Then, need of Repeated Capacity Building of medical and paramedical staff in management of Hepatitis C is another challenge. Further, issue of 'loss to follow up', despite availability of free diagnostics and treatment is also a major concern. Tele medicine in this situation is very helpful and we are able to generate the 'alerts' before these come in case of medicines; and thus, increasing the compliance with the patients also. The Punjab Model was very much successful and therefore, the same was also taken up by the Central Government to start the National Viral Hepatitis Control Programme (NVHCP) for combating viral hepatitis. I am the Chairperson of the TAG Group of this Programme and we have published three SOPs -Diagnosis and Management of Viral Hepatitis at National Level which includes all the types of hepatitis, 'A', 'B', 'C' and 'E'; National Viral Hepatitis Control Programme with operation guidelines and the National Laboratory/testing guidelines also; and now the programme has evolved at the national level also to combat the viral hepatitis at the national level.

Conclusion: 1) HCV infection is a real public health problem in different parts of India; 2) If left untreated, then HCV infection causes substantial morbidity and mortality; thus large number of HCV patients need to be treated at the Public Health Level; 3) The goal of Punjab Model is HCV elimination by 2030 (so far we have achieved 25% of the target) using primary care providers and remote treatment monitoring; 4) The model utilizes unique combination of remote patient monitoring and telemonitoring using telehealth technology and biotechnology in improving patient outcomes; 5) Decentralized care of patients with HCV infection using generic all-oral DAA regimens is safe and effective regardless of genotype or presence of cirrhosis. The credit for these efforts goes to the Government of India & Punjab; Mr. Gagandeep Singh Grover (State Programme Officer, Hepatitis C Virus Infection, Directorate of Health and Family Welfare) and Madhumita Prem Kumar (Post Graduate Institute of Medical Education and Research), Chandigarh.

Remarks by the Co-Chair: I would like to thank all the speakers of this session viz. Prof. Balaram, Prof. Jagannathan, Prof. Mishra and Prof. Dhiman for their excellent talks. I would take this opportunity to sincerely thank Prof. (Mrs.) Manju Sharma for inviting me to this event.

Session 3: Entrepreneurship/*Atmanirbhar Bharat*

Chairman

Dr. Renu Swarup

Co-Chair

Dr. V P Kamboj

Dr. Renu Swarup

Congratulations everybody on the Foundation Day of NASI! The topic of the symposium i.e. 'Interface between Biological and Physical Sciences towards *Atmanirbhar Bharat*' is itself so interesting and the way the sessions have been curated to bring out each aspect of it. We cannot have *Atmanirbhar Bharat* without entrepreneurship. The call that we were given during the COVID times, we have seen how the entrepreneurs worked so closely with academia and we have also seen high tech being taken up by these entrepreneurs to be able to set tools for self reliant India locally, but also globally. One of our speakers Dr. Satish Reddy has worked so closely with his team to produce vaccines not for the India, but also for the globe; and that is what the entrepreneurship is. Dr. Ritu Trivedi will elaborate on the natural products and will mention how science can move out from the laboratory to the land and industry as well and the product development. COVID has given us the opportunity to connect the academia and industry so well.

Dr. V P Kamboj

The entrepreneurs of our country have lived up to the expectations of our country in developing the products. India is as far as the due eco system is concerned. But, unfortunately, it has ranked 22nd now as far as the business/ industry in this area is concerned. The limitations include internet issues (speed etc.) and the power availability. We must move to 5G or 6G to cater to the demand of industry. Dr. Satish Reddy has played a critical role in developing Sputnik V COVID-19 Vaccine in our country.

Indian pharmaceutical industry-Journey to Self Reliance

Dr. K Satish Reddy

If we see the defining moment for Indian Pharmaceutical Industry, it was really the Indian Patents Act of 1970, and we called it the Active Pharmaceutical Engineering Industry, popularly known as *Bulk Drug Industry*, because prior to that most of the products, especially the active ingredients used to be imported. The formulations used to be highly priced, because of the lack of availability of raw materials/ active ingredients; and whatever little produced here, for example the antibiotics, was used to be done in partnerships. Taking the example of IDPL, the IDPL had technology provided by Soviet Union for penicillin antibodies in 1967. In 1971, India didn't recognize the products patents, but the process patents; and this in fact spotted the entrepreneurship. Dr. Reddy, the entrepreneur, started his first venture, completely on his own in 1984 and the journey from that point onwards almost traced the evolution of the API (Active Pharmaceutical Ingredients) Industry in India. We were allowed to develop new processes for the existing products. The chemistry skills in India were pretty high at that point of time; and we were able to develop products of very high quality, but continuously kept on innovating on it to commit cost efficient processes. So, product after product traced Dr. Reddy's journey itself. There were off patent products like ibuprofen which was made so cost efficient that we actually displaced the leading manufactures from Japan, Italy to become the third largest manufacturer in the world (in early 90s) which is one example. If we talk of self-reliance, we find that the cost of the products like Quinolones used to be so high; Dr. Anji Reddy worked hard to make it cost efficient and this showed the way of being completely self-reliant on technology.

The new PLI scheme is encouraging the Indian industry towards *Atmanirbhar Bharat* to bring back the indigenous production, especially by establishment of software parts. The second phase starts from the year 2000 onwards, the story is about the generic products where India stands very strong in terms of entrepreurship; and India's endevours are much appreciated, because in terms of policy, the US market being the largest market, encouraged/ promoted the generic companies/ products. The Hatch-Waxman Act of 1984 encouraged the generic companies to challenge the patterns of innovators. Our company (Dr. Reddy's Lab) worked hard to develop product and sell generic medicines to US. If we fast forward 20 years later, India is globally competitive, the generics' player-one in three generic medicines from US, is from India, one in four medicines from UK, is from India. It is not just about the price, it is about the quality; and that's something we have been able to bulid in terms of API success, in terms of generics which shows the scientific talent, the entrepreneurship of people like Dr. Reddy and several others. We just came off with a global summit, inaugurated by Hon'ble Prime Minister. This was about moving on from just being a pharmacy to the world to becoming the innovator from India. It's risky, but highly rewarding. More than anything else, the Indian companies have the capability which is again proven in terms of the products that are there in the clinical development. We are in space of Indian immuno-oncology products; Zydus is in NASH (non-alcoholic steatohepatitis), for example.

Conclusion: I will just conclude by saying that there are host and host of companies investing heavily into research; but, it costs a lot more. It is not just the industry, but also the academia which needs to come along with the partnership with industry. It's also about building innovation hubs in the country; it's also about policies and also the funding which is very important.

All these steps will take India to the next level; something which we are all looking forward, because the success that India displayed in APIs and generics, we would certainly like to see in terms of becoming the innovators to the world.

Remarks by the Co-Chair: This shows how the 1970 Patent Act revolutionized Indian Pharma Industry. This is now the dispensary of the world not only in terms of generics of small molecules, but also in the biologicals. India is the largest supplier of vaccine. We are confident as the Government has come a big way to support in the area of vaccines; and soon we'll come a big way in the area of drugs also, that is, in terms of small molecules as well as the bio-pharmaceuticals.

Herbal remedies to modern Phytopharmaceuticals: an approach towards *Atmanirbhar Bharat*

Dr. Ritu Trivedi

The history of Traditional Medicines (TM)/ Ayurveda is known for nearly 5,000 years. There are 10,000 medicinal plants which represent or contribute to less than 5% of total plant biodiversity. Looking at the 100 years' history of medicinal plants, we find that we have so many NCEs (New Chemical Entities), discovered from the medicinal plants (Aspirin, Quinine, Morphine, Artemisinin, Colchicine, Taxol etc.). We have well established regulatory pathways (US-FDA, DCGI). Over 50% of all NEs approved by USFDA have origin in natural products. In 2005, US-FDA opened up regulatory pathway for botanical drugs; in this area, there were over 500 INDs and 3 NDAs discovered having extracts and enriched fractions, but did not have any identified active principal. This opened up great new opportunity for TM and Ayurveda. Initially, this was used by China. In India, it was 13% of the global trade in spite of the regulator guidelines. But, in 2005, we got a chance when DCGI formulated the Phytopharmaceutical guidelines for us for new drug development and guidance. Considering the influence of traditional and AYUSH medicines with reference to economic context, we find that there are more than 8,000 plant based remedies available in India via AYUSH system. The revenue from the systems viz. Ayurveda, Siddha and Unani alone is annually over half a billion dollars. By 2023, the projected global market for herbal medicine will be worth USD 111 Billion. India's domestic market for AYUSH systems is currently worth Rs. 500 crores. The current valuation of the Indian Herbal Market is at Rs. 5,000 crores showing an annual growth rate of about 14%. We have recently got a lot of key players into it. Several companies in India have come since the phytopharmaceuticals have been introduced. Other companies like Himalaya Herbals, Dabur India Ltd., Hamdard Laboratories, Patanjali Ayurved Ltd. Emami Ltd. and Zandu Care Pharmanza Herbals Pvt. Ltd., Schaper and Brummer, Biotech Corp., Bioforce AG, and Max Zeller etc. are already doing great in herbal and traditional medicine market since the phytopharmaceuticals have come into picture. So, there are a lot of companies coming up, but lack in standardization facilities. Now, the question arises what are the deterrents in the regulatory markets? Why the Phytopharmaceuticals have not been able to penetrate global regulatory markets and make an impact? The answer lies in considering a few aspects: 1) Indian botanical/herbal drug industry meets its more than 90% botanical raw material (BRM) demand from wild collection; 2) There is lack of transparency in chain of custody of BRM from collector to cultivator to consumer industry; 3) Out of approx. 8, 000 Indian ISM industries, about 7,000 are very small and lack in-house quality control and standardization facilities; 4) There is lack of inclusion of ISM plants in global pharmacopoeias (only 100 plants included till date). Recent inclusion of 90 Indian plants in US Pharmacopoeia has opened new business opportunity for us; 5) Lack of aggressive policy in promoting Indian Systems of medicine in Global markets; 6) Regulators should form laws which are helpful in promoting exports; 7) There is lack of concerted efforts in validating the claims of traditional drugs using modern scientific tools. So, these are the reasons why we lag behind to make an impact. To illustrate this, CSIR-CDRI has developed a product, Bacosides Enriched Standardized Extract of Bacopa (BESEB). It's a clinically researched product for dementia, particularly children suffering from ADHD, elderly persons with Age Associated Memory Impairment (AAMI) and maintaining cognitive health. It has undergone vigorous chemical, clinical and pre-clinical investigations in 1980s; and was developed like a modern medicine. Further, it was licensed to Lumen Marketing Co., Chennai for extensive marketing; and also made its place in South Africa and Australia (where it was marketed under the brand name 'KeenMind') as well where around 4,000 children with ADHD and 10,000 elderly patients with AAMI regularly consume this product. But, it could not have made the kind of impact and place it should have got, because of lack of marker and content

uniformity. So, learning a lesson from this, the CSIR-CDRI followed DCGI regulatory requirements for phytopharmaceuticals promulgated in 2015 which include: A) Description of the product and documentation of its traditional use, composition, safety, bioactivity, present usage, PK/PD monograph etc.; B) Identification, authentication and source of plant (4 markers); C) Process for extraction and subsequent fractionation and purification; D) Formulation of phtopharmaceutical drug; E) Manufacturing process of formulation; F) Stability data; G) Safety and pharmacological information; H) Animal toxicity and safety data; I) IND approval and Clinical Trials. The USFDA guidelines /regulatory requirements for botanicals, known as botanical drugs in US (promulgated in 2005 and modified in 2015) are also to be considered. Before filing USFDA, clinical consideration is a must with respect to its efficacy, safety to be verified in randomized, double blind (placebo) controlled clinical trials.

The possible growth drivers of phytopharmaceuticals include:

- Pharmaceutical touch in dosage formulation: The pharmaceutical dosage forms are processed traditionally as well as pharmaceutically. Pharmaceuticals are also processed as technology-based pharmaceutical formulation processes (this minimizes the risk of contamination or adulteration as instead of crude plant based materials, standardized bioactives are incorporated in dosage form which enhance the psychological adaptivity towards phytopharmaceuticals). Converting Ayurvedic aqueous extract to a phtopharmaceutical with the help of technology-based approaches.
- Evidence-based approach: This will promote research and interest of innovators, national laboratories and industries in phyto-pharma sector.
- Attitude difference: This has actually come up after the prevalence of COVID-19 pandemic with more emphasis on enhancing the overall immunity of the body. Long term use of allopathic drugs only mitigates specific symptoms rather than stimulating body to self-heal. Herbal medicines are perceived as being safer; hence in the last two decades, there has been a significant increase in the use of herbal medicines. Around 65% of people in India only use traditional medicines.
- The Government and AYUSH initiatives: The Council of Scientific and Industrial Research (CSIR) has conceptualized the Phytopharmaceutical Mission to bring transformative change in the medicinal plant sector. The phytopharmaceutical mission for the North-east region is aimed at cultivating and promoting the medicinal plants of that region. Another initiative is to increase educational approaches by AYUSH as well as to raise the standards of herbal and traditional medicines globally, bringing several changes in AYUSH curriculum. Further, the NITI Ayog is also making strong recommendations. So, the initiatives taken by the Government has eased the rigid platforms through which specifications of plant materials can be revalidated in a much productive manner.

So, all these growth drivers backed with strong mechanist research will help consumers in getting confidence on herbal products available as phytopharmaceuticals. All these factors would surely provide lucrative opportunities for the pharmaceutical business in India; and the final acceptance will come from various regulated markets/consumers for these products. CSIR-CDRI has contributed in a small way towards *Atmanirbhar Bharat*.

Remarks by the Chair: We got the snapshots of what the entrepreneurship is and how important it is for *Atmanirbhar Bharat*. We saw the Research Institutes and we saw the Industry. In fact, COVID has actually taught us how important the entrepreneurship is. We have seen our COVID S&T solutions to diagnostics, vaccines etc.; and the role which the entrepreneurs have played in this. But, I think, clearly the message that has come to us that how we succeeded in this entrepreneurship; it's all through **c**ollaborations, **c**onversion of ideas and most importantly, through the **c**ommitment. So, these three 'C's have played a very important role. You need the people (the human resource) and you need policies to take it ahead; but, most importantly you need quality products (as Dr. Reddy said). We need to focus on three 'I's, that is, 'Innovate In India'. To innovate in India, you have to make sure that you have the right investments for it. Our focus has to be on indigenization. We work on indigenization; and we take it for global acceptance**.**

NASI Foundation Day Lecture

Felicitation of Prof. Balram Bhargava

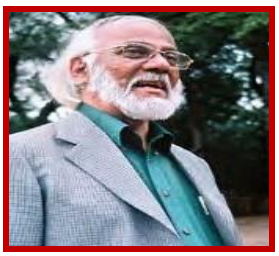
Remarks by the Convener

Prof. Manju Sharma

NASI is working hard and spreading awareness on COVID-19 all across the country through its Programme on 'Jagrukta Abhiyan'. So far, we have organized more than two dozen of webinars. It was decided by the NASI Council to give some awards to the younger people, health professionals and scientists who have really contributed during this period for the benefit of society. So, an expert committee met and decided to give awards to such people. Then, the committee also decided to give awards to some senior people who have done monumental work during this period of pandemic. With their dedication and commitment, it has been possible to cover the COVID related aspects with the application of science and technology and actual prevention and control of the disease. So, the first person, the committee recommended was **Prof. G Padmanaban**. He made tremendous contribution towards spreading awareness by delivering talks on COVID-19, its prevention, use of masks etc. The committee selected him for the award because of his work and also communicating awareness about vaccines, the related aspects including research and also about the vaccine hesitancy. He has written several articles on vaccine; so, NASI has conferred upon him the award of honour for his exceptional contribution during COVID-19 pandemic.

The committee also selected the name of **Prof. Balram Bhargava** and felt that he has worked round the clock for the last two years, created facilities and made tremendous contribution towards prevention, control, monitoring and management of all aspects of COVID. The most important contribution made under his leadership (from ICMR) is the vaccine, the Covaxin which has now benefitted crores and crores of people in this country; and we are living safely because of that. So, the committee decided that Prof. Bhargava will be honoured/ felicitated with the award of outstanding contribution during this period. The country is proud of Prof. Padmanaban as well as Prof. Bhargava's contributions.

Remarks by the Chairman



Prof. G Padmanaban

We are very much grateful to Prof. Balram Bhargava who has agreed to deliver this foundation day lecture in spite of tremendous pressure in these trying times. He is the Director General of ICMR and Secretary of the Department of Health Research, Government of India. He is an eminent cardiologist who earlier worked at All India Institute of Medical Sciences, Delhi and well recognized over the globe. He has been awarded with the 'Padma Shri', the fourth highest civilian award for his tremendous contribution to the field of medicine; and also the recipient of SN Bose Centenary Award by the Indian National Science Congress, The National Academy of Sciences Platinum Jubilee Award, Tata Innovation Fellowship and OP Bhasin Award in the field of Health and Medical Sciences, just to name a few.

As already pointed out by Prof. (Mrs.) Manju Sharma, the way he gave the leadership to the team of ICMR in the real pandemic time is something we feel really proud of. The entire team under his leadership was involved in testing, tracing and most importantly, developing the vaccine (inactivated viral vaccine) with its trials at various centres all across the country which is being much appreciated all across the globe. The credit really goes to Prof. Balram Bhargava for his exemplary leadership.

NASI Foundation Day Lecture

Prof. Balram Bhargava

It was a really tough time for all of us and we definitely learnt from this pandemic. The scientists, research institutions and laboratories worked together in a collaborative way; and it was whole of government approach involving various ministries which facilitated to fight with the pandemic. India is safe only when the world is safe. So, the contribution by India would be very important towards the vaccine manufacture, delivery and export. The pandemic is not yet over; and we still have to follow the 'COVID Appropriate Behaviour'. Today is the Foundation Day of NASI. The idea for establishing the first Science Academy in the country was mooted by Professor Meghnad Saha in 1929; and he established the Academy of Sciences of the United Provinces of Agra and Oudh in 1930 at Allahabad which was registered on December 4, 1930. The name was altered to the National Academy of Sciences, India on December 5, 1936. We have the stalwarts who were the Presidents earlier viz. Prof. Meghnad Saha himself, Prof. K N Bahl, Prof. N. R. Dhar, Dr. B Sahni, Dr. S M Suleman and Dr. D R Bhattacharya. NASI also had successfully celebrated its Golden Jubilee, Diamond Jubilee and Platinum Jubilee events graced by renowned personalities viz. Smt. Indira Gandhi (the then Prime Minister), Dr. APJ Abdul Kalam as well as NASI's Past Presidents. Today, there are 1955 fellows, 1932 members, 113 Foreign Fellows, 15 honorary fellows, 21 Chapters and 22 Tribal Centres of NASI all across the country. Currently, Prof. Ajoy Ghatak is the President; Prof. G Padmanaban is immediately Past President. The other Past Presidents include Prof. MGK Mennon, Prof. V P Sharma, Prof. T N Khosoo, Prof. U S Srivastava, Prof. M S Swaminathan, Prof. A K Sharma, Prof. K Kasturirangan, Prof. Anil Kakodkar, Prof. (Mrs.) Manju Sharma and Prof. G Padmanaban. A festschrift, dedicated to late Prof. MGK Menon, the former President of NASI was released by Hon'ble Prime Minister, Shri Narendra Modi at his residence, in the presence of Prof. Akhilesh Tyagi (the then President of NASI) and Prof. Manju Sharma (the Past President of NASI). This truly speaks how important this Academy is for the nation and the services rendered by the Academy (1930-2021) in 91 years towards Science and Society of India. The mandate of NASI is 'Science & Society' which includes the scientific programmes for the society viz. Science communication, Entrepreneurship development, Technological Sensitization of Women Scientists, Programme for tribals, Safe water and Sanitation, Health & Nutrition issues, Children Science Meet etc. The efforts in this direction would be strengthened manifolds, specially by involving more and more younger generation in Science and Society programmes which has been the backbone of the society. Now, I would like to mention about the book 'Going Viral: the inside story of COVAXIN' which records the inside/ encouraging story of tackling the pandemic in India by the ICMR/ Government of India, efforts of all who worked tirelessly and making of Covaxin (which is a whole virus vaccine). The foreword has been written by the 14th Dalai Lama; and this book has been launched just a few weeks back. The Indian Council of Medical Research, one of the oldest medical research bodies in the world was founded as Indian Research Fund Association (IRFA) in 1911; and renamed as Indian Council of Medical Research (ICMR) in 1949. It conducts, coordinates and implements medical research for the benefit of the society. It is also translating medical innovations into products/ processes and introducing them in to the public health system. I remember; and would like to mention here what Dr. E. Sreedharan, the Metro Man always used to say, "If you have to be successful in life, you need four things, i.e. you need to be punctual, you have to have utmost integrity, professional competence and commitment towards the society". This Academy and the Indian Council of Medical Research are conducting and coordinating medical research and trying their best to the benefit of the society. If we look at 111 years of service to the nation, the Beri-Beri Enquiry was done in 1918; Malaria Survey of India in 1938; the Kala-azar cycle was established/set up in 1942. Further, we had the Domiciliary treatment for Tuberculosis in 1959; first Oral Polio Vaccine Trial in 1963; low-cost calorie supplements for PEM in 1969; Oral rehydration therapy in

1970; Double fortified salt in 1994; and now we are also looking at Double fortified salt as iodine as well as DEC (diethylcarbamazine) for elimination of the lymphatic filariasis in the country. The COVID pandemic has taught us that India being the largest democracy has recalibrated its intervention as needed. We were fortunate as the pandemic started about three months later than it had started in the western world; and therefore, we could get some learning from the western world. We were serious right from the beginning when the first case of COVID-19 was detected/reported on Jan 30, 2020 by the NIV when a medical student who travelled from Wuhan to Hong Kong; Hong Kong to Kolkata; Kolkata to Bangalore; Bangalore to Cochin and finally to his hometown. A number of contacts were traced for him (more than two hundred), because that was the first positive case. It was whole of the government approach-calibrated, proactive, pre-emptive, graded response as well as science-driven with best practices and evidence based; and also, the strong leadership with excellent communication from our leadership that was able to keep our country together with the formula/mantra of test, track and treat. We never realized, embraced or thought of the concept of herd immunity unlike other countries in the west; but believed in maintaining test, track and treat and following the COVID Appropriate Behaviour. India was the fifth country in the world to isolate and culture the virus on 5th of March, 2020. This was given to Bharat Biotech in the first week of April, 2020; and then, they provided us with a product which we characterized as well as looked at in terms of small and large animal studies. We were the first country in the world to culture the alpha variant, which was the UK variant in January, 2021; and we tested the efficacy of the vaccine against the Alpha, Beta, Zeta and Delta variants; and now trying to culture the samples of omicron variant, so that we can look at the efficacy of the vaccines viz. covaxin and covishield in the laboratory as well as for the society. The work done at ICMR was much appreciated; and we started setting up the laboratories and we were able to set up the laboratories from one laboratory at NIV, Pune which was established as one of the containment laboratories; the first of its kind in South Asia Region in 2012-13 and the second was the Wuhan lab in 2017. So, this laboratory was established with the support of the earlier Director Generals and visionaries like Prof. Katoch, Prof. Ganguly and other Senior DGs of ICMR. In the month of February 2020, we were only testing the travelers; and at that time we didn't have enough testing materials. Much of the testing material was supplied from the western countries and China. It was a suppliers' market, so we had to purchase it in a matter of hours, otherwise, it was diverted to other countries. We had to work with them; but, with the help of young entrepreneurs and other science agencies viz. Department of Science & Technology, Department of Biotechnology, CSIR, we were able to manufacture more testing equipments/kits. By the month of June/July, we were able to export the testing materials to the different parts of the world. In April, 2020, we were able to use the repurpose molecular testing 'TrueNat' for the diagnosis of the tuberculosis which was again a collaborative effort of the Indian Institute of Science, the Department of Biotechnology, the CSIR and the ICMR. We repurposed it for the first time in the world for Nepa and Leptospirosis virus and then started for COVID-19 and a similar test was developed in UK, called DNA, about six months later (in September/ October, 2020). We already had more than 7,000 such machines around the country. So, we were able to repurpose those machines; although the number of the tests done was very small, but, it was portable and could be taken to remote areas. This all happened in the month of April, 2020. India was the first country to start the Rapid Antigen Test in June 2020 when we had the peak of the pandemic in Delhi which started giving us results in 10-15 minutes. Then, we started manufacturing the kits in the large scale and exporting to the different parts of world. By September 2020, we were testing on demand, such categories which included high risk people, pregnant women, symptomatic neonates, pool testing etc. We have tested more than sixty three crore samples till date. We have 3,000 molecular testing labs and the National Testing Average is about 1,000-1500 tests per million per day which is 10 times what WHO recommends. WHO recommends 140 tests per million. The costs of these tests have been reduced because of the young entrepreneurs of India. The cost of RT-PCR test is now $ 2/ test and RAT is $1/test. All the laboratories are continuing to work and still we are doing 13 lacs tests per day; 32% labs are working on 3 shifts. We have now upscaled the TrueNat, a molecular test with the collaborative efforts of Science Ministry and Science Agencies of India. The COVID-19 TrueNat testing has been started from April and the WHO pre-qualification for TrueNat testing for COVID-19 is awaited. On June 9, 2020

a gazette notification was passed by ICMR that every medical college has to set up a BSL true laboratory for testing; and now around 534 out of 536 Medical Colleges have established BSL true laboratory; 664 districts out of 741 have RT-PCR testing and almost all the districts have RAT testing facility, except 50-60 districts where the work is still on. During the lockdown, a special mission 'Lifeline Udaan' was implemented / carried out in four phases from March 24 to March 31, 2020, under which our scientist worked round the clock during the lockdown to carry consumables, testing commodities, medical supplies to various parts of the country. We had collaborations with Indian Railways, Indian Air force, India Post, and Ministry of Civil Aviation and we were able to carry out this mission including the mission of Testing Laboratory at Iran because more than 6,000 Shia pilgrims were stranded in Iran in February, 2020; and NIV, Pune left for Tehran to set up RT-PCR lab in the basement of Indian Embassy at Tehran. 2,028 samples were collected from five cities out of which 308 (15%) were tested positive. Special flights were operated by Indian Air force and Iranian Airlines for repatriation. Similar samples were collected in Wuhan, Italy and Japan. So, it was whole of the government approach in case of vaccine development or RT-PCT testing; similar cases/stories exist with PPEs, Masks, Ventilators/oxygen and other paraphernalia where various Government Agencies/Ministries worked together. We also bust the myth of convalescent plasma by performing the PLACID Trail, a multicenter randomized controlled trial and also one of the largest trails. This was done in record time of two months; we published randomized trail where we clearly demonstrated that convalescent plasma is not working and does not lead to reduction in progression to severe COVID-19 or all-cause mortality. We had two editorials on this showing how democratization of research has happened where small hospitals were connected and participated in the trails and being monitored every day by BCs and the data had also been collected. We also carried out four rounds of National Sero-surveys in 70 districts, 700 villages/ wards and 21 states. In the fourth round in the month of June/July, 2020, we found 66.7% sero-positivity in individuals and more than 50% in small children; the papers have been published in various journals. The Indian SARS-CoV-2 Genomic Consortium of 37 laboratories was created in December, 2020; and this has been functioning overtime with the help of ICMR, CSIR , DBT, NCDC and MoH&FW detecting the circulating variants; and recently, we have detected three patients of omicron variant which is a genuine concern, because it is found to be highly transmissible. So, we have to follow COVID appropriate behaviour. COVAXIN is whole kill virus vaccine which allows broad spectrum immunity. It's a traditional/conventional vaccine unlike the modern vaccine which requires a virus culture and difficult to produce. The virus was given to Bharat Biotech; and is a classic example of how public private partnership works together. We had to do preclinical studies on mouse, rabbits and rats. We had very limited monkey breeding facilities and the monkeys were not available in the nearby cities during the lockdown period (now, under the aegis of ICMR, we could establish two Monkey Breeding Centres-one near Mumbai and other in Hyderabad for breeding the monkeys and other large animals for scientific testing). Within 5-6 days, we were able to capture monkeys from Telangana border, Karnataka border and Maharashtra. We captured 24 monkeys and tested them. Because they were captured from the wild, so we had to perform the IGRA test (the tuberculosis test), x-rays etc. for which the machine was purchased overnight at NIV, Pune. They were kept in the air conditioned cages at maximum containment laboratory and given the vaccine intramuscularly, and then the virus challenge had to be given by brochoscopy. The bronchoscopy of the monkey was done for the first time by the pulmonologists who did the bronchoscopy and gave the virus inside the third generation of the bronchi; and did the bronchial lavage (after the seventh day) every day for seven days under anesthesia for the monkeys. We collected and observed that the virus was not growing. That was the turning point where we realized that the vaccine had showed remarkable immunogenicity/ it was working. Then, we did Phase-1, Phase-2 and Phase-3 trails on 25,800 volunteers; the study was published in Lancet and other editorials appraising not only the killed-virus vaccine, but also the adjuvant which was the novel adjuvant and added for the first time in the vaccine. The adjuvant was developed by the start-up company (comprising the Indians who were there) in US; and this also contributed to its antigenicity in a big way. On November 3, 2021 we were able to script history by getting WHO emergency use licensing for this vaccine. After that, we have given more than 17 to 18 crores of this vaccine to several countries and more than 100 countries are using this vaccine now.

This vaccine neutralizes various variants, viz. alpha, beta, delta, zeta, kappa. We have set up various national task forces on COVID-19; the roles/responsibilities included calibration of testing strategy, advising government on lockdown and containment strategies, developing advisories (discharge policies etc.), providing oversight for all ongoing research, recommending the required clinical trials (drug/ vaccine), exploring newer/ repurposed treatment options and developing clinical management protocols. We had more than 140 meetings of task forces to discuss more about the new variants as well as the newer pharmacological and other treatments. We have more than 250 publications on research on COVID-19 in peer reviewed international journals and more than five special issues of Indian Journal of Medical Research. The management protocols have been given by AIIMS, ICMR, Ministry of Health and Family Welfare and the Joint Monitoring Group which has been the backbone of providing the guidance for the treatment of different states. We have provided the home isolation and care guidelines which have been very useful during the second wave for the people under home isolation and self care. So, the COVID-19 highlights include: countrywide scaling up of diagnostic laboratories (1-3,000) within a year; diagnostic kits self sufficiency (100% import to export); nationwide sero-surveys (four rounds); validation of diagnostics and handholding of local manufacturers; indigenous vaccine development (virus isolation to phase III); preclinical animal studies of international standards; extensive national and international COVID research (more than 250 peer reviewed articles); treatment/diagnostic guidelines and Public Health Advisories; innovative service delivery of drones (we have been delivering/transporting vaccines in the entire north-eastern region under ICMR programme called I-Drone; and started at Manipur and Nagaland and other remotest areas/places with distribution of vaccines, syringes, iron tablets etc.); socio-behavioural research on stigma vaccine hesitancy and mitigation. India has achieved the feat of more than 1.4 billion of dosage. This could be possible because of strong political will (from top to bottom) and whole of the government approach. Further, India has very successful Universal Immunization Programme (UIP) for several decades with more than 348,000 public and 28,000 private vaccination centres, 2.3 M ASHA frontline workers, millions of doctors/ nurses/ANM and 28,000 cold chain facilities which have been used in UIP for 27M newborns and 100 M boosters/year. Same has been repurposed in the fight against COVID; and India is now the vaccine manufacturing superpower viz. SII, Bharat Biotech, BioE, Cadila, Panacea and many others with the IT prowess of digitally monitor vaccine, CoWin open source platform with appointments, scheduling and providing QR coded vaccine certificate. There has been people's participation with SHG, local government support and digital strategies. Therefore, it has been a successful programme with whole of the government support/participation including the Cabinet Secretary, the empowered groups of the Government of India, the National Task Force, Ministry of Health and Family Welfare, the Drug Controller General of India, the National Accreditation Board, the Pharmaceuticals, Emergency Medical Relief, NCDC, State and District Surveillance Officers. During this entire journey, we have lost 28 colleagues of ICMR who have laid down their lives working either as technical officers or as scientists. We are grateful to them and pay our tributes to them today and every day for their contribution. This has been a huge journey and we have realized that both the Science Ministry and whole of the government as a nation can work together during the crises; and together, we can deliver not only the simplest things, but the most complicated things, if our will is strong.

Remarks by the Chair: It was a panoramic and graphical view of what has happened behind, because several people don't actually know what happened behind to fight this pandemic. We are emotional, but feel proud for the people who have sacrificed their lives to fight this disease. We would like to complement you for all your leadership that you have provided and the interaction between all the government departments. I do believe and suppose, this will continue and this collaboration will surely help India to move forward in health sector.

Remarks by the President, NASI: We are so happy and proud to hear that the collaborations between the government, the medical people, ICMR and in fact the entire country-all came together to tackle this extremely difficult situation and the leadership provided by the people like you. We are overwhelmed by your talk and the contribution that you have made to our country. It was a phenomenal lecture. Thank you for the efforts that you have made.

Vote of Thanks

Prof. U C Srivastava

All the lectures that we heard today were quite informative; and I gained a lot. I express my gratitude to Prof. Balram Bhargava, the Director General, ICMR and Secretary, DHR, Government of India for taking out time and delivering the NASI Foundation Day Lecture.

We congratulate him for the Award of Honour conferred upon him by the National Academy of Sciences, India (NASI) for his exceptional contribution and outstanding leadership during the COVID Pandemic; and round the clock scientific management of COVID 19. He made us remember all the activities which are being executed by NASI as per its Science & Society mandate. It was really wonderful.

The lecture covered the entire journey of the pande
mic and how ICMR actually tackled it with the support of the government and collaboration of different government organizations. The research was published in Lancet. The information that was delivered by your lecture was wonderful.

There are many things that we wish to say, but we are very much thankful to Prof. Bhargava for sparing time and delivering a wonderful lecture. I am also thankful to Prof. (Mrs.) Manju Sharma for conducting this symposium and giving all of us this opportunity.

Session-4: Engineering

Chairman

Prof. Ashok Misra

Co-Chair

Prof. Indranil Manna

Prof. Ashok Misra: A very warm welcome to all the distinguished guests attending the session on the second day of the symposium and 91st Annual Meeting of NASI. As you all know, the theme of the symposium is the 'Interface between Biological & Physical Sciences towards *Atmanirbhar Bharat*. Yesterday we heard outstanding talks in Biological Sciences from industry, academia and research as well. Today, we shall focus on the same theme, i.e. the '*Atmanirbhar Bharat*' and correlate with how the people from the Physical Sciences areas viz. Physics, Chemistry are taking their research forward. Some of them may overlap with the Biological Sciences; but, the main focus would be on Physical Sciences. The first session would be on 'Engineering'.

Prof. Indranil Manna: This is a very distinguished panel having experts from various disciplines of Physical Sciences. I am thankful to Prof. Manju Sharma, the Convener; and Prof. Ashok Misra, the Co-Convener. We have three distinguished experts from three important disciplines of Engineering, viz. Communication Engineering, Microelectronic Engineering and Polymer Science Engineering. So, we all are looking forward to listening to these experts.

Information and Communication Technology for *Atmanirbhar Bharat*

Prof. R K Shevgaonkar

The topic 'Information and Communication Technology' is very much close to everybody's heart. So, we'll focus on what is going today in this area, what is the technology behind it and where does our country stand as far as the ICT is concerned. The engineering interventions in 20th century have not only impacted their respective disciplines, but also other fields such as Electronics, High speed transportation, Communication/Information technology, Biotechnology, Material Science. As far as the telecom technology is concerned, India got on board quite late. Most of the countries in the world had telephones, internet connections etc. Until the 1980s, a telephone was considered a luxury. Looking at the history of Telecom in India, the Department of Telecommunication (DoT) was separated from the postal and telegraph services. The essential change in Telecom sector came into play after 1990 and in 1997, TRAI was set up. Bharat Sanchar Nigam Limited (BSNL) came into existence in 2000; and in 2002, the Mobile phones launched in India. Optical Fiber System was laid in the country in 2007; and from 2008 onwards, 3G services were introduced in India and then, from 2010 onwards the private players/4G services were launched. In India, the essential expansion in Telecom Sector has taken place in about last 25-30 years. Looking at the Communication Technology, it can be divided into two categories: 1) Access Technology and 2) Backbone Technology. Predominantly, this connection is through copper wire. Then, the wireless came and many of the connections were made through the radio, microwaves and millimeter waves. So, the *Access Technology* gives you the mobility; and also the connection to the nearest hub where the data, voices and many other services are integrated and then taken to the next destination. On the other hand, the *Backbone Technology* requires a much larger bandwidth, because it has aggregated information which could be a combination of voice, data, images videos etc.; and then, with a large bandwidth requirement, the data is taken from one location to another which is called the *Information Superhighway* or the *Superhighway for the information communication*. The optical fibers play a very important role in this technology, because they have very high band width. The wireless communication can range from a very short distance like blue tooth which could run a few feet. It could be a Wi-Fi communication (running from one's own house) or a cellular communication from a local area or satellite communication across the globe. The wireless technologies play a big role encompassing the present and future communication technologies such as Wi-Fi, 5G cellular (IoT), Vehicle-to-Everything (V2X), Long-range Wireless Power, Low Power Wide-Area (LPWA) network (NB-IoT etc.), Wireless sensing (Robots, Drones), Enhanced Wireless Location Tracking (Supply Chain), Millimeter Wave wireless (30-300 GHz), Backscatter network, Software Defined Radio (SDR) providing a future platform. There is a huge optical fiber network laid which primarily connects the large data centre, different countries/ continentals, sub marine optical cables and so on. Looking at the capacity the optical fiber has created at telecom side, we find that the systematic progress from 1980 onwards, the data rate which the optical fiber was capable of supporting has increased from 100 Mbit/s in 1980 to 100 Tera-bits per second in 2020 which is further going to be increased by essentially using Special Division Multiplexing (SDM) techniques. So, in near future, the combination of wireless technology and backbone technology including the large band width optical fiber has created avenues for large number of global applications, especially in India. ICT has played a big role anywhere and everywhere in development of the country as whole viz. applications to connecting the computers, smart phones, smart grids, smart cities, industrial internet, automated digital technology (video camera etc.) and other electronic devices in the form of IoT, the smart homes equipped with IoT. It provided transparent and

efficient governance, e-commerce, healthcare, and education to every section of the society, agriculture, navigation, infrastructure and much more. So, the ICT is everywhere right from one's own house to the largest possible distance in the world one can imagine. Implementation of Aadhaar is one of the landmark achievements of India that is admired worldwide. Uninterrupted functioning of education system during COVID-19 pandemic is another example. As per 2019 data of ICT position of countries with highest number of internet users, India stands at the second place after China which is at the first place. Out of urbanized population (56.5%) around the world, 61.7% are unique mobile phone users; about 60% are the internet users, out of which 55.1 % are the active social media users. Comparing this global data with India, we find that India is doing phenomenally well as far as the ICT is concerned. Out of 1.39 billion population, 35.2 % population is urbanized. 1.10 billion is having unique mobile connections, 624 million population is having internet connections, 448 million (32.3%) are active social media users. So, India is running almost at par with the world, so far as ICT is concerned. The population of internet users in urban India has grown from 55 % (in 2017) to 67% (in 2020) whereas in rural India it has increased from 15% (in 2017) to 31% (in 2020). It is predicted that by 2025, there will be 900 million users in the country with more users in rural India. India launched a 'Digital India' programme in July, 2015 which has put India on the digital global map. There are three pillars of 'Digital India'-1) Digital infrastructure as a core utility to every citizen (this includes availability of high speed internet, unique authenticable digital identity, citizen participation in digital and financial space through mobile phone and bank account, easy access to common service centre, shareable private space on a public cloud-MeghRaj, safety and security for all); 2) Digital empowerment of citizens (universal digital literacy, universally accessible digital resources, availability of digital resources/services in Indian languages, collaborative digital platforms for participative governance, e-submission of government documents/certificates); 3) Governance and services on demand (integrated services across departments/jurisdictions, availability of services in real time from online & mobile platforms, portability and availability of citizen's entitlements on the cloud, digitally transformed services for improving ease of doing business, making financial transactions electronic and cashless); most of the transactions are done on mobile devices, so a common man today is essentially getting almost all the services on demand. The MEITY (Ministry of Electronics and Information Technology) Vision Report (2019) has identified nine areas/themes to be achieved for Digital India 2025 viz. Governance, Next Generation Financial Services, Commerce, Agriculture/doubling farmers' income, Health, Quality education, Energy (smart grid and renewable), IT infrastructure and software capabilities, Make for India/Make for the World, Jobs and Skills for future India. So, these are the themes projected by Digital India to be achieved by 2025. There are some Mission Mode Projects under eKranti, divided into three domains viz. the central government (banking income tax, insurance, central excise, pensions, NMEICT, passport, immigration, visa, e-office, e-bhasha, central armed paramilitary forces, e-sansad), the state government (Transport, e-district, Commercial Taxes, Municipalities, Employment Exchange, e-Panchayat, CCTNS, Health, Education, Rural Development, Women and Child Development, Agriculture 2.0) and integrated services (India Portal, NSDG, CSC, E-Trade, e-Courts, e-Procurements, NGIS, Road and Highway information system, social benefits, Urban Governance). The National e-Governance Plan (NeGP) takes into account several things/facilities which we, as the citizens are availing such as Aadhaar, myGov.in, Digital Locker, PayGov, Mobile seva, UMANG-PF,PAN and state level services to be used by common citizens. National Digital Health Mission (NDHM) is another domain of Digital India, under which an ecosystem has been developed to connect various parts of society viz. the policy makers from central and state governments, administrators, non-profit organizations, healthcare professionals, allied services and service providers-all put together to make the mission successful. ICT plays a big role in Healthcare such as training the healthcare professional especially, the paramedical staff during the time of emergency time, evidence-based practice by sharing the information, peer interaction and advice, continuing professional development, Geographical and Professional isolation (especially when the doctors/ are not available in the rural areas, so that the people in rural areas can get connected with medical professionals in rural areas and the isolation may be reduced), wearable electronics and App-based health monitoring,

providing Health-ID for every citizen (to maintain and keep personal healthcare records), DigiDoctor (a telemedicine healthcare platform under digital health mission that provides multiple medical specialty services for the patients), telemedicine facility, e-pharmacy facility. The ICT has significantly impacted and also played a big role in agriculture sector where the agriculture sector is making its use such as information, awareness and education, advance information about weather (so that the farmers could take immediate action for protecting the crops from damage), Near real-time Market and Pricing information (for the farmer who can get online pricing information for deciding the selling strategies to get profit on their crops), information about government schemes (to the farmers), information on Agrifinance, Agriclinics, Agribusiness and online farmer community (where the farmers can exchange their ideas to leverage the knowledge available in different domains of farming). Government initiatives on ICT for agriculture include National e-governance plan for agriculture (NeGP-A) for timely access to agriculture related information for the farmers, Krishi Vigyan Kendras (for providing knowledge of agriculture), Touch Screen Kiosks, Kisan Call Centres, Common Service Centres, mKisan for the farmers (using the power of mobile to get information), Kisan TV (a TV Channel for providing agriculture related information to the farmers) etc. ICT has also impacted Education. The fact has been realized and experienced during the time of the global pandemic COVID-19 which brought the human lives including all the activities to standstill; but, the education continued even during the countrywide lockdown without much disruption only because of ICT and its importance in education was realized. The Indian initiatives in Higher Education are available in the form of several platforms providing wide exposure to education, research and some platforms available for teaching and training purposes viz. SWAYAM, Swayam Prabha, NAD, NDL, e-Shodh Sindhu, Virtual Labs, e-Yantra, e-Acharya, e-FOSSE, Vidwan, e-PG Pathshala, BAADAL, GYAN, NIRF, IMPRINT, SAKSHAT, ATAL Innovation Mission, Ranking, Know Your College, ShodhGangotri, SOS (SW and Simu.) tools. During the COVID-19 pandemic, PM eVIDYA (One Nation One Digital Platform) has been launched by the Government of India for multi-mode access to on-line education as well as to provide quality education to the students; there are several activities to be taken under this programme. All these initiatives together have provided e-commerce, the financial wellness for the country. By the year 2025, it is envisaged to have $1trillion economy in the country, out of which 40% is supposed to come from start-ups. With the emerging ICT, India will emerge as Digital Factory of the world by becoming a hub of innovation in edutech, healthtech, agritech and other areas of technology innovation; it will also emerge as data analytic engine for the world producing a large number of skilled workers as well as the global supplier of man power/digitally skilled workers. So, India with ICT has moved forward commercially as well the other domains of the country; but, there are the certain challenges for the Digital India viz. 1) Technological challenges: this involves low cost affordable device for all; lack of computer literacy; lack of accessibility to internet; security (risk of personal data leakage/theft in cyber domain); system reliability; cyber-crimes; unauthenticated information circulation; uncontrolled social media (comprising fake news and manipulated information and anti-social activities which take place on social media).2) Social challenges: these involve reduced face-to-face interaction; social disconnect; reduced physical activity; limited development of all senses; affordability (so that the technology may not remain confined to the affluent class); privacy and safety; social vulnerability; e-commerce impacting small vendors as during the pandemic times most of the commercial activities were performed on-line. While the ICT is shaping our society/country, it is primarily decided by the information flow and the governance driving factors as far as the ICT is concerned. There are many factors deciding the development index viz. well-being (well-being, prosperity, happiness, health, time affluence); community with social cohesion (the ICT envisages to create a cohesive society having the lease possible disparity); environment and sustainability (for maintaining the eco system and protecting the land and environment). The Future directions for the ICT include 1) Defining a paradigm which takes the country beyond information and skill; 2) Creating a good amalgamation of knowledge, skills, value system, sustainability, happiness; 3) Preservation of cultural, geographical, biological, natural diversity; 4) Living with cooperation with nature to maintain the sustainability.

Conclusion: Re-creating the Bharat by using ICT which was not only rich and '*Atmanirbhar*', but led the world towards a sustainable future for humanity as a whole. India could definitely be the role model by taking into account all these aspects for promoting the ICT.

Remarks by the Co-Chair: The need and influence of the ICT in the entire country and its future has been well brought out. There is no denying the fact that the communication technology has revolutionized the world.

Lab on Palm - The Future of Diagnostics in Healthcare

Prof. Navakanta Bhat

The next generation of affordable healthcare, specifically in the context of disease diagnostics will be driven through the strong collaboration between Biological Sciences and Physical Sciences. In this talk, I will describe our efforts in such interdisciplinary research in the last few years traversing through scientific discovery, engineering innovation, entrepreneurial venture and manufacturing scale-up to create one of its kind multi-analyte point of care diagnostic device - *Lab on Palm* for the management of diabetes, anemia, malnutrition, kidney and liver disease and COVID-19 sero-surveillance. This technology and product is currently being used by clinicians for performing multiple blood tests using electrochemical bio-sensing technology and has the versatility of enabling a platform to add more tests through continued innovations at the interface of biological and physical sciences.

Let us first look at our journey in physical systems of computing and storage. In the last few decades there has been a phenomenal progress in semiconductor technology, and we have gone from microelectronics technology to nanoelectronics technology. There are two main aspects of the progress, (i) the miniaturization, i.e. how small can we make the transistors and (ii) the scale of integration i.e., how many transistors can we pack on a chip. Today, routinely we create transistors which are of the order of 10 nm in dimensions. Also, over the last five decades, we started from a computer on chips, INTEL, 4004, having about thousands of transistors. Today, we build 3D (three dimensional) chips which have more than ten billion transistors on the single entity. This is an amazing technological accomplishment that humanity has achieved; and what it has enabled is Intelligent Physical Systems. We have seen an amazing transformation. The first computer called ENIAC was as big as a room, and based on vacuum tube technology; but, because of semiconductor transistors, and miniaturizations, what we have today is not computer in a room, but, computer on your palm. The mobile device which all of us use today has computational capability several folds greater than what the first computer ENIAC had. So, this is what we have been able to achieve and we say that silicon is catching up with nature. The reason for this is the human brain which actually has the seat of computation and interference has 80 billion neurons, the building blocks. Similarly we are able to put around 80 billion transistors in a chip; and that's why we talk of artificial intelligence, machine learning etc. But, still there is lot to learn, because the brain evolves stochastically; and we have made all the chips deterministically.

Let us now turn our attention to the journey of healthcare diagnostics, i.e. pathology labs. The journey of pathology started in 1900 when the clinicians used to do titrations in Chemistry labs by collecting the samples of blood and urine for the diagnostics. There were no sophisticated equipments at that time. But, in 1980's there was a transformation through Immunoassays; and now in 2020s, all pathology labs have sophisticated Auto-Analyzers revealing the concentration of analytes in one's body fluid very accurately. But, these are very expensive and need controlled ambient. In the context of future diagnostics technologies, we need to focus on three aspects 'Availability', 'Accessibility' and 'Affordability' as recommended by the World Health Organization. Keeping this in mind, we started a long and exciting journey with a question 'Can we bridge the Healthcare divide?'. After interdisciplinary collaboration with clinical chemists, doctors etc., we came up with very interesting technologies and inventions that actually led to what we have today. A deep science & technology based unique product which we call *anuPath*, one of its kind in the world. It is protected by several international patents and fully certified and licensed through many national bodies viz.

NIB, ICMR, CDSCO etc. It has also received the support of many government and private agencies in this journey. *AnuPath* is a device which goes beyond conventional glucometer; it performs many tests on a single platform. So, like a mobile, we should have a lab on palm.

For doing things like this, we need to have confluence of disciplines viz. Biology, for interfacing with biofluids such blood, urine etc.; Chemistry which is extremely important to probe these bio molecules; Electronics is required to build the whole system; and Manufacturing for developing such products for society. So, it is all interdisciplinary encompassing, scientific discovery, engineering innovation, technology development, manufacturing scale-up. Then, we also need to think out of box and acquire additional skills including team building, perseverance and patience. When we started this research, our goal was to come up with a new paradigm for diabetes management. Although glucometers are ubiquitously available, for measuring the instant glucose concentration in our body, if we go to the specialists viz. diabetologist or endocrinologists, they say that that mere glucose testing is insufficient for diabetes management. The gold standard for the assessment of diabetes is HbA1c which gives three months' average of blood sugar in the body (Diabetes complications increase exponentially with HbA1c). In addition Glycated Albumin (GAlb) gives two weeks' average blood sugar in the body. We thought of creating a technology for time differential diabetic monitoring with simultaneous measurement of glucose (instant blood sugar), GAlb (two weeks' average blood sugar) and HbA1c (three months' average blood sugar), all at point of care.

We had to build a platform technology to go beyond diabetes by expanding /adding more tests including Serum albumin (Liver and Nephrotic syndrome), Hemoglobin (anaemia), micro albuminuria (CKD & Diabetic Nephropathy), Urine Creatanine (CKD & Diabetic Nephropathy), Urine ACR (CKD & Diabetic Nephropathy) for defining the base line of our research. This is where Biosensors play a very important role. Unlike autoanalyzers, biosensors are self-contained integrated receptors transducers devices. There are different ways you can build receptors - enzymes, antibodies, aptamers, ligands, metal ions etc. There are many ways of transducing also. We decided to focus on electrochemical biosensors with field stable receptors.

Prof. Leland Clark is known as father of Biosensors. In 1960s, he came up with the phenomenal advancement in science of electrochemistry for glucose sensors which forms the basis of all glucometers today having two important components viz. the electronic reader and disposable test strip containing carbon printed lines forming electrochemical cell with counter, working and reference electrodes. The working electrode is functionalized with glucose oxidase enzyme, and a mediator which is typically Ferri-Ferro cyanide couple. the receptor that is selective only to glucose. Glucose gets oxidized to gluconic acid, mediated by enzyme. On application of redox potential at working electrode, the electrons are shuttled to the working electrode, resulting in faradaic current that is proportional to glucose concentration. Since the invention of glucometers, there has been an exponential growth in the publication off research papers. However, when you look at the market most of the products in point of care segment are still based on glucometers. There have been extensive review papers published highlighting the challenges in this area. It turns out that the lack of field table receptors for other bio analytes is the main stumbling block. We decided to take up this challenge.

Our endeavour has been to develop novel receptors for electrochemical detection of variety of markers. I will illustrate this with detection of serum albumin as an example. Albumin he is one of the most abundant proteins in the plasma. Albumin structure is made up of 585 amino acids just like any other protein. However, there is no redox active site in the structure of albumin. Hence in the context of electrochemistry, albumin is like an insulator. We started looking at Physiology of albumin to understand its role in the body. It was clear that albumin is called molecular taxi in the human body since it binds to a variety of substances. In particular we noted that it binds to copper and hemin with very high binding association constant. We came up with an idea of detecting serum albumin indirectly by functionalizing the working electrode with copper salt such that, when a drop of blood is dispensed onto the working electrode, albumin should bind to the copper and hence the copper redox current which is due to unbound copper would be inversely proportional to the concentration of serum albumin. Indeed we were able to develop a very robust serum albumin sensor

with an appropriate functionalization of working electrode. Subsequently, we could combine boronic affinity principle on to the disposable test strip for the detection of glycated albumin. Hemoglobin sensing chemistry was developed using heterocyclic receptors. This was extended for the detection off glycated hemoglobin using boronate affinity principle.

Then we have to develop a novel handheld reader with the capability of adopting to multiple test strips. It is as if integrating multiple glucometers on a single device. This was non trivial and required a unique electronic design. Then the device had to be prototyped and validated as per stringent medical guidelines. We have been able to complete all necessary regulatory requirements in India – International Electrotechnology Council certification for Safety and EMI/EMC, ISO 13485 certification and National Institute of Biological and CDSCO Certification. We also had to develop manufacturing process for large scale production of test strips. With all this technological developments, the product is successfully deployed in the field. At present the product is in use in 12 states serving marginalized communities. The technology has received multiple recognitions including INAE Entrepreneur award, BIRAC innovator award, MIT TR35 award, FICCI and CII awards to name a few.

Translational Research with Polymers for High-end Applications Development

Prof. Anup Kumar Ghosh

Generally, translational research is often characterized as requiring a multi-disciplinary approach that understands not only the basic science; but, also has a clear sight on the final products. In transforming lab scale process into industry scale production, the understanding of polymer processability is very critical to develop the desired morphology and properties. The need of the hour is to train translational research scientists to have a fundamental and quantitatively-based understanding of materials and relevant processing technologies; as well as idea for research innovations and creating breakthroughs by thinking differently.

In this talk, a few case studies related to high-end applications will be discussed: i) Design and development of advanced composites orthotic knee joint for health care; the aim was to design, develop and fabrication of lightweight, durable, cost effective polymeric composite knee joint by controlling processability in terms of material selection, formulation and torsional stress analysis; ii) Foamability of high molecular grade polymer and biodegradable polymers using sc-CO_2 (Supercritical carbon dioxide) to study the processability of ultra-high molecular weight polyolefins and development of unique applications. Selection of high pressure CO_2 as a physical blowing agent increases the solubility in polymer matrix and produces foam structure with zero chemical entrapments. Therefore, supercritical assisted foaming processing of polymers is sustainable and green approach to develop zero-toxic foam structure for packaging and health care applications. Generally, the properties of polymer foams not only depend on the intrinsic properties of the polymer, but also on the foam morphology, such as cell density, cell size and size distribution. Foam processablity of biodegradable polymer such as, Poly (Lactic Acid) PLA is studied by compounding PLA with appropriate additives like elastomers, plasticizers, micro/nanofillers etc.

We need to emphasize more on translational research which is taking shape and need of the hour to emphasize more on this area along with polymer technology, especially with two applications where it is utilized by the community and much needed for *Atmanirbhar Bharat*. Research translation, whereby the knowledge is passed anywhere along the translational pathway, i.e. it is the traditional way to translate the research findings into practice, policy or further research. On the other hand, the translational research looks at how best to translate research into practice and/or policy, e.g. research that addresses particular gaps in translation. So, there is a gap between basic research and industrial practice. Translational research can help bridging this gap. Translational research in Medical Science is more common in practice. It is government funded. It started with curiosity-driven basic research with several medical innovations. There is a proposer of the problem, financial support, translation/commercialization steps taken into consideration from the need of the hour situation, capability enhancing technology (development of vaccine during COVID pandemic times are true example of this) and to facilitate patient access to medical advances and that is actually the translational path which is generally followed. There are several ways/ models in medicine. The practice is generally known as 'Bench to Bed-side practice'. There are several famous marker models which mark at every evaluation stage to look into the potential application, efficacy, and then, how it is applied on population base. This will be applied on the Basic Knowledge, Theoretical Knowledge, Efficacy Knowledge, Applied Knowledge and the Public Health Knowledge. All have to be connected together; and this is actually the principle to be followed in other science disciplines reflecting the merger of Physical and the Biological Sciences. There are several models which work on research translation in medicine. The most popular is Stanford University model, also known as Silicon Valley eco-system where the faculty members commonly

invest in start-ups launched by their students or colleagues and in that process. They develop and translate the start-ups which go into commercialization. There are probably more faculty millionaires at Stanford than at any other university in the world. Other models include Bell Lab model, Harvard-MIT Division of Health Sciences and Technology involving biomedical engineering and physician-scientist training programme, ETH Zurich model where regional innovation centres/ industry are being built around existing Research University to catch up for this process. The steps involve selecting a growing industry, building a science park next to Research Universities, providing subsidies and incentives for industries to locate, creating a pool of venture capital to help strengthen the funding situation to train the entrepreneurs, technology licensing office, to make it work. One of the examples is Tissue graft substitutes is one of the case which has been tried out. There are around 4, 40,000 bone fractures and deformities (as reported in India Today). The cases are increasing and require Tissue graft substitution to be done. There is a scarcity of effective treatment solutions. So, the gap needs to be filled with the Product Positioning. The Artificial grafts cost more and the efficacy/efficiency is less. There is traditional ways of putting plates, ridges etc. The product is developed by tissue graft substitute leading to better efficiency and getting large market potentials which have been tried in many of the hospitals, e.g. AIIMS, RML etc. revealing how the translational research has become successful in such cases. Polymeric Materials also involve the intervention of translational research. Polymer Science includes Polymer Physics as well as Polymer Chemistry. They are made up of Commodity polymer, Engineering polymer, High performance polymer, Amorphous polymer, Crystalline polymer going from conventional molecular weight to ultra-high molecular weight. These materials are amorphous and crystalline polymers used for several applications. The road map for translational research in polymer requires equilibrium between efficiency, novelty and utility. To connect efficiency and novelty, Basic Science plays an important role; and this is done by universities and research institutions. Efficiency and utility is connected by Applied Science and Engineering by selecting and modifying different materials to control the structural properties and morphology of the polymeric materials. When we try to link novelty and utility, inefficient research comes into play requiring translational research. In translational research, three stages take place in the polymer; the first stage is done in the lab scale, the second stage at pilot scale and the third stage takes place at commercialization scale. In each stage, lot of development is required for the polymeric material.

We start from the raw materials and go into material development with scientific understanding. We develop new products (this is in the lab scale). These new / developed products have to be translated into pilot scale/ second stage where the compounding of the product determines the yield of the product. For this, we need to look into repeatability and performance of the system. But, that's not enough, because in each step, we need to go back and iterate between the processes. If the yield is made, we need to do process scale-up that involves the cost factor, marketability and sustainability.

In many cases, it has been observed that from lab scale to pilot scale and further to commercialization scale, we have go through the iteration of the material development and fine tuning of the process so that we get the final product for cell development.

The partnership in translational research involves the industry, government, the private individuals and the non-government organizations connecting together. There are different models for Directed Basic and Translation Research collaborations. One of the models is Demand Driven, also called *Kalam Model*. It was presented in a recent meeting of Niti Ayog which states that 1) We need to identify problems in a "Major Mission Mode" programmes; 2) We need to search for Institutions and Academicians having interest/experience of working in the concerned technological disciplines; 3) There is a need to hold discussions in formulating problems & research strategy and identify the requirements of funds, human resource and time schedule; 4) Need to form joint teams of scientists, engineers, academicians, industry partners with a leader and co-leader from both organizations and they are full time task holders; 5) Inter-Institutional Management Platform to be developed for monitoring, according financial sanctions and suggesting mid-course changes; for example Joint Advanced Technology Programme Cell setup at IISc during IGMDP (Integrated Guided Missile Development Programme) .

For developing the new Innovation Eco System, the translational research starts with public funding at the beginning and starts reducing as we move from Basic to Translational Research. During the Translational Research, the public funding comes which actually helps in generating start-ups, incubators, accelerators as well as regional innovation centres which can be taken up by the companies.

The demand to increase investment in Directed Basic Research could be fulfilled through various departments viz. Defence, Atomic Energy, Agriculture, Energy, Health, Railways; and to increase investment in translational research, government must work with industry, National labs and universities to find next generation solutions for our essential needs for successful development of translational research.

For development of commercialization of biodegradable super absorbent pads, we have IIT-Delhi Incubator Programme for Deep Tech Innovations. As per NFHS 2015-16 Survey, there are 78% women using sanitary pads in urban areas, 48% in rural areas and 58% overall. Today, nearly 6 out of 10 women in India have access to disposable sanitary napkins. It is useful, especially in rural areas where there is more demand in schools/colleges; and the percentage is still low. To develop the super absorbent material from the natural fibers, any natural plant like banana or jute can be considered from which micro fibers can be developed (using a unique technology) which could further be converted into micro fibrillated celluloses (MFC) using (Primary Fiber Processing Technology); and then we use Secondary Fiber Processing Technology to develop these absorbents.

There were few challenges involved before the green technology has been developed viz. use of alkali and acids for treatment; multiple step process; requirement of large quantity of water to neutralize the alkali treated fiber; higher processing costs; difficult to scale-up; dominant by cottage industries. But, now we have overcome these problems by developing a Green process by which microscopically, a natural product having 70% of cellulose and 5-10% lignin has gone through the green process with the super critical carbon di oxide system which has been patented. With this process, we have developed the micro hollow fiber and the lignin product. The micro hollow fiber and the lignin together can develop a super absorbent with the anti-bacterial properties of the pads which will go from macro scale to micro scale to the nano scale for this product, a unique product developed under this Green Technology. In this process, the material is kept in autoclave under pressure in presence of CO2 in water which converts by delignification of the cellulose material and we get cellulose to nano cellulose crystals by this process.

The hollow micro fibers have high thermal stability, longer fiber length, higher degree of crystallinity, higher tensile strength and reaction time is less than 5 minutes. The raw fibers available as natural products which is converted into Delignified Macro-fibers (stage-1) and Micro-fibrillated hollow nano fibers having excellent absorbent properties with the capillary effect into the system and this gives the high retention properties.

If we consider the water uptake for the absorbent properties, the Microfibrillated fiber shows a very high water uptake and absorption time without using alkali acids and solvents. It has zero toxicity along with microfibers and very less water consumption. We have developed three patents based on this process; and the products have also been developed. The green extraction process gives us the long staples of the micro fibers which we are converting now into biodegradable non-woven fabrics using a specialized technique. The incubation funding has been converted into a start-up company which is involved in developing the products now being used in patients' beds in hospitals (with the super absorbent layer which is now being developed). This has been tested in few cases/samples and will now be commercialized. The bio insert for the sanitary pads has been used under the non- woven fabrics of the biodegradable materials. The centrifuge retention capacity (CRC-g/g) of these materials is 8-10 times higher than the commonly used materials like cotton and wood pulp (this has been accepted and certified for the biodegradability). There are several prospects for translation/commercialization. This method is applicable to other natural fibers like jute, wheat straw readily available at low cost, especially in India which can be converted into super absorbent fibers. By using green extraction process the cost of hollow banana fibers will be reduced from Rs. 1000 to Rs.200 per kg (one-fifth of the cost of cotton). The cost of each pad (containing one gram of banana micro fiber) is also reduced by four times. Water consumption of the present green fiber treatment process is just 7 to 8 litres per kg which

is quite lower than other existing fiber treatment techniques. This has now been initiated by a startup company started at IIT, Sonepat and now under commercialization.

As part of the second case study, the Multi-functional polymeric orthotic knee joint which has been developed under the grant by Naval Research Board, DRDO which requested us to evolve a fully polymer based light weight Orthotics joint, serving millions of polio and cerebral palsy patients at low cost and improved functionality. So, we have developed knee joint using plastic materials. The statistics reveal that 80% of the total amputees live in developing countries. There are 5.5 million amputees in India; and only 5% of them get prosthetic care they need. Among this total number, 75% live in rural areas where there is limited knowledge of options available for amputees, especially the prosthetics. In case of metal joints, the productivity is less and at least 5-6 times heavier than the plastic products. So, for the translational research, we take different pathways-from basic R&D to proof of concept to material development and mould design and development. The material development and mould design/development are the critical steps followed for processiblity, compounding and analysis; and then, we take it to market and society through transfer technology. We took this challenge for a dream design to develop a joint which is light in weight to improve the gait movement.

It has the following qualities: It is one universal design to cater for the offset and drop lock mechanism. It is comfortable with the patients, compatible with the existing designs of orthosis, light in weight and easy to assemble, maintenance free, no corrosion; it is mass producible and affordable to reach the masses. Traditionally, titanium or aluminum based joints/ metallic joints used to be of 400 gm with the new design now developed with the polymeric material, it is only 30 gm; a big difference for the patience using it because we need two joints per leg (four joints for both the legs), a huge requirement for the purpose. We have developed this joint (of FRP composite) and also added some nanocomposite material for this, keeping in mind that the material provided universality; it should cater for all complex loads, light in weight and easy to assemble, maintenance free and has normal gait. We observed that this material provided high strength/modulus and good impact, low density, easy processing, good wear resistance, low coefficient of friction. So, we developed the joints using four different polymeric materials in different combinations. We used 1) Engineering polymers having high strength, good impact; 2) Polycarbonate- which is the toughest polymer with high strength and stiffness; its crack sensitivity and processability needs care. These were combined to form the blends. The materials are checked in terms of their mechanical properties (of nanocomposites), performance in terms of their ductility, toughness and resilience so that the best/ right kind of the material could be selected for the purpose. We developed the material by considering the morphology, dispersion, compression modulus etc. as per the requirement of the patient for developing this product. Once the material is developed, we go into the second stage of the translational research by looking into mold design and fabrication. We developed the mold at IIT, Delhi in joint collaboration with the local molders and we are now able to do the mass production of moulded joints. Each knee joint could be developed by Injection Molding Process in 30 sec. So, we gave this product a new design, fabrication, material modification and testing, modification of mold for knee joint. More than 1,000 joints were made at IIT, Delhi; and sent to various health centres. We also did the fatigue study and field trials. The field trial has been performed in joint collaboration with ALIMCO, Kanpur; although some failures were also reported and 8 joints were tested till failures; the failures locations were also revealed.

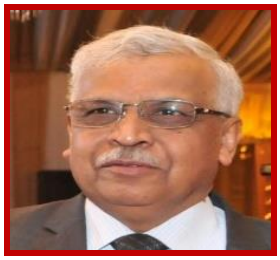
What we observed is that we need to look into the movement of the knee, a kind of rotational movement and we thoroughly studied the additional angles requirement for the human being and what kind of fatigue and stress coming into this product. The normal walking gives a knee movement of 0-40 Newton meter (Nm); climbing on stairs/ramp gives 30-150 Nm while running gives up to 200 Nm. We also studied the Torsional stress developed in knee moment and found that the proper angle takes around 30 degree deflection possible with this material. We also did the modification of material combination and successfully developed the material for torsional purposes. The field trials were performed in Sikkim, Nizam's Institute of

Medical Science (NIMS), Hyderabad, Artificial Limbs Manufacturing Corporation (ALIMCO), Kanpur with different samples on different patients and it was found very successful from walking to running.

Conclusion: We need to have a new paradigm for translational research; in fact we need to reinvent translational research with different stages. An academic R & D facility is the key to its recovery. Translational research has to be recognized as a discipline; and pushed more. There is a need to provide recognitions and rewards for contributions to scientists involved in translational research. Translational research takes tremendous interdisciplinary activities; so, we need to connect all disciplines of Engineering Science viz. Material Engineering, Chemical Engineering, Mechanical Engineering with the Basic Science. Industry must support to have long term strategic transformative vision.

Session-5: Physics

Chairman



Prof. Anurag Sharma

The theme of the symposium is focused on the interface between Physical and Biological science, we have the first two talks connecting Physics to Biology; and the third talk on Astronomy. So, we'll introduce the three speakers.

Prof. K S Narayan is Professor and Dean at Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru, an autonomous institution under the Department of Science & Technology, Govt. of India.His primary research interests are in the general area of molecular (Organic-Polymer) Electronic Devices-Physics and applications. He is the Fellow of National Academy of Sciences, India, Indian Academy of Sciences, IEEE Senior Member & EDS-Distinguished Lecturer. He has been awarded the Superconductivity & Materials Science Prize Medal of the Materials Research Society of India (2008); the Materials Research Society of India medal (1997); DAE-Outstanding Research Investigator Award (2009-2014) and Department of Atomic Energy SRC – Fellowship (2009).

Prof. Gautam I Menon is a Professor of Physics and Biology; as well as the Director of the Centre for Climate Change and Sustainability (3CS) at Ashoka University; and also an adjunct Professor in the Department of Biological Sciences at Tata Institute of Fundamental Research, Mumbai. He was awarded a DST Fast Track Fellowhip for Young Scientists (2002) and the Swarnjayanti Fellowship of DST (2005). He was a Visiting Professor at Mechanobiology Institute as well as the Department of Singapore during the period 2011-13; and also elected a Fellow of the National Academy of Sciences, India in 2019. He serves on scientific review committees of several international agencies and associated with the Human Frontier Science Programme and the Wellcome Trust-DBT India Alliance; and currently works on biophysical problems including nuclear architecture, axonal transport, collective cell migration and cell adhesion. He has written extensively for the general public on the COVID-19 pandemic.

Dr. Seetha is an eminent scientist, superannuated as Outstanding Scientist from the U.R. Rao Satellite Centre (January 2019). She was the former Director at the Space Science Programme Office at ISRO HQ; and was responsible to ensure co-ordination of all space science activities of ISRO. Presently, Dr. Seetha is an Emeritus scientist at Raman Research Institute, Bangalore. She is also the Principal Investigator of the AstroSat, the first dedicated space astronomy mission since April, 2011. Her areas of research are in the field of astronomy, particularly the study of variable stars in x-ray and optical bands. She has contributed extensively to the development of space science instrumentation for Indian science payloads. She is the recipient of several prestigious awards, viz. the C.V. Raman Young Scientist award in Physical Science for the year 2003; the Best woman scientist award for the year 2012 from the Astronautical Society of India; Member of Team excellence award of ISRO for 'AstroSat mission' 2015, to name a few.

Features of Light Controlled Signalling initiated by Organic Semiconductors interfaced to Blind Retina

Prof. K S Narayan

My talk reflects upon all the different aspects covering the theme of the symposium; and I hope I can convey the central idea/message. There are couples of eye related degenerative disorder that appear in the rear end i.e. the retina part of the eye. The whole vision process is very complex event. The incident photons get absorbed by the photo-receptors and there is a cascade of biochemical events; and eventually you get an electrical signal which goes on to the brain. The signaling pathway upon absorption by the photoabsorption occurs using a layered structure of cells within the retina. Then, these cascading events happen in a very sequential way resulting in the time series of spikes generated that go to the brain via the optical nerve. This is another representation of four important layers in the eye. Then, there is an amplification process apart from the signal transformation process. This amplification enables the eye sensitivity to be in a single photon level.

From a device (physics) perspective, this is an amazing camera requiring minimum power; and to get such a large band width, super sensitivity and cleverness embedded within a retina. There are about 100 million rods and around ten million cones which are the actual structures absorbing the light. The RGC stands for the *Retinal* Ganglion Cell is the neuron within the eye which acts as messenger to the brain. There is funneling process occurring right within the eye where there is a convergence of signals through various routes transmitting information through a very compressed button in a *smart* way. There have been numerous attempts to actually understand mini kit outside, very different from conventional CCD camera.

The theme of today's symposium in this context is related to two disorders; the first is inherited retinal disease, known as Retinitis Pigmentosa (RP) having an estimated prevalence of 1 in 4000 worldwide. This leads to generation of photoreceptor layer of retina and the condition is assumed to be linked to over 200 RP-causing mutations and has no cure. The condition is much prevalent and with other comorbid conditions like diabetes, the progression is much faster. The prevalence of Retinitis Pigmentosa (RP) is seen in South Indian population aged above 40 years; and more common in males than females. The second is age-related Macular Degeneration (AMD) which leads to central vision loss. You cannot see fine details, whether you are looking something close or far. The retinal pigment epithelium becomes dysfunctional. This is also very much prevalent in India as reported in population based studies. Globally, this is an unsolved problem. There is no solution as of now; there are two or three approaches worldwide offering some kind of prosthetic cure in retinal implant which barely gives you any vision. There is hardly any resolution. Some clinical trials are performed by the companies; and blind people are willing to pay lot of money to recover some vision. But, these are staggeringly expensive prosthetics with minimal advantages in India. So, the purpose is not served/ vision is not achieved by using any of these prosthetics. The prosthetics these days involve embedding a silicon sensor in place of the receptors. So, these act like electrically stimulated electrodes which capture where the signals come from the camera which is placed somewhere around the glasses and these camera give you the electrical signals which go to the silicon prosthetic and then conveyed to the retina. So, this is a consortium approach involving big team, but, no big success as of now. So, with this background, I'm sharing my journey over the last twenty years working on this problem. Actually, prosthetics implementation encompasses many complexities of engineering, biophysics, photophysics and molecular biology. So, the photo receptors in your eye are embedded in form of protein segments having retinal molecule hanging around the corners. With retinal molecule as absorbing species, the sooner the photon is absorbed, there is a geometrical conformational change; thereby, these are able to control the traffic with the membrane protein

channel. These small events in the iron channel are controlled by light. We deal with these materials in my laboratory. The semi conducting and conducting polymers are the toolkits for interfacing with biology. The polymers in our lab are little bit more specialized in the sense that they are the conjugated back bone and semi-conductors having alternate single and double bond. There is a pi-electron existing in the backbone and gives you a bang gap in the range of absorption which is under your control. So, we have these in the laboratory being utilized as fake photo receptor without its biological components and the other mechanical advantage is that they are soft materials interfacing very well within the tissue explant, because of their mechanical conformity. Because of the proximity of the polymer, you can press it on to the retina and the electrical impendence is really reduced. The reduction in electrical impendence results in a very important feature. You can have the polymer filling and getting in to the proximity of the bi-polar cells, the next layer of the photo receptors, and you can get the electric voltage signal which can have an immediate effect. So, this proximity advantage is significant. We began this journey ten years ago by introducing the polymers right near the ganglion neurons. The ganglion neurons can be placed right on the polymer coated electrodes. The eye which we access is from a chick model from an egg in its early stages, when the receptors are not formed. The chick model was easier for us than the mouse model, a conventionally used model. But, chick is a very popular model, especially when many of the avian aspects are concerned. So, the regulatory process and parameters are much easier in case of a chick. We can take the explants from the chick. Neurons and muscle cells create ion currents through their membranes when excited, causing a change in voltage between the inside and outside of the cell. When recording, the electrodes of an MEA transduce the change in voltage from the environment carried by the ions into currents carried by electrons (electronic currents). When stimulating, electrodes transduce electronic currents into ionic currents through the media. This triggers the voltage-gated ion channels on the membranes of the excitable cells causing the cell to depolarize and trigger an action potential if it is a neuron.

The more advanced is the animal, the more sophisticated functions are outsourced from the retina to the brain. The lower the animal, the more stuff is done in the retina viz. motion and feature detection. The circuitry is involved and the information is manipulated within the eye which is very educational from many different aspects. The egg is put on the polymer coated electrodes; and then the light is introduced both from the top and bottom to transmit electrodes. When you start recording, you start observing the neuronal spikes which are the big signature that the information is encoded like a Morse code. There is either one (1) or zero (0) signal indicating there are spikes or no spikes/ there are neurons fire or no fire. We need to record it very carefully as the signal has to go to the brain. We are able to conclusively say that this is a light induced event which is due to the polymer layer where the neuron is sitting. We were able to conclusively show that indeed we can use the polymer semiconductor as a method to introduce photo voltage which can invoke firing events within the neurons. Neuron has classical properties in terms of light adaptation. It has more adaptation with the differential lights. We performed experiment having functional wave length, pulse width, intensity of lights; and everything points out to the fact that we are indeed seeing the light evoked action of the ganglion neuron. We are able to see the firing patterns within the pulse and outside the pulse looking at the response. So, both encoding and decoding is of prime importance. In another experiment, we took the chick at very early stage and observed a nice progression of development of retina like an epitaxial growth of heterostructure devices. Mullar cells, bipolar cells, rods, amacrine cells, cones, ganglion cells and horizontal cells. The networking is done in a very controlled way by inserting the polymer films at different stages. In order to know what the signal means, you need to know the circuit which the signal goes through. There are different types of cells having different diversity. Diversity is an integral part of the eye because of the complex things we view; and should be encoding. There is diversity between other layers also like bipolar cells. Of late, the molecular biologists have developed a very important tool, so that they are able to pick up all the minute details of every diverse cell. This is a hard way of doing it; but, we are developing some algorithm using some computational Neuroscience approaches in picking up the diverse pathways and are able to sort out nearly half a dozen of the ganglion neurons. The data analyzed for spike sorting and clustering

included the following information: 1) Extra cellular spikes from the 60 electrodes were recorded using MC-Rack; 2) Spike sorting was done with the help of SpyKING-CIRCUS, the raw data was band pass filtered (300-3000 Hz); 3) A value of 6 MAD (Mean Absolute Deviation) was used as a threshold for spike detection; 4) Spikes were sorted into clusters corresponding to different neurons, and only clusters with less than a couple of refractory period violations was used for further analysis. We learnt to handle the data and filtering which is a very established procedure. We conduct an experiment where the light is coming from the artificial photo receptors.

There is a firing pattern within the pulse and outside the pulse. There is on path way and off path way (when the light goes off we see another types of electrodes coming in). So, an electrode in the electrode array can correspond to a single neuron. We can examine close to 30 electrodes which give a reasonable set for seeing a diverse spike behavior. Based on this position, we can sort out within the pulse and outside the pulse. For offside, we can introduce a latency period i.e. how long we have to wait before the spike comes up, whether it comes immediately or later. So, the parameters in the problem include the latency period, the inter spike distribution and also the pulse width to help us out in the spike sorting. We had fantastic results. We have been following some landmark papers in terms of how we do/perform it. This has been done for the first time for the soft semiconductor receptor. We started the journey considering that we could introduce the cell sorting following the computational approach after we grab the data. We can pick up some off cells or can monitor it every day till the day when the chick is finally hatched /mature. So, we have a controlled sample where we don't have a need for a polymer in prosthetics when we compare the results with a natural eye. We can see the progression of different types of circuitry involved and compared with the real eye on. Since we can grab the data from different electrodes, we can grab it at the same time. We can study correlations of different cells. The association between colour and motion can be detected together. Insertion of polymer semi-conductor in the subretinal space of chick retina provides a self-powered method to observe evoked activity at early stages of the development. It was observed that many different ganglion cells fell into clean single unit clusters with marked similarities in firing patterns. The PSTH and the shape of auto-correlogram were used to label and describe the response of different cell types. These features were used to compare with that of the mature neonatal chick retina. The precise and highly reliable aspect of latencies in firing onset was observed across trials for ON and ON-OFF response types, especially in later stages of development of E16-E18. The cross correlation highlights the network mediated activity and similarity in the nature of light evoked firing in the artificial polymer photoreceptor couple blind retina and the neonatal control chick retina.

The introduction of the optoelectronic layer in the retina at developmental stages opens up a method to study other hierarchical systems by monitoring the functional circuitry and *complement* ontogenetic approaches.

The take home message is that we can use the soft materials of polymer semi-conductors where the chick retina is biocompatible and has a great function of light absorbing, mechanically superb. You can use the patterns of semiconductors and make it of any design you want. There is a field called optics genetics. We look forward to approach clinicians and bio medical engineers and offer something in a more concrete way. I acknowledge my former and present PhD students; Dr. Vini Gautam, C.S.Deepak and Abhijit Krishnan for their efforts towards this research project.

Remarks by the Chair: It was an excellent talk sharing the glimpses of research which is truly multidisciplinary. It started with the concepts of Physics, Material Science; and also involved neuroscience and computational aspect and other disciplines. It's is truly a great work.

The Physics of Bacterial Colonies

Prof. Gautam Menon

Cyanobacteria rely on photosynthesis and have thus evolved complex responses to light. These include phototaxis, the ability of cells to detect and respond to the direction, wavelength and intensity of light. I summarize recent models that describe the emergence of collective colony-scale behaviour from the responses of individual, interacting cells. I will highlight the advantages of "active matter" approaches in the study of bacterial communities, discussing key differences between emergent behaviour in cyanobacterial phototaxis and similar behaviour in chemotaxis or quorum sensing.

The tree of life, everything started with the original cell and the branch. So there are three main branches of this tree, technically different from one another viz. the Bacteria, the Eucarya and the Archaea. Here, I'll be discussing about the type of bacteria, called the Cynobacteria. Bacteria come in various shapes and sizes. Some of them have attachments to them; some of them form the colonies while some form long groups. There is tremendous amount of diversity in their shapes which actually affects the nature of the niche the bacteria will occupy. The bacteria in groups are collected. They can have simple circular colonies; they can have regular outward shapes or branches. All these varieties are well known. We are interested to know how the bacteria function. The bacterial communities are called biofilms. The dental plaque is an example of biofilm. The biofilms are found growing on minerals and metals. These can also grow on plants tissues as well as animal tissues; and on implanted medical devices such as catheters. Sometimes these become pathogenic and could be dangerous to our bodies. Bacteria can also switch between motile form and biofilm mode, in which bacterial cells can move around; aggregate and attach to a solid surface. The phenomenon is important from clinical and experimental point of view as there are many clinical applications and consequences of this phenomenon.

The collective cell behavior: How do colonies of bacteria alter their shapes and move under external stimulation?

Bacterial Chemotaxis (Chemo means 'towards the chemical' and taxis means 'motion' in Greek) is one of the classical biological examples to understand their motion (towards food or chemical signal). This is usually accompanied by some sort of swimming motion where the bacteria are suspended in the fluid. 'How do the bacteria swim' is a classical Physics problem. Bacteria are so small that they can swim in a particular regime which imposes a specific constraint on them. Bacteria use another property of drag in different direction. Swimming of one bacterium can affect the swimming of another bacterium. Another way is known as fluid mediated Hydrodynamics.

The other way to study the collective cell behavior is type of singling; a typical example of this is 'Quorum Sensing' as a route to collective behavior-where a group of bacteria releases small diffusible chemicals, which can be sensed by other bacteria and these bacteria, can modify their own behavior. The singling between the bacteria once reaches the critical threshold or the quorum, then everyone believes to react the same way; and this is how the collective behavior is built up with a critical threshold.

This is an example of swimming/ motion of bacteria in a confined suspension, called self-propelled objects. The bacteria contain within the ability, the external gradient, to swim. So we take the self-propelled objects in the fluid.

Bacteria use different ways to move viz. Swarming, Swimming, Twitching, Gliding, Sliding, Brownian motion. The Cyanobacteria is ancient and extremely versatile organism found in nearly every echo system on earth. Like plants and algae, they produce oxygen and use sunlight as an energy source. The collective motion must have the mechanical aspects.

There are certain models for phototaxis in cyanobacteria and can they help explain experimental data and aid conceptual understanding.

Light can be used as lumen device to study the properties of bacterial colonies. The wavelength of the light can be changed. There are some wavelengths over which the bacteria like to move towards the satellite source. The angles (of LED set up) can also be changed. The question comes when the cells respond to the light, do they respond to the vector sum or other light resource, considering that they have the same wavelength. It is actually the vector sum that is important. It is hard to tell from the shapes of colony. The only way one can tell is by tracking individual cells how they move. There are certain experiments which involve multiple light resources.

Where this is useful, especially in context of *Atmanirbhar Bharat*-How to get collective, self-organized dynamical behavior as in Biology, and all other regimes including soft and fluid. In bioengineering problems we think about harder objects. But much of the Biology happens in soft fluids and biomen. The collective behavior comes from the mechanical attachments. There is an important role of slime, which is a complex mixture of polysaccharides.

Cyanobacterial phototaxis in cell colonies works as a good model system unlike the other model system which has been studied. Not fast, small molecule-based signals like quorum sensing. The hydrodynamics like swimming were not important in case of bacteria, but mechanics was important. The role of Slime as intermediary in speeding up the ability of cells to move was also important. We also pointed out that changing Light signals orientation, wavelength and polarization made it a manipulable system e.g. the bacterial swimming system.

There are many advantages of such models. We can study ecological contexts with heterogeneous populations (having different types of bacteria mixing); can study the role of mutants, selection with respect to its motion. This has unusual paradigms; retarded in time interactions, unlike quorum sensing; Information integration for understanding molecular level processes using models that reproduce large scale features and also have cell level description; other practical applications as Biofilms, biofouling all these can be done by setting up the models.

Remarks by the Chair: This lecture provided the details about the life for bacteria, bacterial motion. This talk covered the insights of the computational modeling which is of interdisciplinary nature.

Advancement of Space Astronomy in India

Dr. S Seetha

Astronomy from Space in India has achieved several milestones over the last 50 years. Starting from experiments flown on balloons and rockets, we now have full-fledged satellite missions for astronomy. This talk will provide a brief picture of some of the salient features of this journey. Use of space platforms for astronomy has opened up new wavelength bands of observations, mainly in the UV and X-ray wavebands. This has led to the capability within the country to develop and test space optics and new detectors in these bands. In addition, systems are in place for proposal driven observations, data archival and dissemination. Data from different missions are also made openly available after an initial lock-in period. These developments have brought closer the scientific and technical teams at various academic and research institutes and ISRO; and can enable interfaces for variety of future missions.

I will speak on how we progressed in different phases; from where we started and where we are now and some future mission. As you know, ISRO's plan of activities is towards applied sciences, communication, remote sensing, societal benefits etc. The scientific community has made the best use of each of the experimental opportunities (from what is available) for making the progress altogether. We learn about the universe we live in, based on the Electro Magnetic radiations and also the particles which we receive (particle emitted and different objects emitting different wavelengths viz. the hot stars emitting the UV). Other objects like Gas and Dust can be seen radiating the infra-red bands. Sometimes, the different objects/ processes may lead to emission in different wavelengths; e.g. in sun, the photosphere emits the optical wave band (it's bright in optical wave band) whereas the Corona is relatively faint in the optical but very bright in the X-ray wave bands. We need to go to the rocket heights of at least 120 km and above for UV and X-rays astronomy whereas we can do the infra-red and gamma rays astronomy from balloon heights of few kilometers. The Space Science in India began using balloons and sounding rockets. Balloons were initially used for cosmic ray experiments; and TIFR Balloon facility was established at Hyderabad, now used for Atmospheric Physics and Astronomy (Gamma rays and Infra-Red Astronomy). The Indigenous rocket facility was primarily used for atmospheric and inospeheric studies. The rockets are flown from Thumba and Sriharikota, nearly 500 km, initially using the foreign rockets like Nike Apache and Centaur; and now using the indigenous rockets for this purpose. The next phase-Both the facilities, the balloon and the sound rocket facilities for those who want to do experiments on these. In order to get longer observation times of several days to years, we need to go to satellite platform. The first Space Science Satellite Experiments were performed on the very first Indian satellites Aryabhata & Bhaskara-I using Astronomy, Aeronomy and Solar Physics. We also used other facilities such as the NASA's Space Lab facility; Indian cosmic ray experiment Anuradha, Onboard, NASA's Space Lab-3 (1985); Direct measurements of ionization states of individual nitrogen, oxygen and neon states in anomalous states cosmic rays.

The Indian satellites and Indian launched vehicles became available in the 1980s; we started making experiments for Indian satellites flown on Indian launched vehicles. Initially, the capability of Indian Launched Vehicles was rather small, so we had to fly experiments which worked in the few kg limits with few watts of power and also included tropical research. We performed Gama Rays Burst (GRB) experiment and the Retarded Potential Analyzer (RPA) experiment on SROSS series of satellites; and we joined the Interplanetary network (IPN) for localization by triangulation.

We then used the IRS platform which became available with the Polar Satellite Launched Vehicle (PSLV);

because we needed tons of capability for flying X-ray astronomy experiment in collaboration with TIFR. This experiment actually enabled us to look at specific X-ray binary pointing to specific positions in the sky, and was first attempted with this satellite. We had several publications from this experiment for studying binaries, particularly, binaries with black hole and neutron stars. We also had five Ph.D. scholars working on this experiment.

We then entered the next phase based on the success of the individual experiments which was flown on PSLV or even geo stationery platform.

It was explored that we can make space worthy astronomy experiments. It was the time for ISRO to define missions. The first mission was the Chandrayaan Mission (Indian Mission with International participation). It was an internationally driven; and actually carried five experiments. So, it carried six payloads from abroad also on Chandryaan-1, out of which two payloads viz. C1XS and SARA were developed jointly with ISRO. We got 3D images at five meter resolution which was the best resolution at that time. Research for water was the pending problem for several years. The lunar prospector provided some indication of presence of water on moon. It revealed some indications of water ice on the poles of the moon.

The SARA experiment also provided indication that the interaction between the solar winds and the top surface of the moon still needs to be understood and better modeled.

The next mission was the Mars Orbiter Mission which was made very popular, because India reached the Mars orbit on its very first attempt. India gained this capability to actually go on inter-planetary missions. Because of its unique elliptical orbit, we could actually take full disc images of Mars in single snapshots of few hundreds of mili seconds and that was greatly appreciated because earlier, full disc images had to be mosaic images of several hundreds of images taken with high resolution cameras on earlier satellite. When this Mars orbit mission came close to the Mars on its orbit few hundred kilometers, it could take few medium resolution images of few tens of meters also.

Then, we moved on to another mission called AstroSat which is India's first dedicated multi-wavelength Astronomy Satellite covering the UV and wide X-Ray band. It is on a low earth 650 km orbit having 6 degree inclinations. The payloads were developed outside ISRO.

So, we could make UV coatings and take excellent snap shots of galaxies within few seconds of imaging. We also developed indigenous X-ray optics for x-ray telescopic experiment; and also developed high pressure counters for expanding the x-ray response up to energies of 80 Kvs.

The discovery detected the LyC (Lyman continuum) emission from one of the clumpy galaxies at redshift of 1.42 (z=1.42). It is so important because Lyman continuum is one of the indicators of early universe going back to redshift of 6 or 9. This gets red shifted from low to high red shift and no other satellite detected any Lyman continuum emission and we were the first to detect one such galaxy.

Other achievements included polarization from GRBs, multiwavelength modeling of X-ray binary, Cyclotron features around neutron stars in x-ray binaries, Study of star formation galaxies, Stellar evolution in clusters; and detection of ELM (Extremely Low Mass) white dwarfs.

Chandrayaan-2: unfortunately, the lander and the robov could not be achieved; however, the orbiter has six experiments and all these experiments are functioning very well and we have now improved the data results showing the presence of water on moon as well as elemental abundance of aluminum, sodium and potassium on the surface of the moon with extra fluorescence spectroscopy.

Apart from the space segment, we have also greatly improved the ground segment. The AstroSat is being operated as space observatory from India and every year we invite proposals from the world over for observations using the AstroSat. More than 50 percent proposals come from India and several from abroad. We need to have softwares and web-based links to receive proposals, get them reviewed, get the rescheduling done, making operations on the satellite; and the ground segment of receiving the data (data processing), verification, data archival and dissemination using various web-based tools for making the operations on the satellite. This could be possible with the support of the National Knowledge Network with the payloads operation centres spread all over India at various scientific and academic institutes. The

Future Missions include 1) XpoSat (X-ray polarization Satellite) to study X-ray polarization and polarization and spectra of X ray sources; 2) Aditya-L1 mission to study the eruptive processes from corona and chromosphere of the sun; in orbit around sun-earth L1; 3) Gaganyaan Mission which plans to take first the Human's capability, i.e. human using ISRO's capability of going to orbit. This will be the first mission where the interface from Biology comes in not only to study the health of human beings going in the cruse, but also to carry out the experiments connected with biology for this project. The study comprises different disciplines viz. the Astronomy, Geology, Physics. The astronomers from the world over are moving towards search for life in terms of either astrochemistry or astrobiology with the discovery of over three thousand planets and planetary systems around primarily in our galaxy and outside the solar system. These are called exoplanets. There is vast scope in this field to observe why there is life as we actually see; can we actually see the life not only in solar system but outside the solar system and to study actually how the life originated on earth itself. So, we could study all this in Astronomy and have had '*Atmanirbharta*', which is the theme of the symposium in terms of innovation, facilities developed like Indian Space Science Data Centre from where we are disseminating the data; M.G.K. Menon CleanLab for integration at IIA; Capacity building (we have 1000s registered users of data Chandrayaan-2 and Astrosat with 100s of publication from single mission); Miniaturization; Industry interface has been developed– Gold coating of X-ray mirrors, precision machining ; Spin Off ; Thermal coatings developed for AstroSat; Pressure transducers, adhesives, light weight composites and materials being used for biological context, paraffin actuator hold down and release, materials, Low energy X-ray spectrometer, Pisharoty Sonde system for atmospheric Physics, radiation spectrometer; Technology transfer, NewSpace India Ltd. (NSIL). Recently, Vikram Sarabai Centre has also developed medical oxygen concentrators and ventilators specifically to combat the COVID situation. Finally, enthusing large number of students towards science has a huge impact.

Remarks by the Chair: It was an excellent exposition on how satellite platform has been used for carrying out the experiments based on different levels and measurements and atmospheres viz. lunar. You have eluded about the use of Astrochemistry and Astrobiology which have an important role, because now the scientists are looking life on other planets. And finally, all these development have led to engineering and material science that led to the developments in other areas as well.

Session-6: Chemistry

Chairman

Prof. J P Mittal

Co-Chair

Prof. A K Singh

Reliance RELCAT™ Catalyst Technology for Polyolefin REPOL™ and RELENE™ Materials: Idea to Market

Dr. Virendra Kumar Gupta

Discovery of transition metal based catalyst for olefin polymerization in 1950's by Karl Ziegler and Giulio Natta have made enormous scientific, technological and societal impact through industrial production of polyolefin materials. The scientific contribution of Ziegler & Natta is recognized by awarding the Noble Prize in 1963.

Continuous innovations in catalyst and polymerization technology have resulted in current global production of olefin based polymer touching to ~190 million ton / annum. It is close to 60 % of total synthetic polymer produced worldwide annually. The applications of polyolefin materials cover most of high growth sectors like packaging, transportation, agriculture, automobile, defense etc.

The present talk presents the development of advanced catalyst technology for homo and copolymers of ethylene as well as propylene. The production of polyolefin materials is accomplished through homo and copolymerization processes catalyzed by organometallic compounds controlling different polyolefin product characteristics such as molecular weight, thermal, rheological etc.

Reliance Industry Limited has established three mega growth engines in a single decade and oil to chemical / polymer is one of them. These platforms create an eco-system of innovation which support in successful translation of fundamental work into technology development. Therefore, the RIL is able to open up many opportunities to move from fundamental science to commercialization of technology. Now, the question is why the synthetic materials / polymers are going to be important in coming decades. If we consider the

fourth industrial revolution, it is the amalgamation of physical, biological and digital worlds. In this world, the synthetic or the design materials have a big role to play to develop end use applications which are important for the societal benefits; and therefore, the synthetic materials are becoming much more important for India to have a lead in emerging technology. It is high time we should develop our own technology to see that the benefit is translated to our own society.

The nature has already and very intelligently produced materials like carbohydrate, lipids, proteins and created different functional products and applications. It is only after the First World War, the need was realized (when the oil was getting converted to kerosene) that how we can create synthetic polymeric material which are useful to the society and provide the solution. So, the real journey of synthetic polymer has started in the last century only with new developments. Today, if we look at thermoplastics and elastomers, we find that a variety of building blocks have been used to convert into different kind of materials having different kind of functionality. Such materials we call the high-performance thermoplastics and elastomers. The reason for these materials to be quite successful is their use in high end applications. One can design thermal & rheological characteristics unlike the material which was known before the previous century. So, these synthetic polymeric materials have opened up the opportunity for different applications. Further, the materials are not of any use unless these provide solution/benefit to the society. Examples include energy transition, oil to solar and hydrogen requiring advanced or synthetic material to create new technology, transportation. The health sector has recently witnessed (in the last two-three years) high growth for the use of synthetic material, particularly, how the polyolefin became very useful in combating the societal challenges during the COVID pandemic, e.g., manufacturing of masks/ PPEs etc. The problem of ffood and water is another challenge which is also going to emerge in the years to come. Further, agriculture, housing and infrastructure, retail, defense and aerospace sectors are the growth drivers for synthetic plastics and elastomers. Therefore, the high economical and societal impact is only possible if we develop our own technology in this area and continuously keep it improving. During the 100 years (1900-2000), major growth or innovation has taken place materials between 1920 and 1970 for synthetic materials. The synthetic polymers/ materials are more versatile as compared to other metals like copper, aluminum etc. due to ease of conversion into any design of products at a much lower temperature for different end use applications. This uniqueness has been reflected in global growth projection of approx. 1,124 million tons of synthetic polymers and elastomers by 2050. This is probably the highest growth we expect in synthetic polymers during the years 1950-2050. The reason for this kind of growth is emergence of the many growth sectors in India as well as globally. Among the different classes of materials, the polyolefin is the major class of polymer material. Around 40-45% of the material comes from the family of polyolefin. Today, around 190 plus million tons of polyolefin is being used worldwide. Therefore, for India to become '*Atmanirbhar*', developing of technology for these kinds of polyolefin materials is very critical. Industry and academic interaction is essential so that the industry could speed up the commercialization of technology for different products required in market. The knowledge of the total value chain of materials / polymers is essential for developing successful commercial products and its technology. In case of polyolefins, the knowledge of monomers, catalyst, polymerization, products, and applications are required to have confidence in developing impactful technology. The development of polyolefin technology requires know how in three areas viz. the catalyst, the polymerization and products and applications. Most critical is to have our own catalyst technology (indigenous technology) in India so that we are not dependent on global players. Catalyst and polymerization technology is essential for India to acquire global technology leadership position in polyolefin.

It is easier to create macromolecules based on ethylene as compared to polypropylene because of only presence of hydrogen in ethylene molecule as compared to propylene where hydrogen and methyl group are present. The catalyst discovery in 1950s by Karl Ziegler and Giulio Natta got the Nobel Prize and opened up an opportunity to develop more advance catalyst technology. Today, this advanced catalyst technology has reached to a level to provide high performance of catalyst as well as the product characteristics. If India

wants to be the global leader, then whatever we develop should be the globally competitive technology. We have successfully patented catalyst know how of our trade mark RELCAT™ and also commercialized developed technology for production of PE and PP grades. We have close to 100 patents all over the world for this technology and products are in the market. Today, the young leaders have the opportunity to translate their ideas in a much faster way due to capability now developed in India.

The journey that we travelled had undergone several stages of from concept to commercialization including the bench scale catalyst , the pilot scale catalyst trial, commercial production of catalyst and finally the commercial scale polyolefin production such as LLDPE (Linear Low Density Polyethylene). It took ten years to develop the technology at RIL which is now successfully operational. We have developed different film grades as different films have different characteristics viz. mechanical rheological and other characteristics. We have developed products for different sectors viz. film, irrigation, agriculture sectors etc. We got recently 'Product innovator of the year' award by FICCI, at India Chem 2021 event, held on March 17, 2021. The PP Catalyst technology developed by RIL has been selected among the top five technologies developed worldwide by Hydrocarbon Processing Award Committee.

In Summary, the emerging sectors have indicated exponential growth in coming decades requiring thermoplastics and elastomers with different functionality for sustainability. This forms a part of fourth industrial revolution and convergence of the physical, biological and digital world. These advanced synthetic materials, especially the polyolefin is going to play a very important role in impacting economy, business, nation, society and the individuals. It is extremely difficult to comprehend or anticipate how the velocity of disruption or the acceleration of innovation will take place. So, the concept of *Atmanirbhar Bharat* has given us the right platform to develop/create new technologies for India using fundamental knowledge created in academics and industry. The academia-industry interaction/ partnership is essential for speedy commercialization which requires understanding of molecules, catalysts, novel reactors, processes and finally the products. Further, the fundamental to value creation is also intra disciplinary/ cross disciplinary. This is demonstrated in our present development and commercialization of RELCAT™ Catalyst Technology for Polyolefin REPOL™ and RELENE™ Materials as shared with all.

I'm sure, we will be able to develop more processes and product technologies (as we have developed in case of polypropylene and polyethylene) to other emerging materials like IPVC, Sulfur Polymers and FESBR on which the RIL team is working.

Continuous Flow Processes: A step towards *Atmanirbhar Bharat* in Chemicals Manufacturing

Prof. Anil Kumar

Continuous flow process provides a potential alternative to batch synthesis because of its inherent advantages such as very efficient heat exchange, high batch to batch reproducibility, fast mixing, high throughput, safety, and the ability to do multistep telescoping synthesis. Due to these advantages, these processes have been referred to as the most promising "Green Technology". In fact, continuous flow processes are projected to be the "CHEMICAL FACTORIES" of tomorrow. Continuous flow process also enables the synthesis of designer materials with wide-ranging applications. We have been exploring continuous flow processes for the synthesis of conjugated polymers, nanoparticles and nanofibers, fine chemicals, catalysis for heterogeneous processes etc. We have also developed a module to train the next generation of human resources in this important domain. In this presentation, I will review some of the recent advances in these directions and some efforts from our laboratory.

People generally ask, "What is Continuous flow processes, and what's the big deal about it?" Actually, this technology is there for more than 100 years viz. the ammonia synthesis, the Haber-Bosch process is a continuous process. All the petro chemical industry (like the reliance industries) is a continuous process. Not only petro chemical industry, but also the food industry and auto industry; all are continuous process and have been functional for many decades. But, when it comes to other parts of manufacturing like pharma, fine chemicals, flavor and fragrance, we don't do a continuous manufacturing. We still rely on the standard batch technology, because of which we come across such issues as accidents etc. The reason we cannot do continuous manufacturing in terms of fine chemicals is that the volumes are very small in fine chemical industries and the number of processes is very large. As we just heard that in case of polyolefins, they produce 25 to 75 tons per hour whereas the fine chemicals will have that much of volume only for the month(s) or a year. The large one what we are looking for is about 45,000-50,000 tons per year. So, this continuous manufacturing is always the domain of large industries, because the amount of time and energy required to develop a continuous manufacturing is huge and difficult in terms of handling, safety and nothing much can be done here, because the number of products is very large and the volumes are very small. So, can we do continuous manufacturing that we are doing in large volume to small volume products? This can only happen when we develop some technology which allows us to make a quick transition from lab to the production to small volume continuous manufacturing. This idea has come up from the last 15-20 years and people have been working on this technology that how can one miniaturize these continuous manufacturing units to smaller plug and play model systems which a chemist can use and if a chemist can use, then, the process could be developed in the lab itself at very small scale.

Now, the technology has reached a stage where we have many small reactors available like FUMI Spin Disk, spinning disk reactor etc. The advantage of these reactors is that these reactors are very small at lab scale.

Once the chemist has developed, various reactors could go to different range as per their capacities. So, if we go through the traditional method, the first task is performed by the chemist in the lab; then, the process engineer takes it to pilot scale and further develops it to the large scale. In every trail there is a new process and we optimize the scale. That's why the time take from lab to production is very large. The chemist is not

in a position to go for the large scale production and we have to hand it over to the next team and so on. Things are changing very fast now. Because of the continuous flow technology, the chemist can develop this at a small scale and take it to the production, because transition from small scale to large scale does not require technological inputs and that's the revolution which is happening in fine chemicals and pharma where people have now to adapt to this instead of doing reactions to the flasks so that the transition can be quickly taken to production scale. Currently, we are talking about the transition from the lab to the production scale which takes six months. Then, you do the optimization at the lab scale, take up to the production scale, and set up to your reactor and start producing it. That makes a huge difference, especially when you consider the economics (of affluent) and safety. So, the days of transitioning from lab to the production which used to take few years with lot of cost has been completely eliminated; and it's a matter of weeks and months and a chemist can take the step of first level of production which is a significant change using additional chemistry which we have been doing over the years. So, this continuous flow process which is now suited for fine chemicals, pharma and fragrance industry to adapt to the continuous manufacturing. The traditional way is changing very fast for designing a reactor for doing nano synthesis of the chemicals/particles. This can happen only when these are treated with the petro-chemical industries and can be done using time resolved synthesis. So, for an industry to develop in different ways, continuous flow is required to increase the production.

You can convert it into 10 ml reactor. You have extremely small miniaturized reactor; they give you production which are of typical kind; in addition, they give you safety.

Continuous flow processes: a step towards *Atmanibhar Bharat* in chemicals manufacturing-we need to do such processes if we want to be globally competitive in chemical manufacturing. Organic chemist, flow chemist, process engineer-Chemist are comfortable with flasks and tools. We learnt to develop all the processes and developed all the tools. Then, we started handholding by the industries to train their manpower. There are various industries trained in our lab viz. UPL, Syngenta, Glandpharma etc. to convert their batch process into flow. We then developed a practical course providing all the tips to do continuous manufacturing. After training the industries, we realized that we are the only one giving this training and it is extremely difficult to train everybody. So, we decided to make it freely available to the community. We now have full course uploaded on the YouTube and have large number of audience to learn continuous manufacturing from there.

Apart from generating the human resource in this important domain, both at academic and industry level, we also take processes and develop that at IIT, Bombay. We worked in the domain of conjugated polymer. These are the materials for free electronic applications. There are three main polymers involved viz. electrochemical polymers, cells and nanofibre based on polyaniline. In polyaniline continuous flow synthesis, the throughput is 140-450 g/ L/h.

Concluding remarks: Do not try to run batch reactions in flow; learn the tricks of flow process; talk to the people with experience; there is not a single solution for everything, there is a solution for everything.

Remarks by the Co-Chair: It's a great pleasure to listen to your talk. You have shown how continuous flow processes provide a potential alternative to such type of synthesis, most importantly, the ability to do multi-step telescope synthesis, which is rather unconventional in many ways. It seems that we have to relearn and rethink the retro synthesis strategies/ DOS strategies what we have learnt earlier. These developments are very important from environmental, sustainability, economic viability and safety point of view; and I am sure, these would be very much helpful in conducting chemical reactions during chemical manufacturing in various industries.

Dr. V K Gupta has delivered a brilliant talk. In his talk, he showed us how the fundamental research can be taken up in an Industry set up and further be taken to manufacturing and then to marketing. Dr. Gupta demonstrated design and application of efficient catalyst for a variety of polyolefin-based products of great

value with great commercial outcome. But, the need of the hour is to make available, efficient, environmentally sustainable and economically viable catalytic systems which can catalyze the kinds of chemical reactions which are often used in such processes. Design and development of catalytic systems, in my opinion, is going to be pivotal in making India *Atmanirbhar Bharat* as far as manufacturing of chemicals in chemical products is concerned.

Apart from the polymers and pesticides, most of the chemicals that we need in India are imported because of unavailability of efficient and modern catalytic systems which also affects the environmental sustainability and economic viability.

The research on design and development of environmentally sustainable and economically viable catalytic systems for those chemical reactions which are very often and routinely used in manufacture of both-basic chemicals as well as specialty chemicals including the nutraceuticals must be looked into . I am sure the younger generation would have been benefitted by these talks.

Concluding Session

Prof. Anil Kakodkar

Prof. Manju Sharma

Prof. Ajoy Ghatak

Prof. Anil Kakodkar (In Chair)

It was a great experience to go through NASI's Annual session. The symposium has a focus on interface between biological and physical science towards *Atmanirbhar Bharat*. I always admire NASI's efforts to bridge the basic sciences on one side, application to industry on the other; and finally connecting the whole science and technology to the society in a distinctive and holistic manner. We heard from Prof. Manju Sharma and Prof. Anurag Sharma, the gist of the entire symposium. The whole country has gone through, and experienced a very critical phase of COVID; but the scientists are not behind and are still in the race to develop newer vaccines. Managing a large population was a big task; but, as a country, we have given a great account of our capability and scientific community along with the industry and could perform several things on the table. Apart from vaccine and vaccination which were the key things, there are several other technologies to work on the interface of physical and biological sciences; for example, detection kits and several other products developed by the innovators have brought to the industry/ market in a very short span of time. We are proud of Indian scientific capability. The COVID-19 episode has demonstrated the capability of the Indian scientific community to the country at large. So, the theme for this symposium has been very thoughtfully selected; and it has been a very productive meeting. I want to use this occasion for talking about a few larger challenges. We all know that certain important things are useful for the society; and it is very important to work on the interface. Also, there are several areas in Physical as well as Biological sciences which are emerging very fast and also look very transformative viz. the cognitive sciences, the genetic engineering, the artificial intelligence etc. and emerging very fast. The other areas seem to be the frontiers as far as the basic or the open ended research is concerned and will be a domain of major technologies. For developing the technologies, nano or micro technologies, you require large investments at times, and also great research environment as well as the industry collaboration/ participation. Many of them require very large platforms and investment which cannot be possible without proper policy frame work of government. By many people, it has been defined as *Triple Helix*. It looks to me that if we have to consolidate the capability, we have great capability in terms of scientific research, industrial activity. If we want to see a big impact and be the front runners in the world, we need to have an eco-system where the agencies can work hand in hand with a futuristic outlook. The Academies, especially, the NASI has the society interface as one of its prime objectives; so, it should certainly convey this kind of message and make sure that if we fail on any of these trades of the *triple helix*, the things will not move. India has been self-sufficient in the field of material sciences all alone, but the country missed the semi-

conductor revolution. But, in the context of the front line topics discussed today which are on the threshold of becoming big technologies, appear so path-breaking. So, this is a matter which all segments of the ecosystem have to be constantly aware of it, but, most importantly work with each other; and that's crucial for India's rise to preeminence place in the competitive world that exists today. In this symposium, one element is interfacing the physical and biological science, but with the objective of towards moving *Atmanirbhar Bharat*. I think, we are '*Atmanirbhar*' in several things. As mentioned earlier, during the pandemic, India has shown '*Atmanirbharta*'. But, we need to be preparing ourselves for the future also. The things are evolving much faster today than they were in the past and will evolve even faster in future. So, there is much greater importance to very agile policy-making, the time frame for which has to be consistent with the evolving world. If we want industries to participate, they have to deal with big money/ investment. If we are to talk about large investment, then, de-risking becomes very important; and mutual confidence between these three elements of the triple helix. So, for the industry to come forward, the industry, R&D and the government connect has to be of much better quality than it has been so far. This is the message we need to convey for concluding this meeting.

Prof. Manju Sharma (Concluding Remarks)

You have given very important message for the future and also the direction to be taken, particularly in this evolving world and also the *Triple Helix*, how it works in frontier areas.

Prof. Ajoy Ghatak (Closing Remarks)

I express my gratitude to Prof. (Mrs.) Manju Sharma and Prof. Ashok Mishra for creating this symposium on 'Interface between Biological and Physical Sciences towards *Atmanirbhar Bharat'*. It was a delightful experience to listen to the eminent speakers including Prof. Padmanaban, Prof. Chidambaram and the other invited talks; and also to experience the motivation of each speaker revealing a core message that bringing together the Government, the Industry as well as the Academia is very important which was beautifully illustrated by Prof. Balram Bhargava and was an eye-opener. We also heard about the tremendous contribution by the healthcare workers during the extremely difficult times of pandemic, a very eye opening. But, the pro-active and positive action of the government is required. There are a few shortcomings also. So, the three important components of this network have to come together. We, as scientists, need to focus on product development. We have a tremendous pool of scientific man power. The only thing is to provide the right environment and the coordination for the youngsters to thrive. These people can do so well in their country as well if they can succeed outside India. India ranks 101st in the Global Hunger Index list which is so embarrassing. It is only through the science and technology that we can think of removing the poverty. A massive investment is required from the country to promote research. We need to educate the people of rural areas of our own country as well.

Recommendations:

The event underlined the role and importance of Agriculture, Health for all, Intellectual Capital, Translational Research and Industry-Academia partnership towards making India 'Atmanirbhar'.

1. **Intervention of Agriculture Sector for achieving Sustainability Development Goals:** Climate Smart Agricultural practices need to be adopted to predict the future situation for enhancing productivity, quality, improve nutrition outcome and have resilient/efficient production system. Ergonomic and safety aspects to be considered in the design of farm tools, equipments and machinery; precision agriculture to be used for enhancing the agriculture productivity, efficiency and reducing the drudgery of workers especially, the female workers.
   Action Point:
   List of KVKs be obtained; coordination with ICAR for achieving the Channel.

2. **Health for all:** Identifying pathogens (emerging strains harmful for the human and animals) against which effective therapeutics and prophylactics are not available; and spreading awareness on One-Health (OH) measures/approach for the effective prevention and control of all possible/emerging/ re-emerging human and zoonotic diseases.
   Action Point:
   Coordinated efforts to be made in collaboration with ICMR.

3. **Development of Intellectual Capital:** An intellectual capital needs to be developed in the country; innovations, discovery driven research and industry must be focused upon. Industry and scientific institutions must come together to make a strong 'Atmanirbhar' India.
   Action Point:
   Academy should organize series of workshops/events in collaboration with the scientific/research institutes (which can play a big role with knowledge generation in fundamental research) to develop entrepreneurial temperament among the youngsters as well as promoting innovative knowledge for entrepreneurship development and achieving success with a career in entrepreneurship for fulfillment of Innovate & Make in India Programme.

4. **Translational research**: This has to be recognized as a discipline; scientists involved in translational research must be recognized for their contribution.
   Action Point:
   The Academies should start a joint programme for encouraging such research; the Research Institutions may be roped in to foster such programme by facilitating affordable access/ creating facilities to the students including researchers; the recognition of translational scientists should be encouraged as unique practitioners of an independent scientific discipline.

5. **The academia-industry interaction/ partnership:** This is essential for speedy commercialization which requires understanding of molecules, catalysts, novel reactors, processes and finally the products; the research on design and development of environmentally sustainable and economically viable catalytic systems in manufacturing of chemicals and chemical products is needed for making our country 'Atmanirbhar'.
   Action Point: The Science Academies should collaborate with the industries and academia to foster the cooperative research as well as innovative aspects of scientifically developed products.


राष्ट्रीय विज्ञान अकादमी, भारत
THE NATIONAL ACADEMY OF SCIENCES, INDIA

Annex. 7

The National Academy of Sciences, India

Department of Science & Technology, Ministry of Science & Technology, GoI

- Founded by Prof. Meghnad Saha in 1930, the National Academy of Sciences, India (NASI) is the first Science Academy of India; also recognized as an AI of the DST, and as SIRO of the DSIR, GoI.
- NASI is involved in recognizing & promoting scientific and technological research related to the problems of societal welfare, through its Fellows & Members (more than 3500), and 22 Chapters spread all across the country.
- It is also regularly publishing proceedings since 1930 (of international repute), journals, memoirs, transactions and other works as may be considered desirable.
- It organises meetings and holds discussions on scientific and technological problems to undertake, through properly constituted committees and bodies, the scientific work(s) of technological or public importance.
- Communicating science among the students, teachers and general mass to make them aware about different socio-scientific issues like nutrition, environment, health, etc. as well as to sensitize the women, rural mass and tribal to become self sufficient (*Atmanirbhar*) through different scientific endeavours.