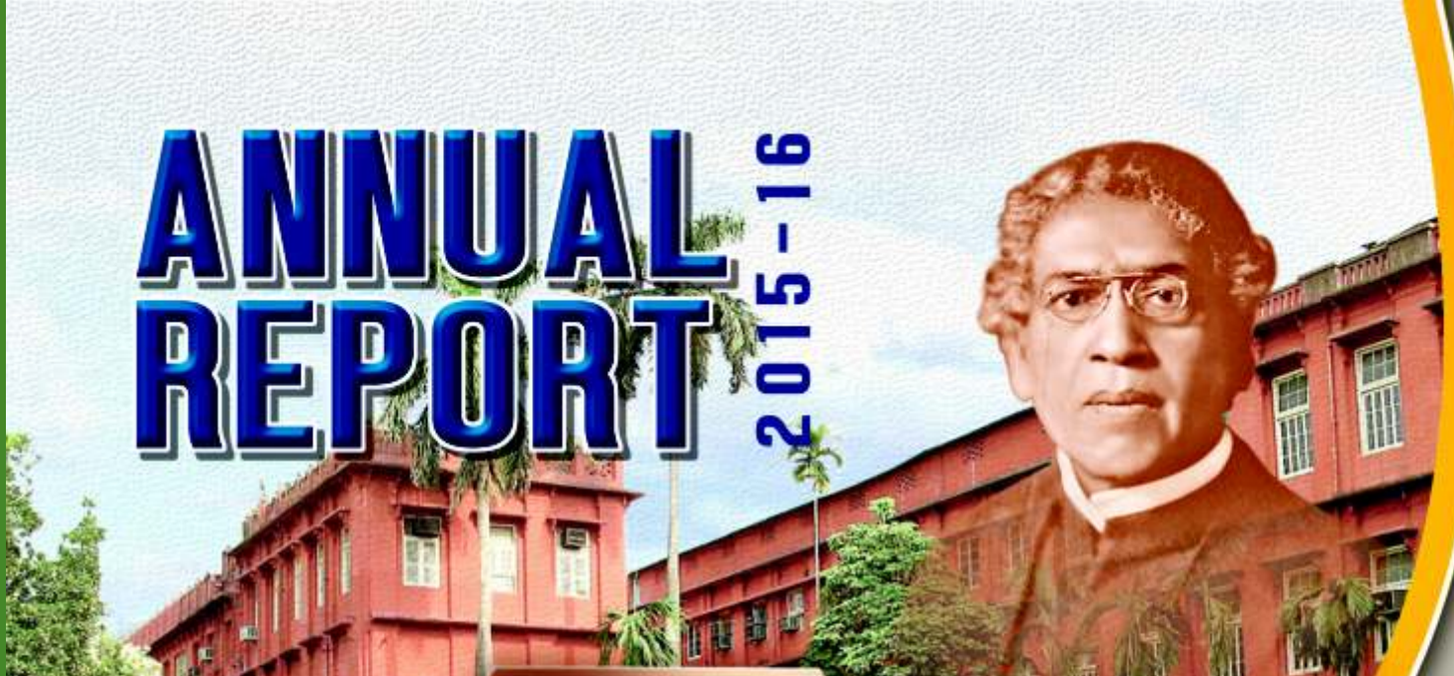
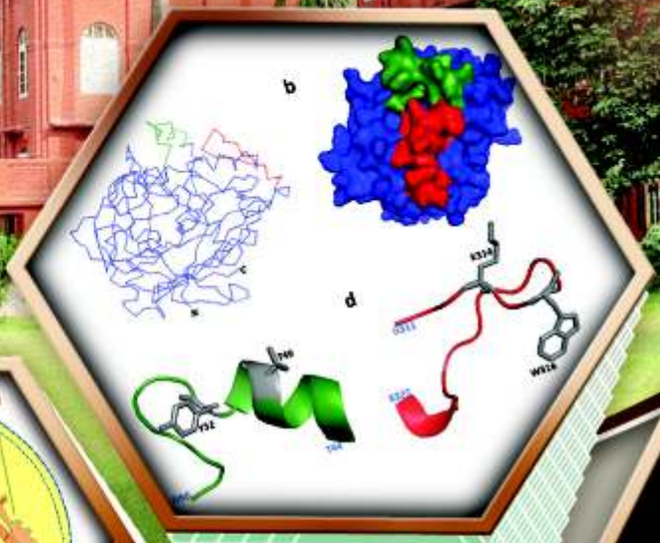
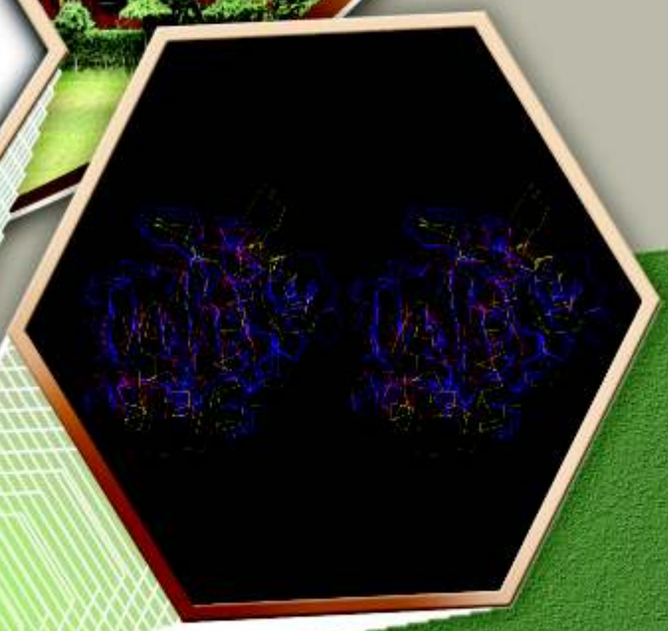
ANNUAL REPORT

2015–16

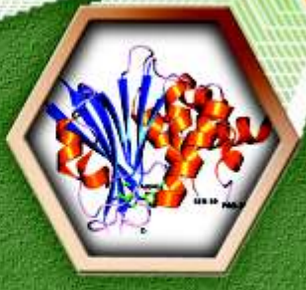














Bose Institute

Kolkata

ANNUAL REPORT 2015–2016 BOSE INSTITUTE







Visited Bose Institute and Inaugurated Central Animal House & Research Facility on 02-05-2015

Central Animal House & Research Facility, located at the Acharya J.C. Bose Biotechnology Innovation Centre, Bose Institute, Madhyamgram, Kolkata, was inaugurated by Dr. Harsh Vardhan, Hon'ble Union Minister for Science & Technology and Earth Sciences, Govt. of India on May 2, 2015. The facility is a state of the art world class environmentally controlled "Central Animal House and Research Facility" for Developmental and Toxicology Research with comprehensive facilities for breeding, maintenance and experimentation on small laboratory animals. This facility will be utilized for experimental research in molecular life sciences in accordance with the principles of good laboratory practices and CPCSEA, Ministry of Environment, Forest & Climate Change, Government of India guidelines. Further, it would facilitate research and development in partnership with academic institutions, industries and funding agencies for drug discovery and development on devices of translational medical research with the objective of advancement of biological knowledge useful for saving the lives and /or alleviating the suffering of human beings. The experiments will be performed with due respect to animal ethics. The Centre will also be involved in skilled manpower development through education and training in laboratory animal care and experimental techniques. The main objective of the Centre will be to supply defined strains of laboratory animals like mice, rats, guinea pigs, hamsters and rabbits for Bio-medical Research to the scientific community of the Eastern and North Eastern part of India.

Dr. Harsh Vardhan, Hon'ble Union Minister also visited Bose Institute Main Campus on May 2, 2015. He visited the Museum, offered flower at Samadhi Mandir and marked his comments in the visitor's book there.

ANNUAL REPORT

OF

BOSE INSTITUTE

2015–2016



Compiled and Edited by the
J. C. Bose Centre
(comprising J. C. Bose Museum and Publication unit)
consisting of the following members :

Prof. Dipankar Home	(Chairman)
Prof. Gautam Basu	(Co-Chairman)
Prof. Kalyan Kr. Mukhopadhyay	(External Expert, Advisor)
Prof. Pradip Kr. Parrack	(Member)
Dr. Gaurab Gangopadhyay	(Member)
Shri Tarun Kr. Maji	(Member)
Smt. Ishani Chatterjee	(Convener)

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From the Director's Desk



I feel privileged to present the Annual Report of Bose Institute for the period 1 April, 2015 till 31 March, 2016, during which Bose Institute completed its journey of 98 years in the service to the Nation and the humanity. This Annual Report seeks to provide an overview of the various activities pursued by the Institute during the period under considerations. Our activities are multifold in terms of making fundamental and applied contributions to the repository of scientific knowledge. We also actively nurture a range of outreach programmes that are specifically aimed at bringing benefits to the society directly.

I take this opportunity to mention that Bose Institute is presently placed at a critical juncture while approaching the completion of its 99 years, thereby marking the beginning of its Centenary celebration. On this historic occasion, Institute aspires to add new dimensions to its activities by appropriately honouring the historic legacy of our Founder, the pioneer of modern Indian science – Acharya Jagadis Chandra Bose. Finally, I would like to express our deep gratitude to our funding agency, the Department of Science and Technology, Government of India, for their sustained support that has enabled us to continue our quest towards greater excellence.

Siddhartha Roy
Director (Officiating), Bose Institute



Front View of Bose Institute

BOSE INSTITUTE
Established: 30th November,1917

Introduction

Bose Institute was founded by Acharya Sir Jagadis Chandra Bose in 1917 for the advancement of science and dissemination of knowledge. The Institute has served the nation for the past 99 years through its pursuit of advancement of knowledge in science and technology and by developing highly competent and able scientific manpower for the country. The Institute has on its staff highly qualified and experienced scientists devoted to original and path breaking research in the fields of Plant Sciences, Structural Biology, Molecular Biology, Biomedical Sciences, Biotechnology, Quantum Mechanics, Astrophysics and Condensed Matter Physics. Bose Institute started with three original departments, Botany, Chemistry and Physics. With time more departments were added the Animal Physiology Section (1930), Department of Microbiology (1942), Department of Biochemistry (1974), the Plant Tissue Culture Section (1976, subsequently renamed Plant Molecular & Cellular Genetics Section in 1989), Department of Biophysics (1985), the Environmental Science Section (1992) and the Immunotechnology Section (1992). Very recently, a division of Molecular Medicine has been established, absorbing the sections of Animal Physiology and Immunotechnology, along with the induction of a few scientists from the Departments of Chemistry and Microbiology. In addition, the institute hosts support and service centres like the Central Instruments Facility (CIF), the Distributed Information Centre (DIC), Library, Workshop, J.C. Bose Centre (comprising the Museum and the Publication sections). The wide-ranging and comprehensive base of available scientific infrastructure at Bose Institute also comprises the Acharya J.C. Bose High Altitude Research Centre at Darjeeling and the experimental field stations at Falta, Madhyamgram and Shyamnagar. Recent augmentations include the establishment of a National Facility on Proteomics and Genomics, a National Facility on Astroparticle Physics and Space Sciences, a Centre of Excellence in Bioinformatics, a Rural Biotechnology Training Centre at Falta and the J.C.Bose Biotechnology Innovation Centre based at the Madhyamgram campus. The facilities available in the institute for scientific enquiry and its applications also cater regularly to the scientists from several universities and research centres in the country. Special efforts have been undertaken to upgrade and modernize the library of Bose Institute during the recent years.



The eminence of Bose Institute scientific research spanning a wide range of disciplines is evident from the large number of research publications in the most competitive peer reviewed international and national journals, the recognition received by the

scientists in the form of S.S. Bhatnagar Prize, INSA young scientist award, fellowship of the National Science Academies, fellowship of the Third World Academy of Science, Nehru Fellowship, K.S. Krishnan Fellowship, Rockefeller Foundation fellowship and Homi Bhabha fellowship. The institute has over the years provided yeoman service in manpower development, having trained a large number of Ph.D. students many of whom are now reputed experts in their fields in India and abroad; on an average, 30-40 scholars are awarded Ph.D. degree every year. Over the past decade, scientists of Bose Institute have maintained an enviable record of publication in peer reviewed journals. A number of its scientists and research scholars participate every year in numerous academic activities (seminars, conferences, workshops) in India and abroad as invited speakers, chairpersons and resource persons.

A large number of extramural research projects, with support from various government agencies as well as international funding agencies, are carried out at Bose Institute.

Research Activities

At the time of founding Bose Institute, the illustrious founder, Sir J. C. Bose had unequivocally declared that the objective of Bose Institute would be to practice seamless science, without compartmentalisation on the basis of specialisation. Bose Institute strives to achieve this ideal, encouraging inter-disciplinary research to the fullest. Broadly, the current research activities of our scientists cover the following areas:

Institutional Plan Projects for the 12th Five-Year Plan (2012-2017)

I. **Plant Functional Biology of Stress Responses for Improvement and Exploring Plant Genetic Resources**

II. **Structural Studies and Biophysical Problems**

III. **Computational Biology**

IV. **Molecular Medicine**

V. **Basic and Applied Microbiology**

VI. **Systems Biology**

VII. **Basic and Applied Problems in Physical and Environmental Sciences**

Manpower Development, Academic

Bose Institute has recently started a new chapter in the realm of manpower development. In collaboration with the University of Calcutta, an integrated M.Sc.-Ph.D. course in Plant Molecular Biology & Technology has been initiated in September 2007.

Science and Society

In addition, a Rural Biotechnology Centre has been developed to provide the knowhow of basic biotechnology to the rural people to improve the socioeconomic status. Although the beginning is modest, the response of the local people, the primary beneficiaries of the project, has been one of tremendous enthusiasm and efforts are now on not only to sustain it but also to substantially expand its scope.

MANAGEMENT OF THE INSTITUTE

Bose Institute is a grant-in-aid autonomous institution under the Department of Science and Technology (DST), Ministry of Science & Technology, Government of India. It has a Governing Body consisting of twelve members including the Director. The management of the Institute is vested in Bose Institute Council. The Institute also has a Finance Committee responsible for the financial policies and management.

Members of the Governing Body

1. Prof. Debi Chakravarti
2. Prof. S.N. Chatterjee
3. Shri Somnath Sanyal
4. Prof. D. Banerjea
5. Dr. Anutosh Chatterjee
6. Dr. Manish Sekhar Chakraborty
7. Shri D. Mandal
8. Shri Dilip Bhattacharyya
9. Prof. Parul Chakrabarti
10. Prof. Bikash Sinha
11. Vacant
12. Director, Bose Institute - Secretary

Members of the Council

1. Prof. Bikash Sinha, Chairman — One eminent active Scientist with expertise in the area(s) of research pursued at B. I. nominated by the DST.
2. The Secretary, Department of Science and Technology, Government of India or his nominee
3. Prof. S. N. Chatterjee — Two eminent and active scientists in the area of research pursued in B.I. nominated by the
4. Shri Swami Atmapriyananda — Governing Body. They may not necessarily be members of the Governing Body

5. Prof. MRS Rao — Two eminent and active Scientists to be nominated by the DST
6. Prof. JP Khurana
7. Financial Adviser, Department of Science and Technology, Govt. of India
8. The Chief Secretary, Government of West Bengal or his nominee
9. The Director, Indian Association for the Cultivation of Science, Kolkata
10. The Director, S. N. Bose National Centre for Basic Science, Kolkata
11. The Director, Bose Institute
12. The Registrar, Bose Institute – Non-Member Secretary

Members of the Finance Committee

1. Principal Secretary, Higher Education Department, Govt. of West Bengal.
2. Shri Somnath Sanyal, Representative of the Governing Body
3. Joint Secretary and Financial Adviser to the Department of Science and Technology, Govt. of India or his nominee
4. Accountant General (A & E), West Bengal
5. Director, Bose Institute
6. Registrar, Bose Institute, - Secretary.



SCIENTIFIC REPORTS

| I |

Plant Functional Biology of Stress Responses for Improvement and Exploring the Plant Genetic Resources

Participation in Institutional Projects for the 12th Five-year Plan (2012-2017)

Dr. Sampa Das (Coordinator), Dr. S. Gupta-Bhattacharya, Dr. S. R. Sikdar, Dr. Debabrata Basu, Dr. Gaurab Gangopadhyay, Dr. Pallob Kundu and Dr. Shubho Chaudhuri

Dr. A. N. Lahiri Majumder (Emeritus Scientist, Raja Ramanna Fellow), Dr. S. Sen Mandi (Emeritus ICMR), Dr. A. Pal (Emeritus CSIR), Dr. D. N. Sengupta (Honarary Scientist), Dr. Anupama Ghosh (Inspire Faculty), Dr. Akansha Jain (SERB DST Young Scientist), Dr. Subha Das (SERB DST Young Scientist).

Introduction

To address various biotic and abiotic stress induced physiological, plant yield and plant development related problems- proteomic / transcriptomic/ next generation sequencing and other molecular technique based attempts are being made to identify novel genes / proteins/ regulatory elements and their key functions associated with plants' metabolism. Recent initiatives have also been undertaken to understand epigenetic, transcriptional/post transcriptional and post translational regulations of selected key genes, upstream regulators, miRNAs and proteins playing role in plant defense response and plant developmental processes under variable situations. Using plant genetic engineering technology, effective exploitation of selected novel genes and regulatory elements are being pursued to improve the efficacy of target plants in the field.

Attempts are also being made to identify a number of allergenic proteins through immunoproteomic analyses from air borne pollens and fungal spores.

Dr. Debabrata Basu

Professor

| Scientific Reports |

Regulation of Gene Expression in indica Rice cultivars and Analysis of the IR64 rice transformed to overexpress SAMDC enzyme and OsBZ8, a transcription factor

Differential expression of PLD genes and enhancement of PA level is associated with resistance response of Sinapis alba against Alternaria brassicicola. The role of Phosphatidic Acid

(PA) as early signalling molecule has been monitored during the interaction of the necrotrophic fungal pathogen *Alternaria brassicicola* with resistant *Sinapis alba* and susceptible *Brassica juncea*. Differential expression pattern of six different homologues of PLD, i.e., PLD α, β, γ, ε, δ and ξ, which are involved in the biosynthesis of PA have been quantitatively measured by real time PCR from both *S. alba* and *B. juncea* on the challenge with the pathogen. Selective upregulation of PLD β, γ and ε in *S. alba* compared to unchanged expression of the genes in B. juncea within 24 hours after inoculation (hai) indicated a PA mediated early signalling in the resistant plant. This has been further validated since a quantitative increase in PA level was observed in resistant *S. alba* compared to a decrease in PA level in B. juncea. In addition to that, this early PA mediated signalling was correlated with the ABA response as a number of ABA biosynthetic and responsive genes were showed upregulation in *S. alba*. Spraying of PA suspension in the susceptible B. juncea, showed not only increased resistance but also enhanced expression of ABA responsive genes, which is analogous to the expression pattern of the genes in *S. alba* on the challenge with *A. brassicicola*.

Publications:

1. Chakraborty J, Sen S, Ghosh P, Sengupta A, Basu D and Das S (2016) Homologous promoter derived constitutive and chloroplast targeted expression of synthetic Cry1Ac in transgenicchickpea confers resistance against Helicoverpa armigera. Plant Cell, Tissue and organ Culture, 125,521-535.
2. Saha U, Mazumder, Mukherjee, Parveen S, Mondal B, Maji S R and Basu D (2016) Acritical analysis of phosphatidic acid mediated resistance response in Sinapis alba against Alternaria brassicicola: Physiological and Molecular Plant Pathology, 94, 90-99 10.1016/j.pmpp, 2016.05.003.

Dr. Shubho Chaudhuri

Associate Professor

Scientific Reports

Epigenetic regulations during plants response to different environmental or developmental stimuli.

Understanding the epigenetic regulation involved in the transcription of salt and cold stress induced genes in rice

Reprogramming of cellular function in response to external stress stimuli is one of the important mechanism by which plants adapt to the environment. Stress adaptation involves alteration in the expression levels of several genes. The highly complex structure of chromatin imparts resistance to several nuclear processes including transcription. Several covalent modifications at the N-terminal tails of histones and changes in DNA methylation together generate epigenetic code to promote

accessibility of nuclear factors to their cognate binding site. Using rice as a system, we have studied different epigenetic changes involved in regulating the expression of stress responsive genes. Our results indicate that there are differential epigenetic marks at the promoter region of stress responsive genes in response to different abiotic stress-induced transcription. These epigenetic changes cause significant rearrangement in the chromatin architecture at the promoter region of the genes. In different stress tolerant varieties of rice, enrichment of such chromatin modification marks was observed in these loci, even in absence of stress. These findings indicate an important role of epigenetic control in the transcriptional activation of different inducible genes of rice in response to abiotic stress. Genome-wide ChIP on chip analysis has indicated differential regulation of Histone H3K27methylation and H3K27 acetylation during cold stress response. The transition of repressive H3K27me3 to activating H3K27ac correlates with the expression of cold stress responsive loci in rice plant.

Investigating the role of ARID/HMG in modulation of chromatin structure in planta

ARID-HMG belongs to a novel HMGB group of proteins where AT-rich interaction domain (ARID) is fused with HMG-box domain in a single polypeptide. ARID-HMG family is highly plant specific with homologs found both in higher plants as well as in lower plants such as *Physcomitrella*. These proteins are ubiquitously expressed in different parts of the plant tissue and are primarily localized in the nucleus. The DNA binding shows that ARID-HMG can bind to double stranded DNA but have weaker binding affinity compared to canonical HMGB protein. The protein prefers AT-rich DNA as a substrate and also shows structural bias towards supercoiled DNA. Structure based on protein DNA docking of ARID-HMG and DNA complex indicates that the protein interacts with the DNA through major groove and the ARID domain and the junction region between ARID and HMG-box domain are the major interacting regions. Interestingly, both the domains of ARID-HMG when expressed separately retain their DNA binding property. The HMG-box domain shows stronger affinity towards DNA while affinity of the ARID domain is similar to full length protein, suggesting that DNA binding of ARID-HMG is mostly mediated by the ARID domain. Moreover, both ARID-HMG and its HMG-box domain can induce supercoiling in a relaxed plasmid DNA. Also, docking structure indicates that HMG-box domain of ARID-HMG interacts with nucleosome near entry/exit point. Collectively, these results signify that both the domains of ARID-HMG contribute to different DNA-dependent activities that are essential for proper functioning of ARID-HMG *invivo*.

Grants-In-Aid Schemes:

Title of the Scheme	Schemes funded by
Investigating the role of ARID/HMG4 (At1g04880) protein in transcription regulation of cold stress responsive gene.	CSIR
Investigating the genome wide changes in histone H3K27 acetylation and gene expression in rice during cold stress. SERB/SB/SO/PS/80/3013	DST

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Participated in the International symposium on "Plant Abiotic Stress Tolerence III" organized by Vienna International Science Conference & Events Association (VISCEA) at Vienna, Austria.

Dr. Sampa Das

Senior Professor & Coordinator

Scientific Reports

Identification and Expression of insect/pathogen resistant gene(s)/ protein(s) with special emphasis on understanding plant's defense response to biotic stress.

During the last two decades, the search for potential biological pesticides has focused on plant lectins. Interestingly, monocot mannose binding lectins (MMBL) isolated from various plant sources have been recognized as potential and broad range biological insecticides which affect both the hemipteran and lepidopteran pests. One such lectin, CEA was isolated from tubers of *Colocasia esculanta* belongs to MMBL super-family with significant insecticidal activity against range of sap sucking insects. Our current studies with CEA demonstrated the basis behind such entomotoxicity. Initially confocal microscopy analyses revealed the binding of CEA to the midgut of sap sucking read cotton bug (RCB), a damaging pest of cotton which is considered as the key event behind induction of entomotoxicity.

Moreover, localization of CEA in the midgut, haemolymph and ovary of CEA supplemented diet fed RCB indicated the internalization of the lectin through midgut epithelial cells that subsequently alters the integrity of perimicrovillar membrane (PMM) of the insect. Interestingly, absence of *CEA in the haemolymph of RCB fed with heat denatured CEA points to the importance of functional integrity for internalization. Furthermore immune ligand binding analyses detected* ATPase and Cyt P450 like essential proteins as interacting partners of CEA in the midgut of RCB that indicates to a novel mechanism for exerting entomotoxicity of plant lectins (Roy and Das 2015).

Through a parallel project a lectin like protein, mASAL, newly designed in our laboratory was characterised with significant antifungal features against *Rhizoctonia solani*, the serious pest of rice (Ghosh *et al* 2015). Also the transgenic mASAL expressing rice plants demonstrated significant resistance against the pathogen (Ghosh et al 2016).

Fusarium oxysporum f. sp *ciceris* (Foc 1) as a damaging pathogen has been reported as one of the major biotic factors which affects annual yield of the important crop, chickpea to the extent of 10-90%. No gene has yet been reported to impart resistance to eight reported pathogenic Foc races which is major constraint for resistance breeding approach in chickpea. Comparative functional genomic approaches between *Fusarium* resistant/susceptible genotypes disclosed differential

expression of several redox responsive transcripts, cellular transporters, transcription factors, wound inducible transcripts, secondary metabolism related genes as well as several components linked to primary metabolism of host. This stimulated the present investigator to apply the MS-MS based proteomic and high through put next generation sequencing technologies to Foc-1 infected resistant/susceptible chickpea genotypes to decipher protein information and gene sequences involved in resistance response against Foc-1. Metabolic sub networking of the selected key molecules with associated partners may help to enrich the understanding and build up strategies to develop resistance against *Fusarium* and thus contribute to the improvement of crop yield.

Publications

1. Chakraborty J, Sen S, Ghosh P, Sengupta A, Basu D and Das S (2016) Homologous promoter derived constitutive and chloroplast targeted expression of synthetic Cry1Ac in transgenicchickpea confers resistance against Helicoverpa armigera. *Plant Cell, Tissue and organ Culture,* 125,521-535.
2. Ghosh P, Roy A, Hess D, Ghosh A and Das S (2015) eciphering the mode of action of a mutant Allilum sativum leaf agglutinin (mASAL), a potent antifungal protein on Rhizoctonia solani. *BMC Microbiology*,15, 237.
3. Ghosh P, Sen S, Chakraborty J and Das S (2016) Monitoring the efficacy of mutated Allium sativum leaf lectin in transgenic rice against *Rhizoctonial solani*, *BMC Biotechnology*,16, 24.
4. Jain A and Das S (2016) In-sight to the interaction between plants and associated fluorescent *Pseudomonas* spp. *International Journal of Agronomy;* Article ID 4269010, 8 pages.
5. Roy A and Das S (2015) Molecular Mechanism Underlying the Entomotoxic Effect of *Colocasia esculenta* Tuber Agglutinin against *Dysdercus cingulatus*. *Insects,* 6 (4), 827-846.

Students Awarded Ph.D.

Name of Student (University/Year	Title of Thesis
Prithwi Ghosh (C.U., 2016)	Monitoring the Efficacy of *Allium sativum* Leaf Lectin in Rice against *Rhizoctonia solani*

Grants-In-Aid Schemes:

Title of the Scheme	Schemes funded by
With Prof. D. Basu (Co PI) Development of pod borer resistant Transgenic pigeonpea & chickpea	ICAR, National Fund

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Group Members:

Ayan Das (i) presented Poster on 'Interaction of Allium sativum leaf agglutinin (ASAL) with GroEL related receptor interferes with whitefly mediated tomato leaf curl New Delhi virus (ToLCNDV) transmission' at 3rd International Plant Physiology Congress on Challenges and Strategies in Plant Biology Research, Organized by Indian Society for Plant Physiology, Jawaharlal Nehru University (JNU), National Institute of Plant Genome Research (NIPGR), New Delhi during 11th- 14th December, 2015 at Jawaharlal Nehru University (JNU), New Delhi.

Moniya Chatterjee (i) attended workshop on Targetted proteomics HR LC-MS/MS and presented poster entitled 'Analysis of root proteome unravels differential molecular responses during compatible and incompatible interaction between chickpea (Cicer arietinum L.) and Fusarium oxysporum f. sp. ciceri Race1 (Foc1)' in the following International Symposium at IIT Bombay during 10th-14th December 2015.

Joydeep Chakraborty (i) presented papers entitled "Foc-1 induced systemic reprogramming in chickpea mediated via MAPK4 dependent activation of CaL.WRKY40, transcriptionally repressed by CaL.WRKY70".

Senjuti Sen (i) presented paper entitled "Chickpea WRKY70 regulates the expression of a novel Homeodomain-Leucine Zipper (HD-ZIP) I transcription factor *CaHDZ12*, involved in abiotic stress tolerance by modulating ABA signalling and reactive oxygen species (ROS) production" in the 37th Annual Meeting of PTCA (India) & National Symposium on 'Plant Biotechnology for Crop Improvement' Organized by Plant Tissue Culture Association symposium at NBRI (Lucknow) during 25th-27th February, 2016.

Symposia and Seminar Organized

One day Symposium was organised on 17th December, 2015 on a theme "Insight to Plant Biology through Systems Approach".

Dr. Akansha Jain

SERB, DST, Young Scientist
(Mentor: Dr. Sampa Das)

Scientific Reports

Proteomic approach to study the resistance response induced in rice treated with beneficial microbe upon challenge with *Xanthomonas orizae*.

Plant growth promoting Rhizobacteria (PGPRs) the diverse group of soil microorganisms that are huge contributors to enhancement of plant health and systemic plant immune response. To that

end a large collections of soil microbes from three geographical locations obtained and antagonistic microbes purified from the collections were performed. Their antagonising activity against *Xanthomonas orizae*, the important bacterial pathogen of rice and *Rhizoctonia solani* were accomplished (Jain and Das, 2016) .

Publication

Jain A and Das S (2016) In-sight to the interaction between plants and associated fluorescent *Pseudomonas* spp. *International Journal of Agronomy*; Article ID 4269010, 1-8.

Dr. Subha Das

SERB-DST Young Scientist
(Mentor: Dr. Sampa Das)

Scientific Reports

Molecular characterisation of double-stranded RNA mycoviruses potentially affecting virulence of Rhizoctonia solani (AG-1-IA) causing sheath blight disease of rice in India

Rice (*Oryza sativa* L.) is an important food crop, often been infected by several microorganisms including bacteria, viruses and fungi during cultivation. One of the major threats to rice cultivation in India is sheath blight, a disease caused by the fungus *Rhizoctonia solani* (AG1-1A). Management of sheath blight relies heavily upon the use of fungicides, the application of which is associated with increased production cost, utilisation of fossil fuel energy, potential environmental pollution, as well as various non-target effects. Due to these concerns, alternative strategies are required for environmentally-friendly, sustainable control of the disease in India and worldwide.

Mycoviruses (viruses that infect fungi) or viral double stranded RNA (dsRNA) elements have been associated with cytoplasmically transmissible hypovirulence (less disease-producing capacity than normal) in a number of plant pathogenic fungi. At present, we have limited knowledge about the types of mycoviruses being harbored by *R. solani* AG1-1A, as well as their influence on this fungus. Therefore, in this project, my principal objective is to identify and characterise mycoviruses in *R. solani* AG1-1A associated with sheath blight disease of rice in India. Identification and molecular characterisation of virulence-influencing mycoviruses in this fungus would potentially lead us to future development of novel biocontrol strategies to manage sheath blight of rice in India and worldwide.

So far, more than 50 *R. solani* AG1-1A isolates were collected from rice plants showing typical symptoms of sheath blight, obtained from 11 different states in India. Genetic variations among these isolates were examined by sequence analysis of their nuclear ribosomal DNA internal transcribed spacer (rDNA-ITS) regions. To further study the population structure of this fungus on rice, somatic compatibility between selected isolates was also examined. Another 50 isolates will

be collected and characterised by end of this year to get a comprehensive picture of population dynamics for this pathogen in India. These isolates will soon be tested on rice to determine their comparative pathogenicity. Selected isolates will also be screened for their fungicide sensitivity and host-range. Total dsRNAs from less pathogenic strains will be isolated, profiled and sequenced to unveil their identity, as well as their influence on host virulence.

Publication

1. Das S, Falloon R E, Stewart A, Pitman A R (2016) Novel mitoviruses in *Rhizoctonia solani* AG-3PT infecting potato. *Fungal Biology*. 120, 338-350.

Dr. Gaurab Gangopadhyay

Associate Professor

Scientific Reports

Allele specific CAPS marker development and characterization of chalcone synthase gene in Indian Mulberry

Chalcone synthase (CHS) is an essential enzyme in the phenylpropanoid pathway that catalyzes the first step in flavonoid biosynthesis in plants under diverse environmental stress. We have used CHS as a candidate gene in mulberry and developed Single Nucleotide Polymorphism (SNP) based co-dominant Cleaved Amplified Polymorphic Sequence (CAPS) marker associated with the CHS locus. The segregation pattern of the marker is studied in an F_1 population derived from a hybridization programme between two mulberry genotypes showing polymorphism for the CHS locus. Differential CHS activity of the recombinants has been correlated with the segregation pattern of the marker, as molecular markers are essential for mulberry breeding and selection. Bioinformatics analysis like homology modelling and docking studies are performed for both the identified CHS alleles and correlated with respective CHS activity.

Development of allele specific candidate gene based molecular markers for qualitative improvement of sesame oil

Lignans of sesame oil are particularly important for their antioxidant activity against reactive oxygen species. These are important plant secondary metabolites and two major groups exist in sesame, namely oil soluble lignans (sesamin, sesamolin and pinoresinol) and glycosylated water soluble lignans (sesaminol triglucoside and pinoresinol tri glucoside). Besides, sesamol, a free 3, 4 methylene di phenoxy phenol is present in traces. Cultivated sesames (*Sesamum indicum* L.) though are endowed with these oil attributes, but certain wild sesame (such as *S. mulayanum* Nair) has even better oil profile in term of higher unsaturated fatty acids content. We have developed an advanced generation breeding population from an inter-specific hybridization programme between *S. indicum* and *S. mulayanum*. We are in the process of identification of the key regulatory genes in the sesame lignan biosynthetic pathway. This will follow establishment of the credential of these

genes as candidates for allele-specific marker development. The marker will be validated in the aforesaid breeding population.

Understanding the role of WUSCHEL transcription factor behind *in vitro* organogenesis

Organ identity genes play a fundamental role during organogenesis. Molecular analysis of *de novo* organogenesis shows that inductive expression of organ identity genes is essential for organ regeneration under culture conditions. The WUS (WUSCHEL) gene encodes a homeodomain protein, and its protein activity results in signaling to the overlaying stem cells. We are studying the role of growth regulators behind *in vitro* shoot organogenesis vis-à-vis the relative expression of WUS gene in tobacco and *Beta*. Real time (qRT-PCR) analysis of WUS gene expression from leaves of both the materials revealed that the expression initiated within day 1, reached its maxima on 2nd day, maintained an almost steady state up to 3rd day followed by its gradual decline. The results indicate that early WUS gene expression can be considered as a definite marker for *in vitro* shoot organogenesis in tobacco and *Beta*.

Publications

1. Gangopadhyay G (2015) Micro-propagation – Tool for rural entrepreneurship development. In: *Proceedings of "International capacity development program on Training of Trainers (TOT) in utilizing Biotechnology for sustainable agriculture for rural youth" – a UNESCO Vocational Training Program* (UNEVOC), 79.
2. Gangopadhyay G and Mukherjee KK (2015) Chapter 23: Pineapple. In: *Agrobacterium* protocols, Springer protocols, Methods in Molecular Biology 1224, Volume 2, 3rd Ed. (ISSN 1064-3745, ISBN 978-1-4939-1657-3) Ed. Wang, K., Humana Press, Springer, New York, Heidelberg, Dordrecht, London. Pp. 293-305.

GenBank Submissions

1. Sultana M and Gangopadhyay G (2015) *Beta palonga* isolate EMBOSS_001 transcription factor WUSCHEL (wus) mRNA, partial cds. GenBank Accession KT284906.
2. Sultana M and Gangopadhyay G (2015) *Beta palonga* isolate EMBOSS_001 glyceraldehyde-3-phosphate dehydrogenase (GAPDH) mRNA, partial cds. GenBank Accession KT284907.
3. Sultana M and Gangopadhyay G (2015) *Beta palonga* isolate EMBOSS_001 actin (act) mRNA, partial cds. GenBank Accession KT284908.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Candidate gene based molecular marker(s) for screening promising recombinants in mulberry	Central Silk Board Ministry of Textiles, Govt. of India

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(I) Acted as the Resource person of Plant Science in the North-Eastern States Students' Training on Basic Science 2015 (NESST-BASE 2015) at Mayapuri Campus of Bose Institute, Darjeeling during May 22 – 24, 2015. Compiled and prepared the booklet for the trainees (ii) acted as one of the resource persons in UNEVOC (UNESCO Vocational Training Centre) program during November 23 – December 04, 2015 on "International capacity development program on Training of Trainers (TOT) in utilizing Biotechnology for sustainable agriculture for rural youth", organized by NITTTR (National Institute of Technical Teachers' Training & Research, Kolkata) in collaboration with VIB (Vivekananda Institute of Biotechnology, Nimpith, WB). Delivered a lecture entitled "Micro-propagation – Tools for rural entrepreneurship development" in the academic session on December 04, 2015 at VIB, Nimpith, WB (iii) participated in One Day Symposium on "Insight to Plant Biology through Systems Approach" on December 17, 2015 organized by Division of Plant Biology, Bose Institute held at CB, Bose Institute (iv) delivered a project proposal lecture entitled "Candidate gene based molecular markers for screening promising recombinants in mulberry breeding" in the 42nd Meeting of Research Advisory Committee (RAC) of CSR&TI, Berhampore on July 9, 2015 (v) delivered an invited lecture on "Towards second green revolution.....Role of Biotechnology and Molecular Marker Assisted Breeding" at Department of Botany, Asutosh College in connection to Centenary Lecture Series on "Emerging Trends in Plant Sciences" to commemorate the Centenary year of Asutosh College on October 15, 2015.

Awards/Honours Received

(I) Acted as an expert for recruitment to the post of Assistant Teacher in Biology for the Secondary Section of Salt Lake School, CA-221, Kolkata-700064 on December 20, 2015 ii) acted as an external member of the assessment committee for evaluation of Ms Sonia Bedi, CSIR fellow, working at St. Xavier's College, Kolkata for up gradation from JRF to SRF on 21st March 2016.

Dr. Anupama Ghosh

Assistant Professor and DST-Inspire Faculty

Scientific Reports

Survival strategies of corn smut fungus *Ustilagomaydis* during host colonization

Ustilagomaydis is a biotrophic fungus that infects *Zea mays*. During host colonization the fungus is exposed to a number of plant defense responses like for instance elevated levels of reactive oxygen species (ROS) in the vicinity of the invasion site. Depending upon the compatibility of the pathogen and the host strain this ROS stimuli can either initiate a cell death response in the pathogen or could be overcome by the defense response of the pathogen itself. In this project we are engaged in dissecting these survival and death pathways of *Ustilagomaydis* during a compatible and

incompatible interaction with the host plant *Zea mays*. Our current focus is on the metacaspase gene of the pathogen. Metacaspases have been previously shown to be key executioners of caspase independent cell death in many different fungi and other lower eukaryotes. Through generation of metacaspase deletion mutants of *U. maydis,* we found that *U. maydis* metacaspase, UmMca is an exception to this rule. Our data showed that UmMca plays a significant role in aiding the cell to get rid of insoluble intracellular protein aggregates that accumulate during various stress conditions. Besides, we could also show a significant contribution of a group of three small heat shock proteins namely HSP12, 20 and 30 in the pathogenicity of the fungus.

Functional characterization of *U. maydis* effector proteins

In this project we are engaged in investigating the functions of different groups of secreted effector proteins of *Ustilagomaydis* in the context of their role in manipulating host defense responses. Currently we are focusing on the ribonucleases. Our data showed a differential expression pattern of all the six different genes studied over a period of 12 days post infection when compared to the axenic culture. The increased expression pattern of these nucleases during pathogenic invasion of the host tissue that is *Zea mays* indicates their probable role in the virulence of the pathogen. We have generated deletion mutants of *U. maydis* SG200 strains that are lacking some of these ribonuclease genes. Currently experiments are ongoing to access the virulence of these *U. maydis* strains in comparison to the wild type strains.

A proteomic approach to explore the host pathogen interface of rice and *Rhizoctoniasolani* interaction

This project is aimed to study the extracellular proteome of rice in relation to infection by *Rhizoctoniasolani*. Through this study we are planning to investigate both the secretome of *R. solani* during host invasion as well as plant defense proteins involved in plant defense against sheath blight.

Publications

1. Ghosh P, Roy A, Hess D, Ghosh A and Das S (2015) Deciphering the Mode of Action of a Modified Allium sativum Leaf Agglutinin (mASAL), a Potent antifungal Protein on *Rhizoctoniasolani*. *BMC Microbiology*, 15,237.
2. Ghosh A, Raha S (2015) Molecular and functional characterization of a stress responsive cysteine protease, EhCP6 from *Entamoebahistolytica*. *Protein Expression and Purification*; 109,55-61. doi: 10.1016/j.pep.2015.02.005.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Survival strategies of the corn smut fungus *Ustilagomaydis* during host colonization (starting date: 10.10.2013)	DST-INSPIRE Faculty Scheme

Participation in Conferences / Symposia / Workshop & Invited Talks Delivered at Various Organizations

Presented a poster entitled '*Ustilagomaydis* metacaspase UmMca aids in the clearance of stress induced intracellular protein aggregates' at the 56th Annual Conference of Association of Microbiologists of India (AMI-2015) & International Symposium on "Emerging Discoveries in Microbiology" at Convention Center, Jawaharlal Nehru University (JNU), New Delhi during December 7 – 10, 2015.

Dr. Swati Gupta Bhattacharya

Senior Professor

Scientific Reports

Studies on airborne allergenic pollen grains and spores: Biochemical, clinical and molecular approach

Pollen grains and fungal spores are the most common sources of inhalant allergens and are responsible for inducing respiratory allergic disorders. Seasonal variations of aerospora and aero-pollen load were recorded at different locations of Kolkata, Habra and Barrackpore by continuous air sampling. Statistical correlation between hospitalization data and aerospora/aero-pollen load revealed different fungal spores such as, *Aspergilus* spp., *Penicilium, Rhizopus, Curvularia* and pollen grains, viz, *Helianthus, Moringa, Cocos, Phoenix, Carica, Lantana* etc. as the most potent aero-allergens. Detailed immuno-proteomic studies on them unveiled glucan 1, 3-beta- glucosidase A from *Aspergillus oryzae*, subtilisin-like serine protease from *Aspergillus ochraceus, Brn-1 from Curvularia pallescens, aspertyl protease and cyclophilin from Rhizopus oryzae, pectate lyase from Helianthus annuus, and vicilin like protein from Cocos nucifera as the major allergens. Pectate lyase from Helianthus annuus was further purified using anion exchange and gel filtration chromatography. 63% of sunflower pollen allergic patients were found to be sensitized to the purified allergen.*

Major allergen from coconut showing similarity with vicilin like protein has been cloned and named as Coc n 1 according WHO/IUIS allergen nomenclature. The allergen has been over expressed in *E. coli* which demonstrated comparable IgE reactivity to its native counterpart. 5 predicted linear IgE binding epitope containing peptides has been characterised on this allergen and synthesised using Fmoc strategy. Biophysical characterisation and homology modelling has been done on this allergen. Evolutionary relationships with other vicilin allergens have also been studied.

We reported a 44 kDa aspartic protease allergen designated as Rhi o 1 from pathogenic mold *Rhizopus oryzae*. The full length gene encoding the allergen was purified in natural as well as in recombinant form and immunological studies have been performed. We have mapped the major antigenic regions of the allergen and subsequently developed a genetically modified hypoallergenic immunogen, which displayed protective antibody response against the parental allergen.

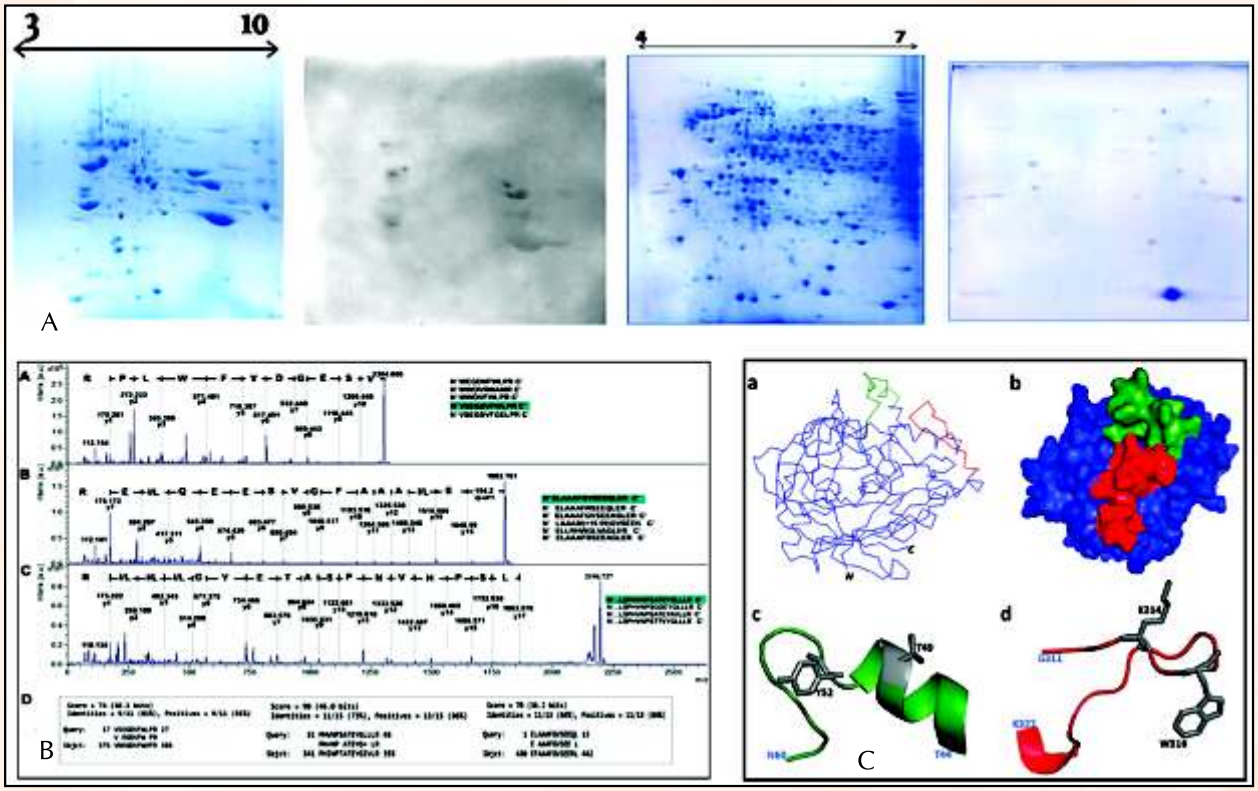


Fig 1: Immuno-biochemical and proteomic characterization of some selected pollen grains and fungal spores. A. Two dimensional gel and subsequent immunoblot of *Helianthus annuus* and *Curvularia palescence*. **B.** Snapshot of *de novo* sequencing of vicilin like protein from *Cocos nucifera*. **C.** Mapping of IgE-epitope on 3D model of Rhi o 1

Publications

1. Dey D, Saha B, Sircar G, Ghosal K and Gupta Bhattacharya S (2016) Mass-spectrometry based identification of allergens from Curvularia pallescens, a prevalent aerospore in India. *BBA-Proteins and Proteomics*. 1864 (7):869-79. doi: 10.1016/j.bbapap.2016.03.012; Impact factor- 2.747

2. Ghosh N, Sircar G, Saha B, Pandey N and Bhattacharya S G (2016) Data on mass spectrometry based identification of allergens from sunflower (Helianthus annuus L.) pollen proteome. *Data in Brief*. 12 (7):735-9. doi:10.1016/j.dib.2016.03.023. Impact factor- 0.11

3. Ghosh N, Sircar G, Saha B, Pandey N, and Bhattacharya S G (2015) Search for Allergens from the Pollen Proteome of Sunflower (Helianthus annuus L.): A Major Sensitizer for Respiratory Allergy Patients. *PloS one*, *10*(9), e0138992. Impact factor- 3.234

4. Saha B, Sircar G, Pandey N and Gupta Bhattacharya S (2015) Mining Novel Allergens from Coconut Pollen Employing Manual De Novo Sequencing and Homology-Driven Proteomics. *Journal of proteome research*, *14*(11), 4823-4833. Impact factor- 4.245

5. Sircar G, Jana K, Dasgupta A, Saha S and Gupta Bhattacharya S (2016) Epitope mapping of Rhi o 1 and generation of a hypoallergenic variant: a candidate molecule for fungal allergy vaccines. *J. Biol Chem*. 291 (34):18016-29**.** Impact factor- 4.573
6. Sircar G, Saha B, Mandal R S, Pandey N, Saha S and Bhattacharya S G (2015) Purification, Cloning and Immuno-Biochemical Characterization of a Fungal Aspartic Protease Allergen Rhi o 1 from the Airborne Mold Rhizopus oryzae. *PloS one*, *10*(12). e0144547; Impact factor - 3.234
7. Sircar G, Saha B, Jana T, Dasgupta A, Gupta Bhattacharya S and Saha S (2015) DAAB: a manually curated database of allergy and asthma biomarkers).*Clinical & Experimental Allergy*. 45, 1259–1261. Impact factor- 5.0

Gene bank submission

1. Sircar G and Gupta Bhattacharya S (2015) *Rhizopus oryzae* cyclophilin A mRNA, complete cds. GenBank Accession KT734861.1.
2. Saha B and Bhattacharya S G (2015) *Cocos nucifera* vicilin-like protein mRNA, complete cds. GenBank Accession KT880469.

Grants-In-Aid Schemes:

Title of the Scheme	Schemes funded by
Diagnosis of mold allergy among inhabitants of urban and rural peoples of Gangetic Plane of West Bengal through aerobilogical and immunobiochemical	CSIR
Studies on mould spore diversity as environmental allergen in outdoor and indoor environments of urban and rural areas of Agartala, Tripura.	DBT
Systematic discovery of biomarkers of asthma caused by common environmental allergens using human plasma proteomics, cytokine profiling and network biology – a systems approach to drug discovery.	ICMR

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(I) Attended 103rd Indian Science Congress (3rd – 7th January, 2016) at Mysore University, Mysore, Karnataka, India to deliver invited lecture in Environmental Science section. (ii) Attended 18th National Conference of Indian Aerobiological Society (28 to 30 September, 2015) at Tumkur University, Karnataka, India to deliver Prof. Sunirmal Chanda Endowment Lecture**.**

Group members:

a. Gaurab Sircar received a Research Exchange Fellowship from European Academy of Allergy and Clinical Immunology (EAACI) and worked as a research fellow at the Institute of

Pathophysiology and Allergy Research, Medical University of Vienna, Vienna, Austria from June 2015 to December 2015.

b. Gaurab Sircar (i) received a travel grant from Austrian Society of Allergy and Immunology (ÖGAI) to give an oral presentation at European Congress of Immunology (ECI)-2015 held at Vienna, Austria, from 6th to 9th September 2015. (ii) Attended 103rd Indian Science Congress (3rd – 7th January, 2016) at Mysore University, Mysore, Karnataka, India for paper presentation and won ISCA Young Scientist Award-2016.

c. Debarati Dey (i) attended European Academy of Allergy and Clinical Immunology (EAACI) Immunology Winter School (4 – 7 February 2016) at Pocol, Cortina d'Ampezzo, Italy to give Poster presentation. (ii) Attended 103rd Indian Science Congress (3rd – 7th January, 2016) at Mysore to give poster presentation. (iii) Attended 18th National Conference of Indian Aerobiological Society (28 to 30 September, 2015) at Tumkur University, Karnataka, India to give Oral presentation in P.H. Gregory award contest and Won 2nd Prize in P.H. Gregory Award Contest.

d. Nandini Ghosh (i) Attended European Academy of Allergy and Clinical Immunology (EAACI) Immunology Winter School (4 – 7 February 2016) at Pocol, Cortina d'Ampezzo, Italy to give Poster presentation and awarded with EAACI travel grant and DBT travel grant. **(ii) Attended** 18th National Conference of Indian Aerobiological Society (28 to 30 September, 2015) at Tumkur University, Karnataka, India to give Oral presentation in P.H. Gregory award contest and Won 1st Prize in P.H. Gregory Award Contest.

e. Koyel SenGupta (i) attended 103rd Indian Science Congress (3rd – 7th January, 2016) at Mysore to give oral presentation.

f. Koyel SenGupta, Bijoya Karmakar and Sangeeta attended 18th National Conference of Indian Aerobiological Society (28 to 30 September, 2015) at Tumkur University, Karnataka, India to give Oral presentation. Sangeeta Roy won best presentation award.

g. Moumita Bhowmik attended 18th National Conference of Indian Aerobiological Society (28 to 30 September, 2015) at Tumkur University, Karnataka, India to give poster presentation.

Dr. Pallob Kundu

Associate Professor

| Scientific Reports |

Genome-wide analysis of Alternaria stress-responsive microRNAs and their targets in tomato

MicroRNAs are crucial regulator of reprogramming of gene expression cascade during plant-pathogen interaction. We have used tomato (Pusa Ruby) plant and early blight pathogen, *Alternaria solani* for the analysis of miRNA and transcriptome expression profiles in a compatible interaction. Next generation

sequencing (NGS) technique based whole transcriptome analysis revealed that, (i) a total of 224 known miRNAs, ranging from 18nt to 24nt expressed in tomato, which belonged to 126 miRNA families, (ii) both conserved and Solanaceae specific miRNAs were differentially expressed, and (iii) 2944 genes expression was varied. Most of the miRNAs were down-regulated, and 13 miRNAs were highly differentially regulated (log2FC $\geq \pm 3$). Furthermore, using stringent selection criteria we could detect 74 putative novel miRNAs. GO terms enrichment and KEGG pathway analyses of predicted targets of differentially expressed miRNAs, as well as transcriptome, indicated that genes of plant-pathogen interaction and plant hormone signal transduction pathways were mostly affected by these miRNAs. We have also found that five different miRNAs target ~37% of tomato NB-LRR genes. These studies were further extended to investigate the mechanism of regulation of miRNA expression. Analysis of the promoter region of the miR167 gene, one of the highly expressed miRNAs, indicated that biotic stress related cis-elements have an important role in transcriptional regulation. Individual miRNA and target interaction are being analyzed to understand the importance of this interaction in the disease biology.

Studies on molecular signalling associated with disease symptom manifestation

During biotic stress response in a plant, a plethora of genes' expression level is altered, either for the benefit of a plant or the pathogen. Pathogen-derived various molecules directly or indirectly modulate expression of host genes. On the other hand, a plant's response towards pathogen-derived molecules will also trigger reprogramming of gene expression cascade. In a susceptible interaction, the resultant effect of these changes would be the development of disease symptoms; in case of tomato and leaf curl virus infection the manifestation is severe curling or puckering of leaves and abnormal vein development. These symptoms resemble leaf shape formation defects. This is probably due to the long-term altered regulation of expression of development related gene(s). Our results show that in the infected leaves the transcript level of TORNADO1 (*SlTRN1*), a gene important for cell expansion and vein formation, increased significantly. Subsequently we have shown that activation of salicylic acid pathway during leaf curl virus infection in tomato leads to the over expression of WRKY16 protein, which in turn regulates the expression of SlTRN1. In transgenic tomato plants harbouring promoter of SlTRN1-GUS constructs the reporter gene expression was limited to the vascular bundle and related tissues, further signifying the involvement of SlTRN1 in leaf vein development. Taken together, these studies have unravelled a new mechanism of regulation of a developmental gene during the biotic stress-response, which could have long term effect in host cell physiology and symptom development.

Genome wide analysis for identification and regulation of expression of membrane bound NAC transcription factors in tomato

Plants' plasma membrane is a facilitator of information exchange between cell and its surrounding. Environmental stresses are perceived and transmitted by cellular membranes, specifically by membrane bound proteins. As NAC transcription factors are known regulators of stress related gene expression, identifying membrane bound NAC transcription factors in tomato (SlNACMTFs), and their characterization can bring out valuable insight about membrane-mediated stress signalling. We have identified 13 SlNACMTFs in tomato. These SlNACMTFs possess NAC domain at their N terminal and transmembrane domain, mostly at their C terminal region as predicted by several softwares. The

SlNACMTFs could also be grouped with Arabidopsis and rice NACMTFs in 6 distinct phylogenetic groups indicating that they are evolutionary conserved. These transcription factors are transcribed in different tissues and found to be actively translated in leaf. Expression level of these MTFs has been studied under several stress conditions and showed that most of them are differentially regulated in biotic as well as abiotic stresses. Among these, SlNACMTF3 and 8 were highly differentially expressed during different biotic stresses, in addition, salt stress positively influenced SlNACMTF8 expression. In accordance, *in silico* analysis indicated that these SlNACMTFs contain several stress-related cis-acting elements including NAC binding sites (NACbs) in their predicted promoter, supporting the possibility of transcriptional regulation during stress. Both SlNACMTF3 and 8 are translocated to the plasmamembrane and the C-terminus truncated forms are localized in the nucleus. Moreover, both the proteins could interact with a consensus NAC binding site and regulated the activity of CaMV35S promoter, as well as several stress related host genes, suggesting their direct role in plant stress response.

Publication

1. Mandal A, Sarkar D, Kundu S and Kundu P (2015) Mechanism of regulation of tomato TRN1 gene expression in late infection with tomato leaf curl New Delhi virus (ToLCNDV), *Plant Scienc*; 241:221-37 (Impact factor: 3.981).

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Exploring membrane-associated NAC-transcription factors (NAC MTFs) in tomato to apprehend membrane-mediated signaling during pathogenesis	CSIR

Participation in Conferences / Symposia / Workshops&Invited Talks Delivered at Various Organizations

Jointly with group members:

Participated and presented the following poster in 3rd International Plant Physiology Congress, JNU, New Delhi India, December 11-14, 2015.

Integrated analysis of miRNA and mRNA omics data from diseased tomato plants: possible application in stress management by Deepti Sarkar, Jayanti Jodder, Sayani Dey, Ranjan Kumar Maji, Rohit Das, Arunava Mandal, Payel Bhattacharjee, Arijita Sarkar, Zhumur Ghosh, Pallob Kundu.

Socially Relevant

Ultimate aim of all these studies is to develop plants having superior disease resistance and more adapted to the changing climatic conditions. This would help in the betterment of the society and healthy living of human beings.

Dr. A.N. Lahiri Majumder

Raja Ramanna Fellow, DAE

Scientific Reports

Abiotic stress regulated inositol and phosphoinositide metabolism in rice

In a collaborative India-Netherlands project, four Phosphoinositide-specific phospholipase C (PLC) genes have been cloned from rice , and their expression under stress studied . Attempts are now made to introgress these genes individually in IR64 rice for expected drought and heat-tolerance.

Three homozygous lines of salt-tolerant transgenic IR64 rice lines have been generated with introgression of *PcINO1*, *PcIMT1* from *Porteresia coarctata* individually and a combination of the two genes. The plants with single copy transgene have been checked for their performance under salt stress as compared to their non-transformed control plants. Similar transgenic lines were obtained through introgression of a chloroplast Fructose-1,6-bisphosphatase (*PcCFR*) gene. The transgenic plants (T3) have been characterized by molecular analysis and physiological experiments.

Comparative analysis of rice and *Porteresia INO1* gene promoter(s) has been done and identification of minimal promoter element made by deletion & expression analysis.

Publication

1. Sengupta S, Mukherjee S, Basak P and Majumder A L (2015) Significance of galactinol and raffinose family oligosaccharide synthesis in plants, *Frontier in Plant Science*, 6 , 656 ; doi: 10.3389/fpls.2015.00656.[IF:3.6]

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
With Prof D.N.Sengupta and Dr Subho Chaudhuri (Co PI)	
Generation of salt-tolerant rice plants: A translational approach (05.10. 2011 – 04.10. 2015)	*DBT, GOI*
Inositol metabolism in relation to abiotic stress in plants: Molecular & transgenic approach (April, 2011- February, 2016)	*Department of Atomic Energy,* *Raja Ramanna Fellowship project*
With Dr Subho Chaudhuri (Co PI)	
Unraveling the role of PLC in plant drought and heat stress tolerance ; Exploring the potential of PI metabolism to improve crop yield (Started in October, 2015)	DBT-NWO (Indo-Dutch collaborative project)

Title of the Scheme	Schemes funded by
Jointly with Dr Rajeswari Mukherjee (PI)	
An approach towards gene mining and bioprospecting of Mangrove genepool : special reference to *Porteresia* and/or *Salicornia* (DBT Bio-CARe project) . (since December 2014)	*DBT Bio-CARe programme*

Dr. Amita Pal

CSIR-Emerius Scientist

Scientific Reports

Molecular phylogeny of 21 tropical bamboo species reconstructed by integrating non-coding internal transcribed spacer (ITS1 and 2) sequences and their consensus secondary structure

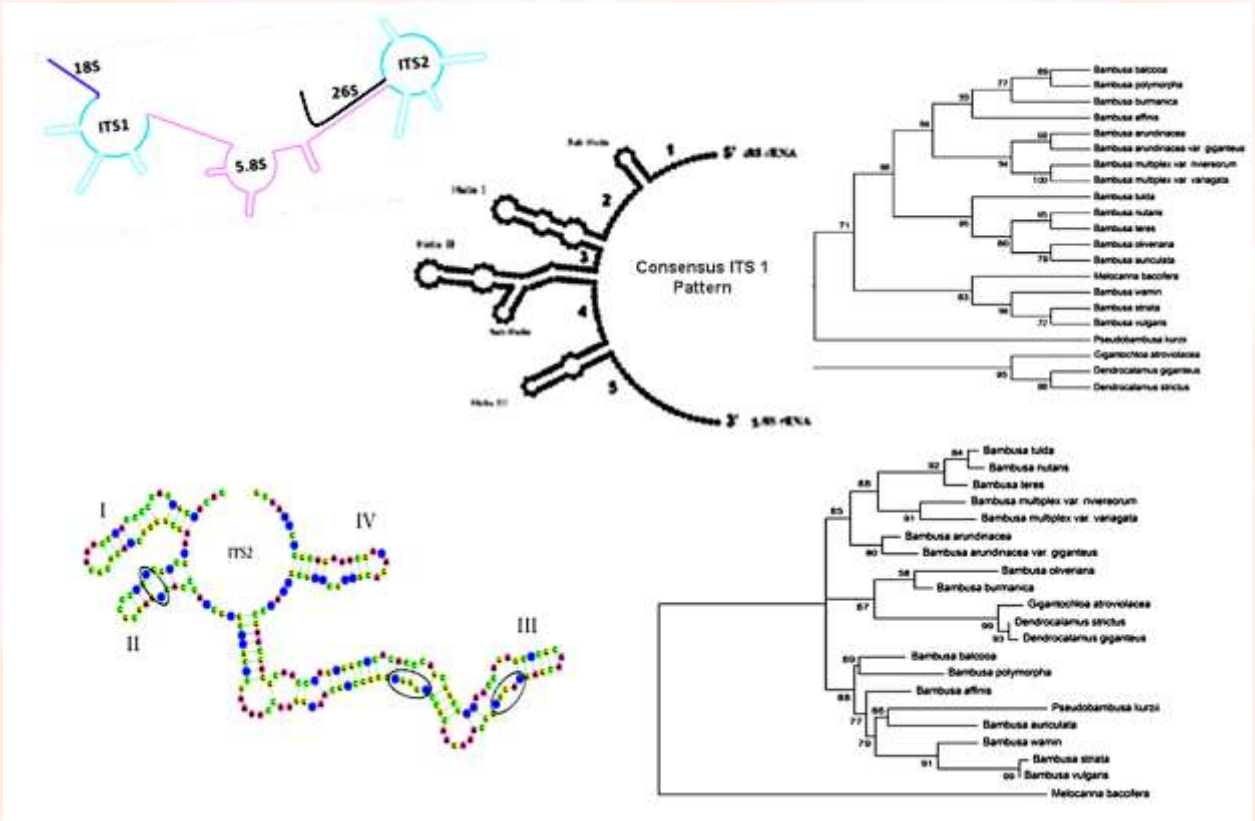
The unavailability of the reproductive structure and unpredictability of vegetative characters for the identification and phylogenetic study of bamboo prompted the application of molecular techniques for greater resolution and consensus. We first employed Internal Transcribed Spacer (ITS1, 5.8S rRNA and ITS2) sequences to construct the phylogenetic tree of 21 tropical bamboo species. While the sequence alone could grossly reconstruct the traditional phylogeny amongst the 21 tropical species studied, some anomalies were encountered that prompted a further refinement of the phylogenetic analyses. Therefore, we integrated the secondary structure of the ITS sequences (vide Figure) to derive individual sequence-structure matrix to gain more resolution on the phylogenetic reconstruction. The results showed that ITS sequence-structure is the reliable alternative to the conventional phenotypic method for the identification of bamboo species. The best-fit topology obtained by the sequence-structure based phylogeny over the sole sequence based one underscores closer clustering of all the studied *Bambusa* species(Sub-tribe Bambusinae), while *Melocanna baccifera,* which belongs to Sub-Tribe Melocanneae, disjointedly clustered as an out-group within the consensus phylogenetic tree. In this study, we demonstrated the dependability of the combined (ITS sequence + structure-based) approach over the only sequence-based analysis for phylogenetic relationship assessment of bamboo.

Isolation and functional characterization of a stress responsive *Vigna mungo* MAP Kinase:

in collaboration Dr. Shubho Chaudhuri

Earlier attempts were made to decipher the mechanism of MYMIV-resistance employing techniques of transcriptomics and proteomics. During such study a plausible signaling mechanism was hypothesized that is central to the immune response against MYMIV. Among these ESTs, one MAP Kinase was identified (Acc. no. JZ168359) with induced expression in the resistant background and

Reconstruction of molecular phylogeny of 21 tropical bamboo species using consensus secondary structures build up from internal transcribed spacers 1 and 2 sequences



was considered as the key player in the early signaling pathway. MAPKs are serine threonine kinases that phosphorylates downstream transcriptional regulators like transcription factors and other kinases in spatio-temporal manner, thereby altering the gene expression pattern. In the present study coding sequence of MAP Kinase, designated as VmMAPK1 (Acc. no. KF318321) was isolated from *Vigna mungo*. Multiple sequence alignment showed typical protein kinases conserved domains. Induction of VmMAPK1 at transcript and protein level in response to MYMIV suggests its role in defense regulation. Purified VmMAPK1 is an active kinase capable of phosphorylation and follows Michaelis-Menten kinetics as evident from biochemical studies. Subcellular localization of GFP fusion protein of VmMAPK1 further indicates its function in both cytoplasm and nucleus. Participation of VmMAPK1 in MYMIV defense pathway is shown by over-expressing VmMAPK1 in the heterologous tobacco plant that restricts virus proliferation. All these evidences validated our earlier finding that had demonstrated upregulation of VmMAPK1 during incompatible interaction with MYMIV.

Publications

1. Ganguli S, Dey A, Banik R, Kundu A and Pal A (2016) Analyses of MYMIV-induced transcriptome in *Vigna mungo* as revealed by next generation sequencing. *Genomics Data* 7: 226–228 doi: 10.1016/j.gdata.2016.01.005.

2. Patel A, Maiti S, Kumar S, Ganguli S and Pal A (2016) An integrated approach to comprehend MYMIV-susceptibility of blackgram Cv.T9 possessing allele of CYR1, the cognate R-gene. *Amer J Plant Sciences* 7: 267-278 http://dx.doi.org/10.4236/ajps.2016.72026.

3. **Submission of transcriptome data in Sequence Read Archive (SRA), NCBI**

   i. Transcriptome Data of *Vigna mungo* Cv. T9 infected with MYMIV (Accession - SRX1058327)

   ii. Transcriptome Library of Mock innoculated *Vigna mungo* cultivar T9 (Accession- SRX1058325)

   iii. Transcriptome Library of mock inoculated *Vigna mungo* RIL VM84 (Accession- SRX1032950)

   iv. Transcriptome Library of *Vigna mungo* RIL VM84 infected with MYMIV (Accession- SRX1082731)

   v. Transcriptome Library from leaves of *Vigna mungo* cultivar T9 (Accession: SRX1558530)

Grants-In-Aid Schemes

Title of the Scheme		Schemes funded by
Identification and functional characterization of genes regulating unique flowering behavior in tree bamboo	(Co-PI)	CSIR
Understanding molecular mechanism of MYMIV-resistance in *Vigna mungo* through genomic approach		CSIR (Emeritus Scheme)

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(I) Delivered a key note address on "Agri-informatics: A challenge for crop improvement", in the Winter School in Bioinformatics; organized by M/s Amplicon Biosciences and The Biome, held in Salt Lake, Kolkata on December 29, 2015. (ii) Chaired the 5th Technical session on "Bioinformatics at the Forefront of Biotechnology Revolution" of the XXVII Annual Bioinformatics Coordinators Meeting held on March 3-5, 2016 at the Kumaun University, Bhimtal, Uttarakhand.

Dr. Dibyendu Narayan Sengupta

Honarary Scientist

| Scientific Reports |

Regulation of Gene Expression in indica Rice cultivars and Analysis of the IR64 rice transformed to overexpress SAMDC enzyme and OsBZ8, a transcription factor

In our DST-SERB financed project on DNA Polymerase λ (a 68kDa protein with N-terminal BRCT domain, a serine-threonine domain and a C-terminal DNA Polymerase β domain) we have amplified

the entire DNA Pol β domain by RT-PCR from indica rice cultivar. After DNA sequencing the partial cDNA was subcloned into pET28a vector, expressed in *E.coli* and the purified recombinant DNA Pol λ with entire domains for DNA Pol β showed polymerase activity sensitive to ddNTP. The expression of its gene in different parts of plants was studied by RT-PCR. Results showed that the gene for Pol λ is expressed after imbibition of the dry seeds and upto 4th day after germination. Low level of transcripts was detected in vegetative tissue like leaves and roots but increased in anthers before it just burst open and in the 1st week of grain filling stage in the flowers. Moreover the gene was found to be inducible by salinity stress, water stress and to some extent by heat. More or less similar kind of enhancement in the activity of DNA Pol λ was detected by *in vitro* activity gel assay and western blot analysis (68kDa). Northern Blot analysis showed the presence of unspliced transcripts in control plants and gradual appearance of the mature transcripts was detected during salinity stress. Effort to amplify and clone the extreme 5′ end (BRCT domain) of the cDNA is going on and subsequently, to over-express the full length cDNA by *E.coli* expression vector. This will help us to characterize its function and the role of BRCT domain in its expression by comparing activity with the partial protein.

The 5 years project on over-expression of SamDC2 and OsBZ8 separately in IR64 rice has ended in Oct'2015 and we have generated several lines of SamDC2 (T3 generation) and OsBZ8 (T1). They will be grown in Green House at MEF and Southern and Northern Blot analysis will be done. Quantification of the ABA from susceptible and tolerant rice cultivars was carried out from different growth stages viz. seedling, vegetative etc. Expression of the genes involved in the ABA biosynthesis like ZEP, NCED, AAO and gene for degradation of ABA like ABA-8-hydroxylase are being measured by RT-PCR upon salt treatment.

For the last 3 years we have started to work on regular 14-3-3 protein family from rice. It is known that there are eight genes in rice genome. During the last year we have studied by RT-PCR the expression of 14-3-3f and g genes which were found to differ during dehydration, salinity, and cold stress and exogenous ABA treatment and also during different stages in IR-29, IR-64, Nonabokra, N-22 and Sahabhagi cultivars (differ in tolerance to abiotic stress). Polyclonal antibody was generated against *E.coli* overexpressed 6X-His tagged 14-3-3f protein. By western blot, the expression of protein level was also checked in different cultivars using antibody made against 14-3-3f. The upstream of 14-3-3f and g genes were amplified, cloned and sequenced from all the rice cultivars in which many abiotic stress responsive, cis-acting elements were detected by bioinformatic studies.

Publication

1. Bakshi S, Sihi S and Sengupta D N (2015) Activity of DNA polymerase-λ **in** dry and germinating seeds of Zea mays L., *Ind J Plant Physiol*.20(4):396–399.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Functional Analysis of the DNA Pol lambda gene and the protein from indica rice cultivars	DST-SERB

Dr. Swati Sen Mandi

ICMR-Emeritus Medical Scientist associated with DPB

Scientific Reports

Murraya koenigii, a medicinally important plant collected from different altitudes in Eastern and North Eastern India viz. Nagaland (1500m), Arunachal Pradesh (744m) and Kolkata (9m) were used to study a) DNA fingerprinting by AFLP analysis using six primer pairs for molecular documentation and authentication of genotypes b) Active principle analysis by HPLC method c) Statistical correlative analysis involving DNA fingerprinting and chemical analysis data to establish Trait Related DNA marker.

AFLP based DNA Fingerprinting data identified the AFLP alleles which are present in all the landraces of *M. koenigii* studied regardless of the location of collection indicating species specificity – a finding that would be useful for molecular taxonomy (Figure 1 a,b,c). Such information would also be useful for authentication of prescribed plants towards production of medicine with uniform efficacy in each batch. Chemical analysis data showing variation in content established that the medicinal potential (viz. Mahanine content) is correlated with altitude difference (Figure 1d). The landraces collected from Nagaland (1500m) shows highest amount of Mahanine (Figure 1e). The landraces collected from Kolkata (9m) contain low amount of this active principle (Figure 1g) whereas landraces of Arunachal Pradesh (750m) have intermediate level of Mahanine (Figure 1f). Statistical correlative study has established that the 98 base pair allele generated by primer pairs EcoRI-AAG / MseI-CTG shows correlation with high mahanine (trait). Such Trait Related Marker for Mahanine would be useful for screening wild germplasms to select elite genotypes containing high amount of active principle. This information would be useful for pharmaceutical companies.

Publications

Ghosh S, Mandi SS (2015). SNP in Chalcone Synthase gene is associated with variation of 6-gingerol content in contrasting landraces of Zingiber officinale.Roscoe. 2015. *Gene 566*; 184- 188. (IF-2.319)

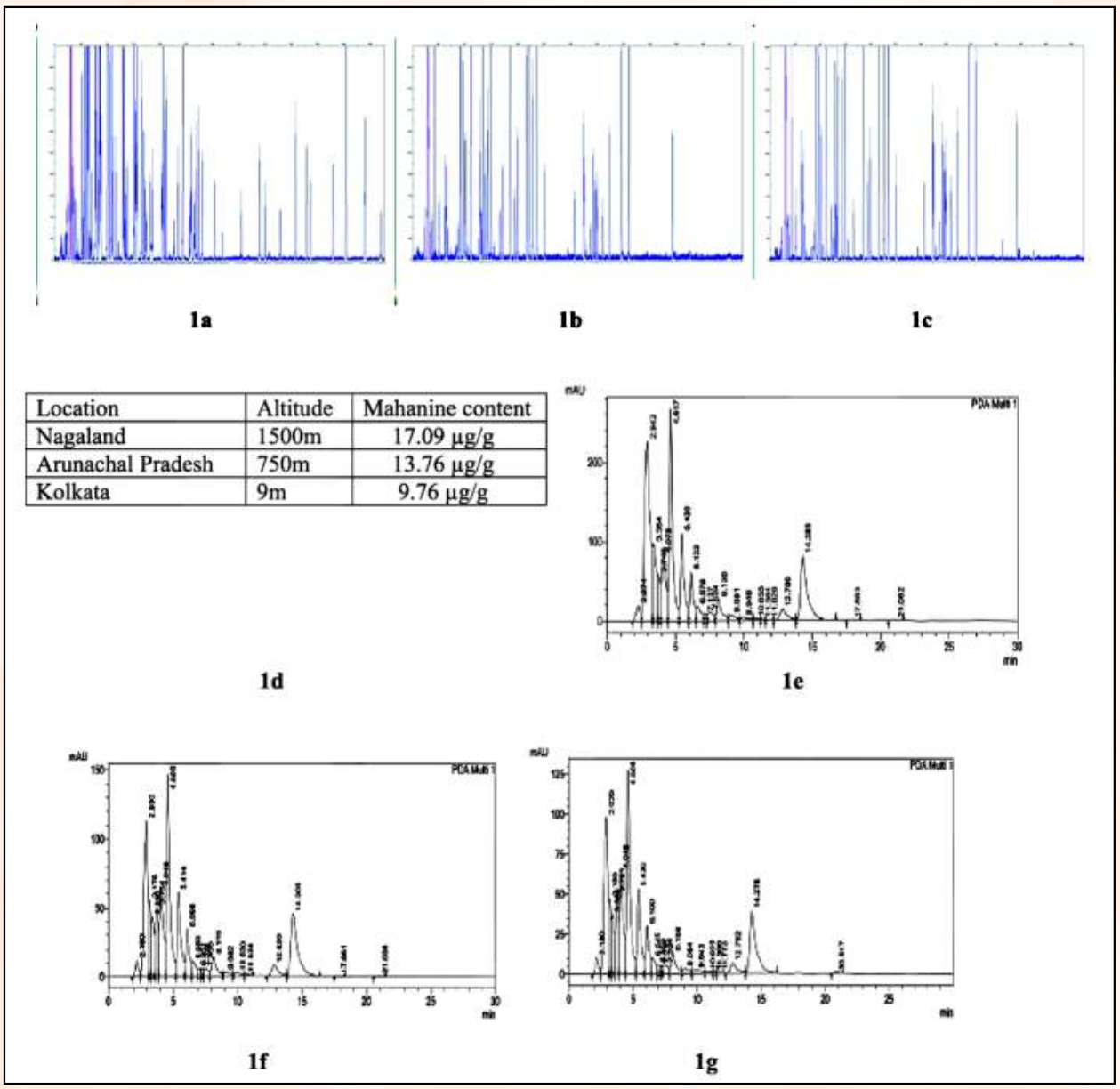
Pal H, Ghosh S, Sen Mandi S (2015). Molecular Authentication of Endangered Medicinal Plant Panax assamicus and Panax bipinnatifidus from North-East India by Species Specific AFLP Marker. The Journal for Threatened Taxa. *Photon 113,* 138-147. (IF – nil)

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Delivered invited Lead Lectures at Workshops in Dhaka, Bangladesh, on 29th February, 1st March and 2nd March 2016. This was organized by the Drug Administration Directorate of Bangladesh, Govt. of Bengladesh.

Symposia and Seminar Organized

Organized the Annual Workshop cum Hands –on –Training for young researchers on DNA fingerprinting and diagnostics of medicinal potential in plants during 9th June – 23rd June, 2015 at



Location	Altitude	Mahanine content
Nagaland	1500m	17.09 µg/g
Arunachal Pradesh	750m	13.76 µg/g
Kolkata	9m	9.76 µg/g

Figure 1 : 1a,1b,1c- Representative AFLP pattern of *Murraya koenigii* landraces collected from Nagaland (1a), Arunachal Pradesh (1b) and Kolkata (1c)

1d- Mahanine content of different genotypes of *Murrya koenigii* collected from different altitude

1e,1f,1g - Representative HPLC chromatogram showing highest Mahanine content (RT-6.1 min) in Marraya koenigii landraces collected from Nagaland (1e), intermediate content in landraces collected from Arunachal Pradesh (1f) and lowest content in landraces collected from Kolkata (1g).

Bose Institute (Main Campus). Participants included research scholars, Assistant Professors, Associate Professors from various Research Institutes / Universities from different states of India including the NE region. The workshop included technical lectures by subject experts and Hands-on-Training in the laboratory of Prof Swati Sen Mandi at Main Campus of this Institute.



Figure : Some Pictures of the Workshop and Hands-on-Training.

Socially Relevant

North East India with its vast repository of medicinal plants and associated traditional knowledge for use of these plants in folk medicine as well as in the Indian Traditional Systems of medicine combined with modern biotechnological research provide leads to developing Alternative System of Medicine to the modern world. Studies along these lines constitute a study area of social relevance worldwide.

In addition to conducting state-of-art research in authentication of plants through State-of-Art technology in DNA profiling for developing species specific DNA markers in plants and evaluation of medicinal potential through chemical analysis together with correlative study for development of Trait Related DNA markers followed by bioprospecting of medicinally important genes, providing scope for translational biology this programme routinely holds Workshops and Hands-on-Training for young researchers countrywide, with particular focus on North East India. Participants of these workshops carry with them technological expertise (and also come back to this laboratory from time to time for updates) for developing medicinal plant biodiversity assessment in their own locations.

Dr. Samir R. Sikdar

**Senior Professor & In-charge, Registrar's Office and Coordinator,
Rural Biotechnology Programme**

Scientific Reports

Exploring wild crucifer *Rorippa indica* for development of aphid tolerant *Brassica juncea* lines through genomic approach:

Full length sequencing and cloning of two highly upregulated genes, defensin (RiD) and HSPRO2 (RiHSPRO2) derived from ESTs through transcriptomic analysis using cDNA-AFLP in response to aphid infestation on mustard aphid (*Lipaphis erysimi*) tolerant wild crucifer *Rorippa indica* have been carried out. The promoter regions of the genes were also studied to understand the role of upstream elements. Both the coding sequences of RiD and RiHSPRO2 were also cloned into expression vector separately, and the respective proteins were isolated and purified. Artificial diet based insect bioassay of the purified proteins against *L. erysimi* gave significant LC_{50} values rendering both as significant insecticidal agents against *L. erysimi*. Biosafety assays have also been carried out to analyse RiD as a safe transgene. Next the susceptible *B. juncea* was transformed with full length coding sequence of RiD, using *Agrobacterium*-mediated plant transformation method. Molecular analyses have been done to confirm the presence and expression of RiD gene in the transgenics. Presently, putative transgenics of *B. juncea* are being developed using RiHSPRO2 coding sequence.

Molecular characterizations of *AbCi* and *PfAb* mushroom somatic hybrids

The rRNA-ITS gene of all *AbCi* (*Agaricus bisporus* + *Calocybe indica*) and *PfAb* (*Pleurotus florida* + *Agaricusbisporus*) hybrid strains (12 and 7 hybrids respectively) and parents were amplified and showed approx. 650 bp size band in the gel. The RFLP analysis of these genes digested with *Hinf*I, *Hae*III and *Eco*RI enzymes showed polymorphisms with a total of 29, 30 and 32 bands, respectively for *AbCi* hybrids and 16, 14, 11 bands, respectively for *PfAb* hybrids. The sequence analysis of rRNA –ITS region of all the hybrids are in progress.

Characterizations of *pfle* mushroom somatic hybrids through mitochondrial subunit genes

Mitochondrial genomes of edible mushrooms *P. florida* and *L. edodes,* and their nine somatic hybrids (*pfle*) were separated from respective nuclear genomes by density gradient ultracentrifugation and the size of the mitochondrial genome of these mushrooms were estimated to about ~ 48 kb. The nine *pfle* somatic hybrids were analysed by amplification and characterization of mitochondrial subunit genes and the sizes of the amplified products of large and small subunits were ~ 600 bpand ~ 300 bp, respectively. *BamH*I digestion produced a total of 28 bands of small subunit gene. DNA sequence data of small subunit gene of hybrids showed similarity with *Pleurotus ostreatus* mitochondrial genome (identity 94%) whereas large subunit gene showed similarity with *L. edodes* mitochondrial genome (99%).

Publications

1. Mallick P and Sikdar SR (2015) Genome instability in fruit body derived lines generated from fruiting *pfle* somatic hybrid lines and development of hybrid strain specific SCAR marker in edible mushroom. *Journal of Horticultural Research*, 23(2):111-120.

Genbank Accession

1. Sarkar P and Sikdar SR (2015) *Rorippa indica* defensin precursor gene: KP893333.
2. Sarkar P and Sikdar SR (2016) *Brassica juncea* var. *juncea* cultivar B-85 defensin mRNA, complete cds: KU513489.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Production and molecular characterization of somatic hybrid mushroom strains *between Agaricus bisporus + Pleurotus florida* and *Agaricus bisporus + Calocybe indica*.	DAE

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Delivered an invited talk on "***Scheduled Tribe-Specific Rural Biotechnology Programme: A Bose Institute initiative towards fulfillment of its social commitment in Indian National Mission" in the National Symposium on "Recent Advances in Biotechnology"*** held on 31.07.2015 in the Department of Biotechnology, Visva Bharati, Santiniketan, W.B.

Group Members

Miss. Poulami Sarkar presented posters on (i) ***Rorippa indica*** defensin: A novel peptide enhances aphid tolerance in *Brassica juncea, in the 37*thAnnual Meeting of Plant Tissue Culture Association (PTCA-India) & National Symposium on Plant Biotechnology for Crop Improvement held at NBRI, Lucknow February 25-27, 2016 (ii)Exploring a putative plant defensin from *Rorippa indica* and its integration into *Brassica juncea* for enhanced pest management, in the 3rd International Plant Physiology Congress: Challenges and Strategies in Plant Biology Research held at JNU, New Delhi, December 11-14, 2015.

Dr. Pijush Mallick, Mr. Sourav Bose, Miss. Poulami Sarkar and Mr. Sayantan Ghosh attended Symposium on "Insight to Plant Biology Through Systems Approach" organized by Division of Plant Biology, Bose Institute, Kolkata on 17th December, 2015.







131st Birthday Celebration of Prof. Debendra Mohan Bose

The 131st Birthday of Prof. Debendra Mohan Bose was celebrated on November 26, 2015, at the Main Campus Lecture Hall of the Institute. Prof. Partha P. Majumder, the founding Director of the National Institute of Biomedical Genomics, Kalyani, West Bengal, and Professor, Indian Statistical Institute, Kolkata, graced the occasion as Guest of Honour and delivered the **D. M. Bose Memorial Lecture** on the topic "**Enabling Precision Medicine for Cancer". Many distinguished scientists, student and other professionals from all over India were present.**

SCIENTIFIC REPORTS

II

Structural Studies and Biophysical Problems

Participation in Institutional Projects for the 12th Five-year Plan (2012-2017)

Dr. K. P. Das (Coordinator), Dr. Pinakpani Chakrabarti, Dr. Pradeep Parrack, Dr. R. Chattopadhyaya, Dr. Gautam Basu, Dr. Jayanta Mukhopadhyay, Dr. Anirban Bhunia, Dr. Ajit Bikram Dutta, Dr. Subhrangsu Chatterjee, Dr. Tanaya Chatterjee

Introduction:

Resolution of Protein structure is the key criterion to determine functional organization of a protein. Study on the structure-function relation coupled with expression analyses have been undertaken to design therapeutically and other economically important protein molecules.

Dr. Gautam Basu

Senior Professor

Scientific Reports

Structure Function of GluRS: *in collaboration with Ajit Bikram Dutta*

We had previously crystallized GluRS from *E. coli* but due to poorly diffracting crystals, the structure could not solved. Towards deciphering the structure of GluRS, we have attempted to crystallized *E. coli* GluRS in presence of $tRNA^{Glu}$, ATP and Glu. In addition, we have also cloned, expressed and purified GluRS from the thermophilic bacterium *Methylacidiphilum fumario*licum. Crystallization attempts are ongoing.

Sequence motifs containing *cis* Pro at helix N-termini

Helix N-capping motifs often form hydrogen bonds with terminal amide groups which otherwise would be free. Also, without an amide hydrogen, proline (*trans*) is over-represented at helix N-termini (N1 position) because this naturally removes the need to hydrogen bond one terminal amide. However, the preference of *cis*Pro, vis-à-vis helix N-termini, is not known. We show that *cis*Pro ($_R$ or PP_{II}) often appears at the N-cap position (N0) of helices. The N-cap *cis*Pro($_R$) is associated with a six-residue sequence motif — $X_{(-2)}$–$X_{(-1)}$–*cis*Pro–$X_{(1)}$–$X_{(2)}$–$X_{(3)}$ — with preference for Glu/Gln at $X_{(-1)}$, Phe/Tyr/Trp at $X_{(1)}$ and Ser/Thr at $X_{(3)}$. The motif, formed by the fusion of a helix and a type VIa -turn, contains a hydrogen bond between the side chain of $X_{(-1)}$ and the side chain/backbone of $X_{(3)}$, a -helical

hydrogen bond between $X_{(-2)}$ and $X_{(2)}$ and stacking interaction between *cis*Pro and an aromatic residue at $X_{(1)}$. NMR experiments on peptides containing the motif and its variants showed that local interactions associated with the motif, as found in folded proteins, were not enough to significantly tilt the *cis/trans* equilibrium towards *cis*Pro. This suggests that some other evolutionary pressure must select the *cis*Pro motif (over *trans*Pro) at helix N-termini. Database analysis showed that >C=O of the pre-*cis*Pro($_R$) residue at the helix N-cap, directed opposite to the N-to-C helical axis, participates in long-range interactions. We hypothesize that the *cis*Pro($_R$) motif is preferred at helix N-termini because it allows the helix to participate in long-range interactions that may be structurally and functionally important.

Publications

1. Jordan P C, Patterson D P, Saboda K N, Edwards E J, Mietten-Granger H, Basu G, Thielges M C, Douglas T (2016) Self-Assembling Biomolecular Catalysts for Hydrogen Production. *Nature Chemistry* 8:179-185.
2. Schwarz B, Madden P, Avera J, Gordon B, Larson K, Mietten H, Uchida M, LaFrance B, Basu G, Rynda-Apple A, Douglas T (2015) Symmetry Controlled, Genetic Presentation of Bio-Active Proteins on the P22 Virus-like Particle using Bacteriophage L Decoration Protein. *ACS Nano* 9:9134-9147.

Dr. Anirban Bhunia

Associate Professor

Scientific Reports

Design, Synthesis and High Resolution Structure Determination of Biomolecules Using Nuclear Magnetic Resonance (NMR) Spectroscopy

(a) Main aim of my lab is to design new antimicrobial peptides which can significantly bind to the outer membrane of the gram negative bacteria and can penetrate through the bacterial membrane. This special kind of peptides not only ruptures the cell membrane but also alters the DNA folding which leads to stoppage of bacterial replication. Both mechanisms of action are different and a solid platform to generate new antibiotic library for the next generation drugs.

(b) Unraveling the molecular mechanism of Amyloid fibril formation requires two important problems to be addressed namely, protein folding and protein aggregation. Though, in recent years, in-silico approaches are successful in predicting the folds of the small to medium sized proteins, the folding of intrinsically unstructured amyloid monomers into ordered Beta-sheet fibril is still a challenge. Accurate experimental constraints are quint-essential to channelize the available information to design molecules for treating Amylogenic diseases. The other side of the problem is to explain how this partially folded peptide aggregate and organize itself into an ordered long beta sheet fiber. The expertise of Dr. Bhunia in using several spectroscopic techniques in combination with computational modeling will be put to use to design small peptide molecules and its analogues, to inhibit the fibrillation process at its inception itself.

(c) In biology, protein aggregation is a fatal event. Various types of diseases including neuronal disorders happen due to misfolding and aggregation of many important proteins. We have designed some short peptides, structured with a β-hairpin loop significantly binding to the amylodogenic states of proteins and helps to prolong their high mass aggregated states. The research is under way and we hope to discover some interesting peptide analogs to stop protein aggregation.

Publications

1. Bera S, Ghosh A, Sharma S, Debnath T, Giri B, Bhunia A (2015) Probing the role of Proline in the Antimicrobial activity and lipopolysaccharide binding of Indolicidin. *J Colloid Interface Sci.*, 452, 148-159.
2. Datta A, Kundu P, Bhunia A (2016) Designing potent antimicrobial peptides by disulphide linked dimerization and N-terminal lipidation to increase antimicrobial activity and membrane perturbation: Structural insights into lipopolysaccharide binding. *J. Colloid Interface Sci.*, 461, 335-345.
3. Datta A, Ghosh A, Airoldi C, Sperandeo P, Mroue KH, Barbero JJ, Kundu P, Ramamoorthy A, Bhunia A (2015) Antimicrobial peptides: Insight into Membrane Permeabilization, Lipopolysaccharide Fragments and Application in Plant Disease Control. *Nature Sci. Rep.*, 5, 11951.
4. Ghosh A, Bera S, Shai Y, Mangoni, ML, Bhunia A (2016) NMR Structure and Binding of Esculentin-1a (1-21)NH_2 and Its Diastereomer To Lipopolysaccharide: Correlation With Biological Functions. *BBA - Biomembrane.* 1858, 800-812.
5. Ghosh A, Ratha BN, Gayen N, Mroue KH, Kar RK, Mandal AK, Bhunia A (2015) Biophysical Characterization of Essential Phosphorylati**on at the Flexible C-terminal Region of C-Raf with 14-3-3ζ Protein.** *PLOS One*, 10 (8), e0135976.
6. Ghosh A, Pithadi A, Bhat J, Bera S, Midya A, Fierke C, Ramamoorthy A, Bhunia A (2015) Self-assembly of a 9-residue amyloid-forming peptide fragment of SARS Corona Virus E-protein: Mechanism of self aggregation and amyloid inhibition of hIAPP. *Biochemistry*, 54, 2249 -2261.
7. Gupta S, Chit JC-Y, Feng C, Bhunia A, Tan S-M, Bhattacharjya S (2015) An Alternative phosphorylation switch in Integrin b2 (CD18) tail for DOK1 binding. *Nature Sci. Rep.*, 5, 11630.
8. Kar RK, Mroue KH, Kumar D, Tejo BA, Bhunia A (2016) Structure and Dynamics of Antifreeze Protein - Model Membrane Interactions: A Combined Spectroscopic and Molecular Dynamics Study. *J. Phys. Chem B.*,120, 902-914.
9. Kar RK, Bhunia A (2015) Biophysical and Biochemical Aspects of Antifreeze Proteins: Using Computational Tools to Extract Atomistic Information. *Progress Biophys. Mol. Biol.*, 119, 194-201.
10. Kar RK, Bhunia A (2015) Will It Be Beneficial to Simulate The Antifreeze Proteins at Ice Freezing Condition or at Lower Temperature? *J. Phys. Chem B*, 119, 11485-95.

11. Korshavn K, Bhunia A, Lim MH, Ramamoorthy A (2016) Ab40 Adopts a Conserved, Partially Folded Structure upon Binding to Zwitterionic Bilayers Prior to Amyloid Formation. *ChemComm*. 52, 882-5. Selected for Cover page !!!!

12. Korshavn K, Jang M, Kwak YJ, Kochi A, Vertuani S, Bhunia A, Manfredini S, Ramamoorthy A, Lim MH (2015) Reactivity of Metal-Free and Metal-Associated Amyloid-beta with Glycosylated Polyphenols and Their Esterified Derivatives. *Nature Sci. Rep*. 5, 17842.

13. Lee DK, Bhunia A, Kotler SA, Ramamoorthy A (2015) Antimicrobial peptides and inhibition by cholesterol: A solid-state Nuclear Magnetic Resonance study. *Biochemistry*, 54, 1897-907.

14. Mangoni ML*, Bhunia A (2016) Editorial: Antimicrobial Peptides in Medicinal Chemistry: Advances and Applications. *Curr Top Med Chem*, 16, 2-3.

15. Nandi SK, Chakraborty A, Panda AK, Ray SS, Kar RK, Bhunia A, Biswas A (2015) Interaction of ATP with a small heat shock protein from Mycobacterium leprae: Effect on its structure and function. PLOS Negl. *Trop. Diseas*., 9, e0003661.

16. Pithadia AS, Bhunia A, Sribalan R, Padroni V, Fierce CA, Ramamoorthy A (2016) Influence of a Curcumin Derivative on hIAPP aggregation in the Absence and Presence of Lipid Membrane. *ChemComm*. 52, 942-5. The paper has been recommended by Faculty 1000 Prime !!!!

17. Roy P, Dhara D, Parida PK, Kar RK, Bhunia A, Jana K, Sinha-Babu SP, Misra A (2016) C-Cinnamoyl glycosides as a new class of anti-filarial agents. *Eur. J. Med. Chem*. 114,308-17.

18. Sharma S, Sahoo N, Bhunia A (2016) Antimicrobial Peptides and their Pore/Ion Channel Properties in Neutralization of Pathogenic Microbes. *Curr Top Med Chem*, 16, 42-53.

19. Sudheendra US, Dhople V, Datta A, Kar RK, Shelburne CE, Bhunia A*, Ramamoorthy A* (2014) Membrane Disruptive Antimicrobial Activities of Human beta defensin-3 Analogs. *Eur. J. Med. Chem*., 91, 91-99.

Patents

- Bhunia A (PI) and Kundu P (co-PI) filed an Indian Patent (Application number: 0493/KOL/2015) on "*De Novo Designed Novel* Antimicrobial and Antiseptic Peptides And Its Application Against Plant Pathogens".
- Bhunia A. (PI) and Das SS (PI) filed an Indian Patent (Application number: 0462/DEL/2015) on "A peptide to neutralize lipopolysaccharide Molecule".

Dr. P. Chakrabarti

Senior Professor

Scientific Reports

Structural studies on proteins from *Vibrio cholerae*

Vibrio cholerae is the causative agent of the diarrheal disease cholera, which is usually acquired by oral ingestion of the bacterium with contaminated water or food. We have been working with a

number of proteins (such as, Ace and HlyU) which are involved in *Vibrio cholerae* pathogenesis. HlyU in *Vibrio cholerae* is known to be the transcriptional activator of the hemolysin gene, HlyA and possibly a regulator of other virulence factors, influencing growth, colonization and pathogenicity of this infective agent. We have found out a 17 base-pair imperfect palindrome sequence, 5-TAATTCAGACTAAATTA-3, 173 bp upstream of *hlyA* promoter, as the binding site of HlyU. We have modelled the protein-DNA complex using the structure of HlyU that was determined by us. The winged helix-turn-helix protein binds necessarily as a dimer with the recognition helices contacting the major grooves and the β-sheet wings, the minor grooves. On binding to HlyU, DNA deviates by ~68° from linearity.

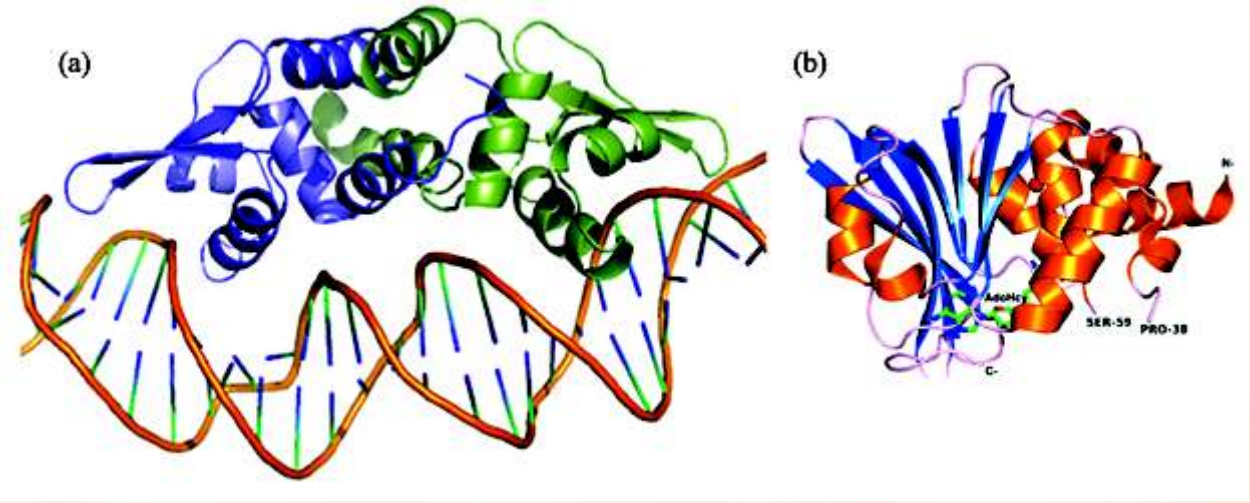


Figure legend: (a) Model of HlyU-DNA complex; (b) X-ray crystallographic structure of PIMT from *Vibrio cholera*.

The repair enzyme Protein L-isoaspartyl-O-methyltransferase (PIMT) is widely distributed in various organisms. PIMT catalyzes *S*-adenosylmethionine (AdoMet) dependent methylation of abnormal *L*-isoaspartyl residues, formed by the deamidation of asparagines and isomerization of aspartates. We have determined the crystal structure of PIMT of *Vibrio cholerae* (*Vc*PIMT), the aetiological agent for cholera, complexed with the demethylated cofactor *S*-adenosyl-*L*-homocysteine (AdoHcy) to 2.05 Å resolution. The kinetic parameters for the methyltransferase activity of the recombinant *Vc*PIMT was determined using a continuous spectrophotometric color-based assay using the peptide substrate [VYP(*L*-isoD)HA]. The enzyme exhibited activity higher than the *E. coli* enzyme and closer to those from thermophilic bacteria and the mammalian source.

Publications

1. Chatterjee T, Sheikh IA, Chakravarty D, Chakrabarti P, Sarkar P, Saha T, Chakrabarti MK and Hoque KM (2015) Effects of small molecule calcuium-activated chloride channel inhibitors on structure and function of Accessory cholera enterotoxin (Ace) of *Vibrio cholerae*. *PLoS ONE*, 10(11): e0141283.

2. Chatterjee T, Mukherjee D, Banerjee M, Chatterjee BK and Chakrabarti P (2015) Crystal structure and activity of protein L-isoaspartyl-O-methyltransferase from *Vibrio cholerae*, and the effect of AdoHcy binding. *Arch. Biochem. Biophys*. 583, 140-149.

3. Chatterjee T, Chatterjee BK, Majumdar D and Chakrabarti P (2015) Antibacterial effect of silver nanoparticles and the modeling of bacterial growth kinetics using a modified Gompertz model. *Biochim. Biophys. Acta*, 1850, 299-306.

4. Dhar G, Chakravarty D, Hazra J, Dhar J, Poddar A, Pal M, Chakrabarti P, Surolia A and Bhattacharyya B (2015) Actin-curcumin interaction: Insights into the mechanism of actin polymerization inhibition. *Biochemistry*, 54, 1132-1143.

5. Mukherjee D, Pal A, Chakravarty D and Chakrabarti P (2015)Identification of the target DNA sequence and characterization of DNA binding features of HlyU, and suggestion of a redox switch for *hlyA* expression in the human pathogen *Vibrio cholerae* from *in silico* studies, *Nucleic Acids Res*. 43, 1407-1417.

Dr. Subhrangsu Chatterjee

Scientist, Ramanujan Fellow

Scientific Reports

Design, synthesis of Novel Aptamers, Peptides, Small molecules selectively bind G quadruplexes

Focus of my research is to design new kinds of aptamers (LNA, BNA, ENA), antimicrobial peptides, small molecules which significantly bind to the telomeric and oncogenic G quadruplexes which are essential structures to be investigated and targeted to cause cancer cell death. We also want to investigate the role of POT1 protein and other transcription factors in controlling the telomerase activity. We employ high resolution NMR and other biophysical techniques to unravel molecular interactions.

Understanding misfolding and aggregation of proteins and peptides by high resolution NMR

Protein and peptide aggregation can be very fatal and cause different kinds of neurodegenerative diseases. Our focus is to design and synthesize new kinds of peptides and small molecules which inhibit protein/peptide aggregation and misfolding.

Publications

1. Bhat J & Chatterjee S (2016) Skeleton selectivity in complexation of chelerythrine and chelerythrine-like natural plant alkaloids with the G-quadruplex formed at the promoter of c-MYC oncogene: in silico exploration. *RSC Advances* 6(43):36667-36680.

2. Chakraborty S, *et al*. (2016) Mephebrindole, a synthetic indole analog coordinates the crosstalk between p38MAPK and eIF2α/ATF4/CHOP signalling pathways for induction of apoptosis in human breast carcinoma cells. *Apoptosis*.

3. Kaulage M, *et al*. (2016) Discovery and Structural Characterization of G-quadruplex DNA in Human Acetyl-CoA Carboxylase Gene Promoters: Its Role in Transcriptional Regulation and as a Therapeutic Target for Human Disease. *J Med Chem* 59(10):5035-5050.

4. Mondal S, Bhat J, Jana J, Mukherjee M, & Chatterjee S (2016) Reverse Watson-Crick G-G base pair in G-quadruplex formation. *Mol Biosyst* 12(1):18-22.

5. Mondal S, Jana J, Sengupta P, Jana S, & Chatterjee S (2016) Myricetin arrests human telomeric G-quadruplex structure: a new mechanistic approach as an anticancer agent. *Mol Biosyst*.

6. Nakka KK, *et al*. (2015) Nuclear matrix-associated protein SMAR1 regulates alternative splicing via HDAC6-mediated deacetylation of Sam68. *Proc Natl Acad Sci U S A* 112(26):E3374-3383.

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8. Saha T, Manna A, Bhat J, Chatterjee S, & Sa G (2016) G-actin guides p53 nuclear transport: potential contribution of monomeric actin in altered localization of mutant p53.Nature Scientific Reports (Accepted).

9. Sarkar P, Jana J, Chatterjee S, & Sikdar SR (2016) Functional characterization of *Rorippa indica* defensin and its efficacy against Lipaphis erysimi. *Springerplus*, 5:511.

Patents

Recently we have invented a new antimetstatic cancer therapeutic agent (filed for patent in USA, Europe and Australia)

AU2013322120(A1) (Australian Publication)

EP2900234(A1) (European Publication)

US2016023996(A1) (USA Publication)

Dr. Tanaya Chatterjee

DST-Women Scientist

Scientific Reports

Antimicrobial effect of gold nanoparticles of different shape and size

We are involved in studying the effect of shape and size of gold nanoparticles on the growth of *Vibrio cholera*, classical and El tor biotypes, with the aim of discovering new nanomedicines as alternative to antibiotics.

Effects of small molecule calcium-activated chloride channel inhibitors on structure and function of accessory cholera enterotoxin (Ace) of Vibrio cholera

Cholera pathogenesis occurs due to synergistic pro-secretory effects of several toxins, such as cholera toxin (CTX) and Accessory cholera enterotoxin (Ace) secreted by *Vibrio cholerae* strains. Ace activates chloride channels stimulating chloride/bicarbonate transport that augments fluid secretion resulting in diarrhea. These channels have been targeted for drug development. However, lesser attention has

been paid to the interaction of chloride channel modulators with bacterial toxins. We have studied the modulation of the structure/function of recombinant Ace by small molecule calcium-activated chloride channel (CaCC) inhibitors, namely CaCCinh-A01, digallic acid (DGA) and tannic acid. Binding of tannic acid destabilizes the structure of Ace, and results in reduced fluid accumulation in mouse ileal loop. The other two molecules have the opposite effect.

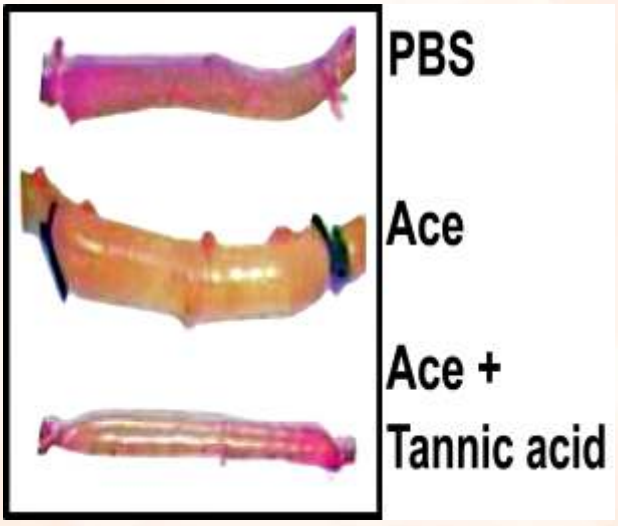

Figure legend: Effect of tannic acid (CaCC inhibitor) on Ace stimulated intestinal fluid accumulation.

Publications:

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2. Chatterjee T, Mukherjee D, Banerjee M, Chatterjee BK and Chakrabarti P (2015) Crystal structure and activity of protein L-isoaspartyl-O-methyltransferase from *Vibrio cholerae*, and the effect of AdoHcy binding. *Arch. Biochem. Biophys*. 583, 140-149.
3. Chatterjee T, Chatterjee BK, Majumdar D and Chakrabarti P (2015) Antibacterial effect of silver nanoparticles and the modeling of bacterial growth kinetics using a modified Gompertz model, *Biochim. Biophys. Acta*, 1850, 299-306.

Title of the Scheme	Schemes funded by
Studies on structure and function of *Vibrio cholera* accessory enterotoxin (Ace) and human protein L-isoaspartyl-methyltransferase (hPMTI) in presence of nanoparticles.	DST-Women Scientists Scheme

Dr. Rajagopal Chattopadhyaya

Professor

| Scientific Reports |

Stability of *Curcuma longa* rhizome lectin: role of N-linked glycosylation

Curcuma longa rhizome lectin, a mannose binding monocot family plant protein of non-seed origin having antifungal, antibacterial and α-glucosidase inhibitory activities, was studied to understand the role of glycans with complex-type oligosaccharides attached to Asn 66 and Asn 110, thereby

elucidating the roles of carbohydrate moieties in lectin stability, denaturation and refolding, described in the previous annual report. Apart from the native lectin, the characteristics of a deglycosylated *E. coli* expressed lectin, high-mannose oligosaccharides at both asparagines and its glycosylation mutants N66Q and N110Q expressed in *Pichia pastoris*, were compared to understand the relationship between glycosylation and activity. The difference in mass from the MALDI-MS of recombinant CLA and native CLA mainly ranges from 2,000 to 2,250 Da; this can be explained well by the existence of two glycans released by PNGase treatment, subsequent chemical modification by MALDI-MS/MS, each Hex3HexNAc2Pen1 at Asn 66 and Asn 110, having the highest permethylated glycan peak of 1331.65 Da corresponding to 1042.3 Da for the unmodified glycan. Hence the additional mass due to two such glycans in the lectin will be 2 x (1042.3 – 18.0) Da or 2,048.6 Da. If one Hex3HexNAc2Pen1 is combined with either Hex3HexNAc2Pen1dHex1 (m/z = 1505.74) or Hex3HexNAc3Pen1 (m/z = 1576.76) in a lectin molecule, those additional masses will still be within 2,250 Da. Thus the difference in mass at the protein level can be explained by those of glycans released and analyzed by MALDI-MS. Paper published online in *Glycobiology*.

Influence of Plant Extracts on Fenton-reaction mediated DNA damage

Transition metals like iron, which is most abundant in our body, can react with H_2O_2 to produce hydroxyl radical ($OH^{\cdot}$) via the Fenton reaction as follows : $Fe^{2+} + H_2O_2 + H^+ \rightarrow Fe^{3+} + OH^{\cdot} + H_2O$. The $OH^{\cdot}$ produced is highly reactive and a major source of oxidative stress in cells, damaging proteins, lipids and DNA. Oxidative DNA damage is implicated in many diseases such as cancer, neurodegenerative and cardiovascular diseases. Thus, considerable attention is being given to research on natural antioxidants because synthetic antioxidants have many harmful side effects. It was reported that Fenton reaction mediated DNA damage is enhanced by the extracts from *Terminalia chebula*, *Terminalia belerica*, *Emblica officinalis, Acacia catechu* and *Spondius dulcis*. No such effect was significant in the cases of *Dolichos biflorus* and *Hemidesmus indicus*. Two active compounds from *Terminalia chebula* have also been identified and isolated for further study. We surmise that the first five plant extracts inhibit the enzymatic activities of human topoisomerases I and II which are known to be important vis-à-vis cancer, while the last two plants show smaller effects. Papers are under preparation for these studies.

Crystal structures of *Colocasia esculenta* lectin solved

High resolution X-ray crystallographic data were collected in late 2014 in our Institute facility for two kinds of crystals of *Colocasia esculenta* (wild taro, called 'gnati kochu' in Bengali) tuber lectin, with and without mannose bound. The lectin molecule is composed of two distinct polypeptide chains, i.e., it is a heterodimer. The mannose-free lectin crystallized in space group $P222_1$ with cell parameters a = 122.01Å, b = 47.20Å, c = 82.25Å, $\alpha = \beta = \gamma$ = 90.00 degrees. The phase problem was solved using molecular replacement using the structure of *R. vivipara* lectin as the trial model. The asymmetric unit in the crystal contains two molecules of the lectin, i.e. four polypeptides. The mannose-free lectin is available from the PDB in entry 5D5G refined using 49,194 reflections in the 21.0-1.74Å range. The crystal structure will be correlated with our biophysical studies in a forthcoming paper.

It has been very hard to find monomeric mannose crystallized with mannose-binding lectins as their binding is weak. The mannose bound form of the lectin crystallized in a trigonal space group $P3_121$ with cell parameters a = b = 75.896Å, c = 124.065Å, α = β = 90.00 degrees, γ = 120.00 degrees. The asymmetric unit here contains one molecule of the lectin (or heterodimer), but the molecular replacement was originally solved in space group C2 for ruling out other trigonal/ hexagonal space groups. Five molecules of mannose have been located per molecule of heterodimer. The mannose-bound lectin structure is available from the PDB in entry 5D9Z refined using 35,187 reflections in the 19.8-1.85Å range.

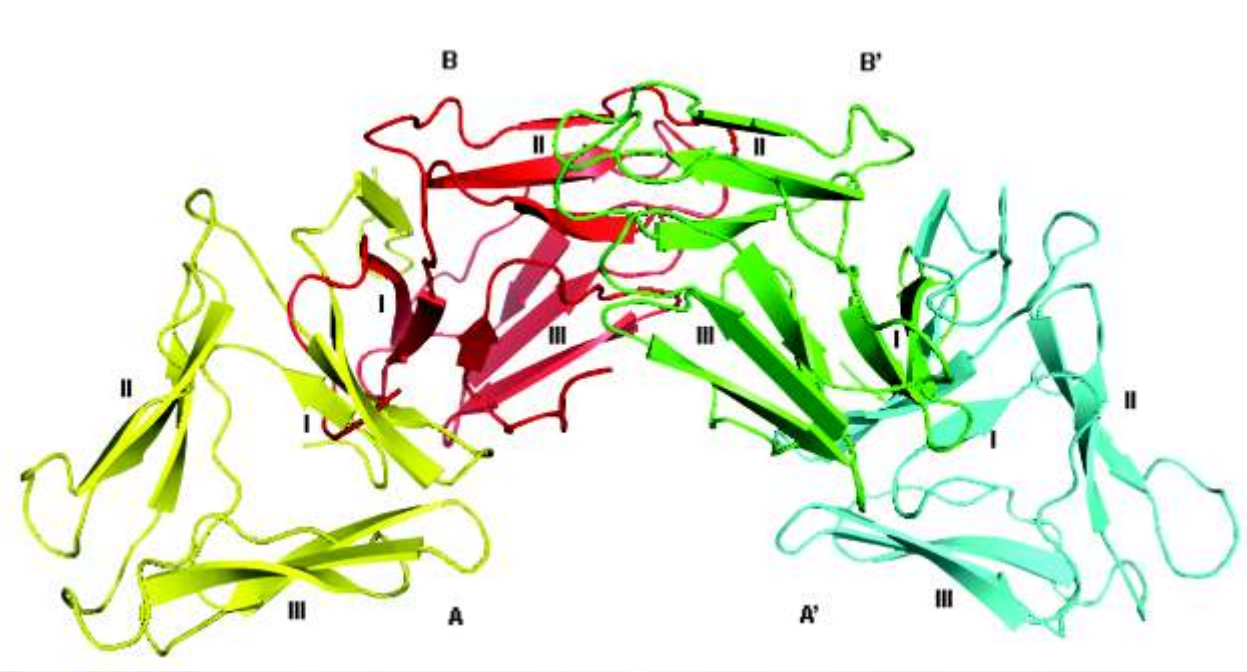


Figure legend : One heterodimer of the β-sheet rich, prism shaped, polypeptides in native *Colocasia esculenta* lectin shown as yellow and red ribbons; another heterodimer with light blue and green ribbons is a symmetry related molecule and forms a tetramer, as shown, taken from PDB entry 5D5G. The other heterodimer in the asymmetric unit (polypeptide chains C, D) also forms a nearly identical tetramer with a symmetry-related molecule within the crystal. Each tetramer has four β-prism II domains, each with a β-barrel made by three subdomains (numbered I, II and III) of amphipathic anti-parallel β-sheets arranged around a pseudo 3-fold axis like three faces of an equilateral prism.

Publications

1. Mondal A, Chattopadhyaya R, Datta A B and Parrack P (2015) Crystallization and X-ray analysis of the transcription-activator protein C1 of bacteriophage P22 in complex with P_{RE} promoter element. *Acta Crystallographica*, F71, 1286-1291.
2. Polley S, Chakravarty D, Chakrabarti G, Chattopadhyaya R and Sau S (2015) Proline substitutions in a Mip-like peptidyl-prolyl *cis-trans* isomerase severely affects its structure, stability, shape and activity. *Biochimie Open*, 1, 28-39.

Dr. K. P. Das

Senior Professor and Coordinator

Scientific Reports

Structural and functional studies of α-crystallin: *in collaboration R. Banerjee, CU and Aritra Chaudhuri, EMBL, Germany*

The concentration of α-crystallin in the lens ranges from 200-400 mg/ml. Most structural and functional studies till date are done at very low concentration. At such high concentration, α-crystallin forms a clear gel-like phase. We have decided to study the properties of α-crystallin at such high concentration by spectroscopic method. We plan to study the water dynamics and dynamics of the fluorophore covalently attached to various parts of the α-crystallin.

Publications

1. Banerjee V, Das KP (2016) Insulin Fibrillation and Role of Small Molecules in Its Inhibition Process, Ch. 46 in "Encyclopedia of Biocolloids and Biointerfaces", *H. Ohshima Ed., John Wiley & Sons,* 575-588.
2. Banerjee V, Das K P and Roy S (2015) Understanding the physical and molecular basis of stability of Arabidopsis DNA Pol λ under UV-B and high NaCl stress, *PLoS One*, 10(7): e0133843.
3. Biswas A, Karmakar S, Chowdhuri A, Das KP (2016) Interaction of some small molecules with □ -crystallin and its effect on its structure and function, *Biochim. Biophys. Acta*, 1860: 211-221.
4. Chowdhury A, Banerjee Rand Das K P (2016) Biophysical Studies of a Miceller Protein alpha-Crystallin by Fluorescence Methods, Chapter 60, in "Encyclopedia of Biocolloids and Biointerfaces", *H. Ohshima Ed., John Wiley & Sons*, 737-752.
5. Karmakar S, Biswas Aand Das K P (2015) Structural stabilization and functional enhancement of miceller protein a-crystallin by ATP and Zn^{+2}. *J. Surf. Sci. Technol.,* 31(1-2), 13-20 doi:1.1371/journal.pone.0133843.
6. Saha S, Das KP (2015) Effect of thermal treatment on the oligomeric size and chaperone activity of apha crystalline, *J. Indian Chem. Soc.,* 92(10): 1531-1536.
7. Sapkota M, Karmakar G, Nahak P, Guha P, Roy B, Koirala S, Chettri P, Das KP, Misono T, Torigoe K, Panda AK (2015) Effect of Polymer Charge on the Formation and Stability of Anti-inflammatory Drug Loaded Nanostructured Lipid Carriers: Physicochemical Approach, ***RSC Adv.,*** 5: 65697-65709.

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Delivered an invited talk on July 25, 2015 at the one day symposium on Trends in Surface Science and Related Areas (TSSRA) held at the Department of Chemistry, West Bengal State University, Barasat.

Dr. Ajit Bikram Datta

Associate Professor

Scientific Reports

Structural and biochemical studies to understand the regulation and and specificity of ubiquitination machinery in eukaryotes

Ubiquitination refers to the post translational modification that occurs to a diverse array of proteins in eukaryotes via covalent conjugation of a small 76 residue protein known as Ubiquitin. Modification of substrate proteins in vivo by ubiquitination has been implicated in a plethora of cellular processes including proteostasis, DNA repair, transcription regulation, intracellular signaling, and cell-cycle progression. Improper functioning of ubiquitination has been found to be responsiblefor various neurodegenerative diseases and cancers. A cascade of three sequential enzymatic steps involving the ubiquitin activating enzyme (E1), conjugating enzyme (E2), and ubiquitin ligase (E3) results in the formation of a covalent bond between the Ubiquitin C-terminus and a specific lysine in the substrate protein. Human genome codes for a wide repertoire of E2s (about 30) and E3 enzymes (>600), which, in a combinatorial manner dictates the substrate selection as well as the modification topology, both being crucial for the specific cellular response. Thus the spatio-temporal specificities of E3-E2 and E3-substrate interaction and their regulations are crucial to elicit the desired the biological reaction.

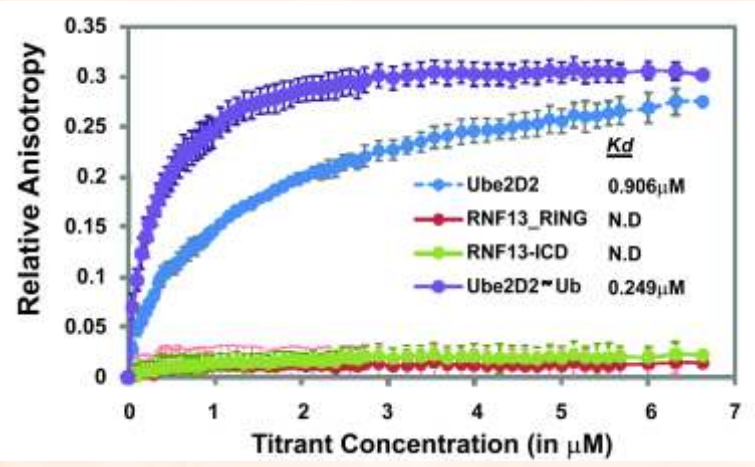


Figure 1. Binding of RNF13 (Fluorescently labelled) with its cognate E2, Ube2D2 and Ube2D2~Ub conjugate.

We have undertaken multiple research projects to understand diverse aspects of ubiquitination machinery and their regulation. In an extension of our work on understanding E2 activity we have now delved into understanding the basis of weak catalytic activity of Ube2E Ubc core domain.

In order to understand various aspects of E3-E2 interactions that lead to the activation of E2~ubiquitin thio-ester conjugates facilitating ubiquitin transfer to the substrate, we also undertook work to solve crystal structures of different E3s in complex with their cognate E2 and also E2~Ub conjugates. Last year we solved the structure of one such monomeric E3, RNF13, in complex with Ube2D2~Ub conjugate. We extended our structural observations to study E3-E2 binding and the in the process of unraveling the molecular determinants in the E3 that are responsible for their E2 binding capabilities.

Last year we had also obtained crystals of another E3 ligase ZNRF1 in complex with its cognate E2 Ube2N. The structure has now been solved at 1.5Å with data collected at RRCAT Indore. This is

the highest resolution structure for any E3-E2 complex till date and gave us unprecedented details about E3-E2 interaction. Based on this structure we have now delved into understanding the choice of E2 enzymes by ZNRF1. This study will pave the path for understanding the E2 specificity of other cellular E3 ligases as well.

Crystal structure of a plant receptor kinase and its mutants: *in collaboration with Prof. M. Dasgupta, Dept. of Biochemistry, University of Calcutta, Kolkata*

In collaboration with Prof. M. Dasgupta, from University of Calcutta we undertook the task of solving the crystal structure of the kinase domain of symbiosis receptor kinase from *Arachis hypogea*. Suchplant receptor-like kinases play crucial roles in different plant signaling pathways responsible for diverse physiological processes. Last year we were successful in solving the structure of two mutant versions of this SYMRK kinase domain. This work has also been extended further as we successfully solved the structure of the mutants bound to ATP analog AMP-PnP. Though we also had obtained crystals for the wild-type version of SYMRK, the crystals diffracted very poorly. Efforts are underway to improve the crystals and obtain the structure for detailed comparative structure-function analysis.



Figure 2. a) 1.5Å crystal structure of a ZNRF1(green) in complex with Ube2N(salmon).

Figure 2. b) Crystal structure of a ZNRF1 (green), in complex with Ube2N(salmon) ~ Ubiquitin(blue).

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Intermediate Fellowship titled "Understanding the structural basis of the substrate and the E2 specificities of ubiquitin E3 ligases" (01.08.2011-31.08.2016)	Wellcome Trust-DBT India Alliance

Dr. Jayanta Mukhopadhyay

Associate Professor

Scientific Reports

Novel mechanism of gene regulation: the protein Rv1222 of *Mycobacterium tuberculosis* inhibits transcription by anchoring the RNA polymerase onto DNA.

We propose a novel mechanism of gene regulation in *Mycobacterium tuberculosis* where the protein Rv1222 inhibits transcription by anchoring RNA polymerase (RNAP) onto DNA. In contrast to our existing knowledge that transcriptional repressors function by either binding to DNA at specific sequences or by binding to RNAP, we show that Rv1222 mediated transcription inhibition requires simultaneous binding of the protein to both RNAP and DNA. We demonstrate that the positively charged C-terminus tail of Rv1222 is responsible for anchoring RNAP on DNA, hence the protein slows down the movement of RNAP along the DNA during transcription elongation. The interaction between Rv1222 and DNA is electrostatic, thus the protein could inhibit transcription from any gene. As Rv1222 slows down the RNA synthesis, upon expression of the protein in *Mycobacterium smegmatis* or *Escherichia coli*, the growth rate of the bacteria are severely impaired. The protein does not possess any significant affinity for DNA polymerase, thus, is unable to inhibit DNA synthesis. The proposed mechanism by which Rv1222 inhibits transcription reveals a new repertoire of prokaryotic gene regulation.

Promoter escape with bacterial two-component sigma factor suggests retention of sigma region two in the elongation complex

The transition from the formation of RNAP-promoter open complex step to productive elongation complex step involves 'promoter escape' of RNAP. From the structure of RNAP, a 'promoter escape' model has been proposed which suggests that the interactions between σR4 and RNAP and σR4 and DNA are destabilized upaon transition to elongation. This accounts for reduced affinity of σ to RNAP and stochastic release of σ. However, as the loss of interaction of σR4 with RNAP results in the release of intact σ, assessing this interaction remains challenging to be experimentally verified. Here we study the 'promoter escape' model using a two- component σ factor YvrI and YvrHa from *Bacillus subtilis* that independently contribute to the functions of σR4 and σR2 in a RNAP-promoter complex. Our results show that YvrI, that mimics σR4, is released gradually as transcription elongation proceeds whereas YvrHa that mimics σR2 is retained throughout the elongation complexes. Thus our result validates the proposed model for promoter escape and also suggests that promoter escape involves little or no change in the interaction of σR2 with RNAP.

Bacillus subtilis δ factor functions as a transcriptional regulator by facilitating the open complex formation

Most bacterial RNA polymerases (RNAP) contain five conserved subunits viz. 2α, β, β' and ω. However, in many gram positive bacteria, especially in fermicutes, RNAP is associated with an additional factor, called δ. Over three decades since its identification, it had been thought that δ

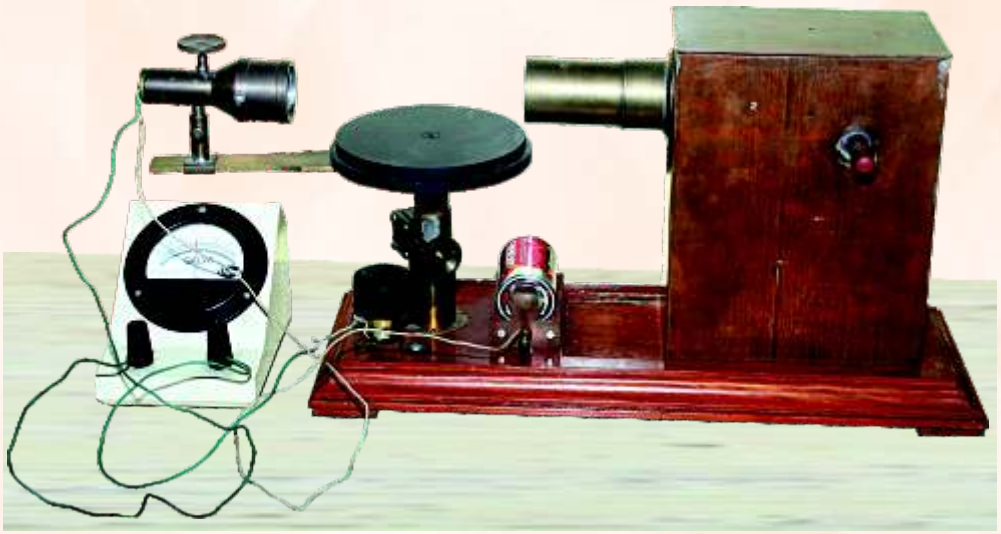
functioned as a subunit of RNAP to enhance the level of transcripts by recycling RNAP. In support of the previous observations, we also find that δ is involved in recycling of RNAP by releasing the RNA from the ternary complex. We further show that δ binds to RNA and is able to recycle RNAP when the length of the nascent RNA reaches a critical length. However in this work we decipher a new function of δ. Performing biochemical and mutational analysis we show that *Bacillus subtilis* δ binds to DNA immediately upstream of the promoter element at A-rich sequences on the *abrB* and *rrnB1* promoters and facilitates open complex formation. As a result, δ facilitates RNAP to initiate transcription in the second scale, compared to minute scale in the absence of δ. Using transcription assay we show that δ mediated recycling of RNAP cannot be the sole reason for the enhancement of transcript yield. Our observations that δ does not bind to RNAP holo enzyme but is required to bind to DNA upstream of the -35 promoter element for transcription activation, suggest that δ functions as a transcriptional regulator.

Dr. Pradeep Parrack

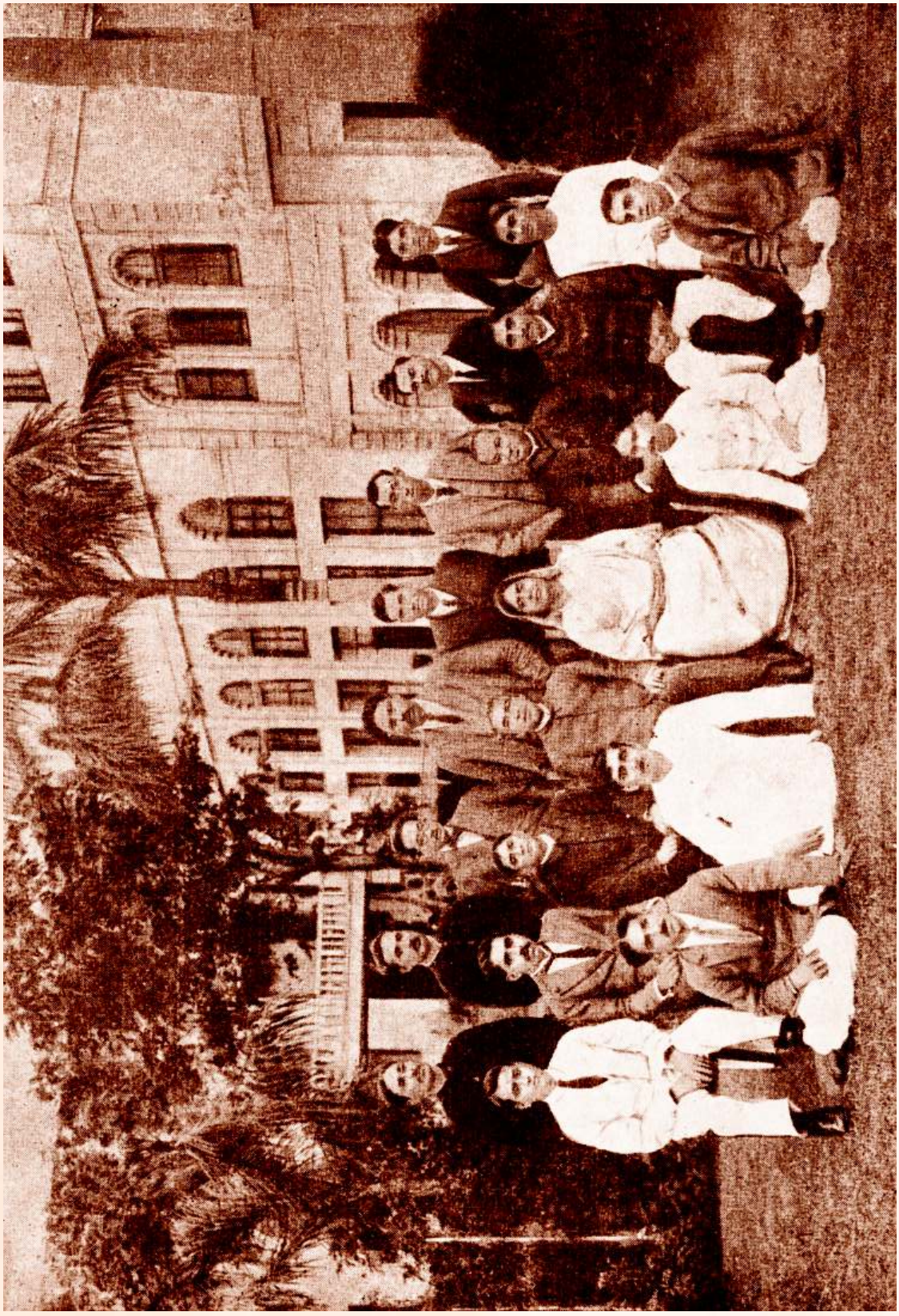
Professor

Publication:

Mondal A, Chattopadhyaya R, Datta A B and Parrack P (2015) Crystallization and X-ray analysis of the transcription-activator protein C1 of bacteriophage P22 in complex with the P_{RE} promoter element. *Acta Crystallogr.*, F71, 1286-1291



Microwave Apparatus



J.C. Bose, Abala Bose with staff of Bose Institute (1926)
Back row- U.C. Sen, L. Mukherjee, Dr. Rao, N. Bal, B.K. Palit, S.N. Sen, S.Deb, G.C. Bhattachaya
Middle Row- K. Mukherjee, N.N. Das, G.P. Das, J.C. Bose, Lady Bose, N.C. Nag, S.N. Das, A.N. Mitra
First Row (seated): M. Chakraborty, B.K. Dutta, B.P. Ghosh, J. Mitra

SCIENTIFIC REPORTS

III
Computational Biology

Participation in Institutional Projects for the 12th Five-year Plan (2012-2017)

Dr. Gautam Basu (Coordinator), Dr. Pinakpani Chakrabarti, Dr. Tapas Chandra Ghosh, Dr. R. Chattopadhyaya, Dr. Tapan Kumar Dutta, Dr. Debjani Roy, Dr. Shubhra Ghosh Dastidar, Dr. Zhumur Ghosh, Dr. Sudipto Saha.

Introduction

The institutional plan program Computational Biology aims to understand a plethora of biological processes, molecules and interactions by computational techniques. Some of our broad goals are: i) microRNA networks in stem cells, ii) mechanistic insight into the molecular biology from structural dynamics, integrating therapeutic molecular design, iii) comparative genome analysis towards the understanding of protein evolution, iv) understanding macromolecular recognition from an analysis of known structures of protein complexes, v) development of bioinformatics tools and web-based servers, vi) identification of network biomarkers in Neurodegenerative diseases, vii) structural studies of c-Jun N-terminal kinase 3 (JNK3), and, viii) a combined in silico genomics and proteomics approach for the development of antiparasitic drugs.

Dr. Gautam Basu

Senior Professor and Coordinator

Scientific Reports

Electrostatic control of protein-protein association rates

Understanding the basis of protein-protein association and prediction of association rate constants is of fundamental importance. We show that a single geometric parameter in crystal structures of protein-protein complexes, the angle between the electric dipole of one subunit and the partner-generated electric field at the same subunit, linearly correlates with experimentally determined protein-protein association rates. Further, the cosine of the angle alone is sufficient to predict association rate constants, with accuracies comparable to currently available predictors that use more intricate methodologies. Imprint of a dynamic kinetic process in a single static geometric

parameter, associated with mutual electrostatic orientation of subunits in protein-protein complexes, demonstrates the universality of electrostatic steering in attenuating protein-protein association rates and would be useful in development of coarse-grained models.

Publication

1. Das M, Basu G (2015) Protein-protein association rates captured in a single geometric parameter. *Proteins: Structure, Function and Bioinformatics* 83:1557-1562.
2. Chattopadhyay S, Haresh A, Basu G (2016) Effect of introducing Aib in a designed helical inhibitor of HDM2-p53 interaction: A molecular dynamics study. *Biopolymers (Peptide Science)* 106:51-61.

Students Awarded Ph.D.

Name of Student (University/Year)	Title of Thesis
Nipa Chongdar (C.U., 2015)	Structural Analysis of Naturally Occurring and Synthetic Peptides

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Setting up of a State-of-the-art 600 MHz FT-NMR with Cryoprobe facility at Bose Institute.	DBT

Dr. P. Chakrabarti

Senior Professor

Scientific Reports

Weak non-bonded interactions in the stabilization of protein structures

Over the past several years we have been analyzing protein structures to identify the manifestation of weak, but geometrically well-defined non-bonded interactions that can stabilize small local structures, which can also be seen in the isolated peptide moieties. We have identified a β-turn mimic, designated as ω-turn (because of its shape), which is found to occur ~3 times per 100 residues in protein structures. 3 residues (i to i + 2) constitute the turn, where there is a C–HO interaction involving the C^{γ}-H group in the side chain at the last position with the main-chain C = O of the first residue. When Cys is the (i + 1)th residue, the motif is usually found in the metal-binding site. Combination of different β-turn mimics gives rise to structures with distinct local shape, one such has been named 'Da', as it has the shape of Bengali letter 'দ'. The identification of the composite turns can be used to characterize the loop region in protein structures.

Structural changes accompanying protein-protein complex formation

To delineate features that characterize protein-protein interactions is a long-standing theme in our group. We have compared a large number of proteins both in the unbound and bound form and found that on going from the former to the latter state there is an increase in the accessible surface area of atoms that constitute the interface in the complex. There can be changes in the temperature factors of the atoms of the interface, as well as disorder-to-order transition; the most common secondary structural changes are extension of helices and strands (at the expense of non-regular structures). There has been a scientific commentary on this work in the same issue of IUCrJ (Laskowski RA and Thornton JM. *IUCrJ*, 2, 609-610).

Molecular dynamics simulations

Dystrophin is a long, rod-shaped cytoskeleton protein implicated in muscular dystrophy. Utrophin is the closest autosomal homolog of dystrophin. Both proteins have N-terminal actin-binding domain (N-ABD), a central rod domain and C-terminal region. N-ABD, composed of two calponin homology (CH) subdomains joined by a helical linker, harbors a few disease causing missense mutations. Although the two proteins share considerable homology (> 72%) in N-ABD, recent structural and biochemical studies have shown that there are significant differences (including stability, mode of actin-binding) and their functions are not completely interchangeable. We have used extensive molecular dynamics simulations to understand the differences and the similarities of these two proteins, along with another actin-binding protein, fimbrin.

Publications

1. Chakravarty D, Janin J, Robert CH and Chakrabarti P (2015) Changes in protein structure at the interface accompanying complex formation. *IUCr J*, 2, 643-652. (Scientific Commentary on the article: Laskowski RA and Thornton JM. *ibid*, 609-610).
2. Chakravarty D, Chakraborti S and Chakrabarti P (2015) Flexibility in the N-terminal actin-binding domain: Clues from *in sillico* mutations and molecular dynamics. *Proteins*, 83, 696-710.
3. Dhar J and Chakrabarti P (2015) Defining the loop structures in proteins based on composite β-turn mimics. *Protein Engng, Design & Selection*, 28, 153-161.
4. Dhar J, Chakrabarti P, Saini H, Raghava GPS, Kishore R. ω-Turn: a novel β-turn mimic in globular proteins stabilized by main-chain to side-chain C-HO interaction (2015) *Proteins*, 83, 203-214.

Students Awarded Ph.D.

Name of Student (University/Year)	Title of Thesis
Aritrika Pal (C.U., 2015)	Structural and functional studies on proteins from *Vibrio cholera* – PIMT and HlyU.
Devlina Chakravarty (C.U., 2016)	Analysis of protein structures and dynamics, and their role in biological recognition and binding.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
J.C. Bose National Fellowship	DST

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Presented papers/attended at (i) UGC sponsored Refresher Course in Chemistry entitled, Impact of Contemporary Chemical Research on UG and PG Teaching", Calcutta University, August 10-29, 2015; (ii) India-Bangladesh Structural Chemistry Conference (IBSCC2015), IISER, Mohanpur, September 18-19, 2015; (iii) National Workshop for HuSim (Human Simulator) Proposal Development, by ITRA (Information Technology Research Academy), at IIIT, New Delhi, September 19-20, 2015; (iv) the 13th Conference of the Asian Crystallographic Association (ASCA 2015), Kolkata, December 5-8, 2015; (v) IUCr-UNESCO-Rigaku OpenLab Cambodia, Phnom Penh, Jan 11-15, 2016. He chaired sessions at (vi) International Symposium on Chemical Biology and Drug Discovery (ISCBDD-2016), Kolkata, March 1-3, 2016.

Group members

Dr. Tanaya Chatterjee, Shamila Sarwar, Jesmita Dhar and Supriyo Bera attended the 13th Conference of the Asian Crystallographic Association (ASCA 2015), Kolkata, December 5-8, 2015.

Dr. Rajagopal Chattopadhyaya

Professor

Scientific Reports

Comparison of three dimensional structures of enteric pilins

The three dimensional structures of four type IVb pilin globular domains in *Vibrio cholerae*, *Salmonella enteric* serovar Typhi, enteropathogenic *Escherichia coli* (EPEC) and enterotoxigenic *Escherichia coli* (ETEC) reported earlier were compared, as reported previously. Our paper on this is now published.

Publications

1. Chattopadhyaya R and Biswas H (2016) Sequence, structure and functional comparisons suggest an alternative structure for the bundle-forming pilin BfpA. *Clinical Proteomics & Bioinformatics*, **1**, 9-14. doi: 10.15761.

2. Mondal A, Chattopadhyaya R, Datta A B and Parrack P (2015) Crystallization and X-ray analysis of the transcription-activator protein C1 of bacteriophage P22 in complex with P_{RE} promoter element. *Acta Crystallographica*, F71, 1286-1291.

3. Polley S, Chakravarty D, Chakrabarti G, Chattopadhyaya R and Sau S (2015) Proline substitutions in a Mip-like peptidyl-prolyl *cis-trans* isomerase severely affects its structure, stability, shape and activity. *Biochimie Open*, 1, 28-39.

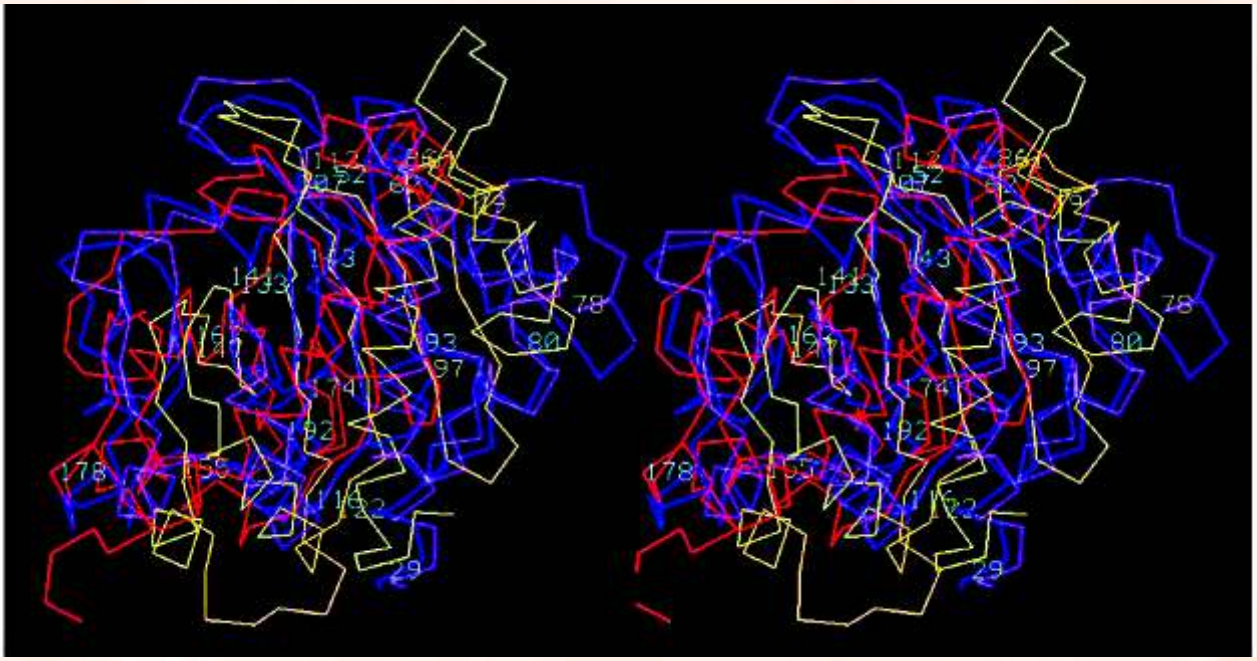


Figure legend. Four type IVb pilin globular domains as Cα models are superimposed in stereo. High-resolution crystal structures of TcpA (blue) and CofA (violet); NMR structures of PilS (yellow) and BfpA (red), are superposed pair wise using the β-strands forming the central β-sheets. Residues at the start of secondary structure elements are numbered in light blue (TcpA) and yellow (PilS). It is seen that TcpA, CofA and PilS share the same topology in their central 5 β-strands and the relative dispositions of four conserved helices α1 through α4 relative to their central β-sheets, but the topology of the BfpA NMR structure (red) is different. The strange topology of BfpA region 60–90 prevents its α1 from coming closer to its central β-sheet and this α1 is roughly at an angle of 60° relative to its β-strands; they are roughly parallel in the others. Vide Chattopadhyaya & Biswas (2016) *Clinical Proteomics & Bioinformatics* for further details.

Dr.Tapan K.Dutta

Professor

Scientific Reports

Bioinformatic analyses of bacterial ring-hydroxylating oxygenases

Performance of the wild type and mutant naphthalene dioxygenase enzymes towards different nitroarene compounds (nitrobenzene, different isomers of mono-nitrotoluenes, and different isomers of di-nitrotoluenes) was being explored on the basis of biotransformation potentials which revealed that several amino acid residues have important roles in determining the catalytic efficiency of the dioxygenase. To further study the role of substrate access channels, *in silico* identification of the probable channel/channels involved in substrate-entry into the active site and product-egress into the

external environment was performed. For experimental validation, the naphthalene dioxygenase, comprising of α-subunit, β-subunit, ferredoxin and reductase genes, were cloned into pET28(a) using *E. coli* XL1Blue as cloning host. Then site-directed mutagenesis approach was carried out to block each tunnel by substituting the smaller amino acid with larger one. Three different mutant enzymes were generated to block three individual channels, identified based on in silico analysis. Activities of these mutants towards different aromatic compounds, varying in number of ring and polarity, are being compared with that of wild type enzyme. On the basis of the results thus obtained, different combinations of above mentioned mutations will be carried out to identify the substrate entry and product egress channel.

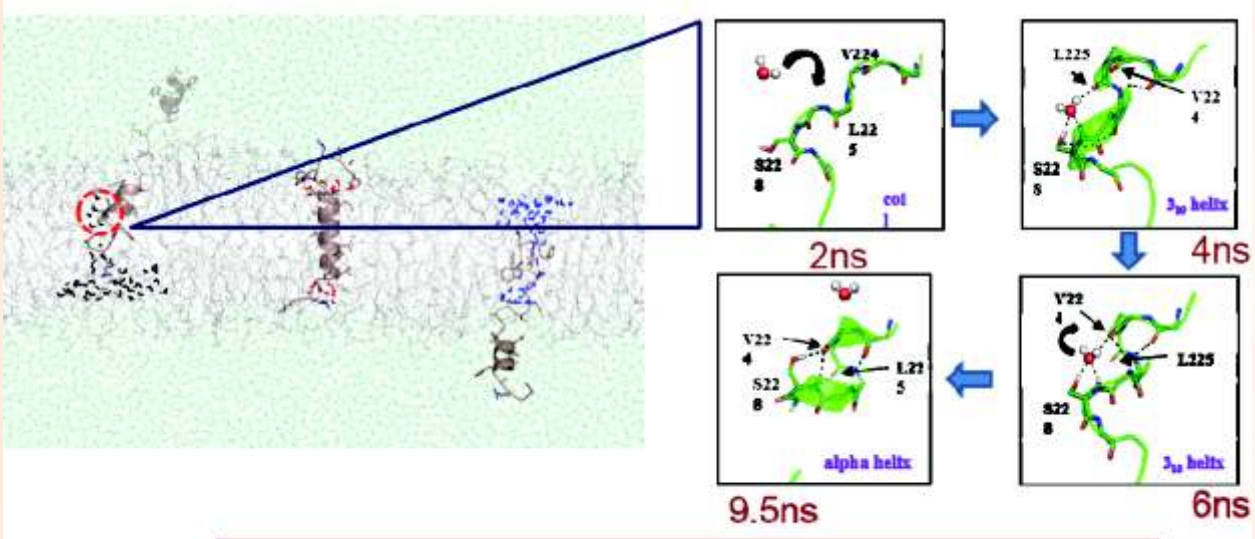
Dr. Shubhra Ghosh Dastidar

Associate Professor

Scientific Reports

Insight into Structural dynamics of biomolecules, leading to drug design

The broader area of interest of our group is to gain novel insight into the mechanism of functioning of biomolecules from computational modeling and simulations of their structures. The research projects aim for the fundamental understanding of the molecular recognition processes and to use that knowledge for designing novel therapeutic molecules. The more specific interest is to understand the role of protein flexibility to determine the protein-protein, protein-ligand and protein-membrane interactions associations. We use high performance computing (HPC) technology to perform our scientific investigations and work in a truly interdisciplinary manner with active collaborations with experimentalists.



Microsolvation mediated helix reformation

The figure briefly outlines the recent findings on the mechanism of insertion of a peptide into a lipid bilayer. The peptide associates a thin layer of water while entering into the membrane. These water molecules catalyze the refolding of the peptide which often partially unfolds during the insertion.

Publications

1. Majumdar S, Maiti S, Ghosh Dastidar S (2016) Dynamic and Static Water Molecules Complement the TN16 Conformational Heterogeneity inside the Tubulin Cavity. *Biochemistry*. 19;55 (2):335-47.
2. Sinha A, Ray A, Ganguly S, Ghosh Dastidar S, Sarkar S (2015) Variation in the ribosome interacting loop of the Sec61α from Giardia lamblia. *Biol Direct*. 30;10:56.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Mechanistic insight into the role of conformational Modulations in driving BC12s apoptotic network: Structural dynamics to therapeutic design	DBT

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Participated conference on Exploring Mechanisms in Biology: Theory and Experiment, MGMS Conference, November 25-27, 2015, Singapore.

Dr. Tapash C Ghosh

Senior Professor

| Scientific Reports |

Evolutionary Bioinformatics

The major theme of our research is to identify and understand different evolutionary forces by analyzing the genomic and functional data of various organisms to gain insight into the structural and functional organization of a genome. Very briefly, the major results of the last one year (2015-16) are as follows:

- Orphan genes are emerging to play critical roles in lineage-specific adaptation of different species to a broad range of ecological conditions. To evaluate the attributes of orphan genes in the evolutionary framework we performed a comprehensive analysis comparing orphan genes with the non-orphan genes in *Leishmania major*. We observed that together with gene age, a number of genomic (like expression level, GC content, variation in codon usage) and proteomic factors (like protein length, intrinsic disorder content, hydropathicity) could independently modulate their evolutionary rate. Our functional analysis highlighted the role

of orphan genes in parasitic lineage-specific adaption, which influences both survival and virulence in the host genome. Our study provides valuable information on *L. major* orphan genes and advocates for further analysis and experimental studies to facilitate the development of novel therapeutic targets in near future.

- Evolutionary rate differences between primary and secondary metabolic genes in *Arabidopsis thaliana have been explored. Primary metabolic genes were observed to be conserved than secondary metabolic genes in A. thaliana. These variations were explained by genomic and functional parameters like gene structure, expression level, tissue specificity, multifunctionality and domain contents.*
- Comparison of evolutionary genomic properties of human small-scale duplicates with traceable human whole-genome duplicates from vertebrates 2R WGD event showed that human WGDs are functionally less similar, diverge more in subcellular level and contain a higher proportion of essential genes than SSDs, all of which is different from yeast. Our study suggests that human WGD duplicates are more divergent and entails the adaptation of WGDs to novel and important functions that consequently lead to their evolutionary conservation in the course of evolution.

Publications

1. Acharya D, Ghosh TC (2016) Global analysis of human duplicated genes reveals the relative importance of whole-genome duplicates originated in the early vertebrate evolution. *BMC Genomics*. Jan 22;17:71. doi: 10.1186/s12864-016-2392-0.
2. Mukherjee S, Panda A and Ghosh TC (2015) Elucidating evolutionary features and functional implications of orphan genes in Leishmania major. *Infect Genet Evol* 32::330-3337.
3. Mukherjee D, Mukherjee A and Ghosh TC (2015) Evolutionary Rate Heterogeneity of Primary and Secondary Metabolic Pathway Genes in Arabidopsis thaliana. *Genome Biol Evol*. 8:17-28.

Students Awarded Ph.D.

Name of Student (University/Year)	Title of Thesis
Sandip Chakraborty (C.U., 2015)	Studies on eukaryotic protein evolution: insights from the protein-protein interaction network and protein complex assembly.
Tina Begum (C.U., 2016)	Structural and genomic analysis of human disease and non-disease genes from the perspective of protein evolution

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Delivered invited talk on (i) Silver Jubilee at school of computational and integrative sciences, JNU, New Delhi on March 2016; (ii) National seminar and workshop on Bioinformatics at North Bengal University, Siliguri on March 2016; (iii) Emerging techniques in bioinformatics and its' application

at Birla Institute of Technology, Meshra, Ranchi on November 2015; (iv) Assam biotechnology conclave at Guwahati Biotech Park, Guwahati on November 2015; (v) 8th NEBInet annual coordinators meeting at Tripura Central University, Tripura on November 2015.

Awards/Honours Received:

Member of Editorial Board:

BMC Genomics (From 2010 -)

Evolutionary Bioinformatics (From 2013-)

Dr. Zhumur Ghosh

Assistant Professor

Scientific Reports

1. Characterizing the naïve and primed pluripotent states: Elucidated the key transcription factors pertaining to these pluripotency states (by analyzing corresponding microarray datasets) which have been subsequently validated in these two pluripotency states.

2. Investigating the role of regulatory RNAs in cancer stem cells: (a) Determined the microRNA and mRNA pool within the stem cell like sorted population from the AML cell line KG1a (generated corresponding RNA-seq data). We are elucidating the potential miRNA-mRNA pairs (using in-house target binding protocol) within these dataset. Subsequent experimental validation will be performed. (b) Ovarian teratocarcinoma (OVTC) arises from germ cells and comprises of stem cells that can be used to study cancer cell stemness. We have generated the piRNA profile in human OVTC cell line PA1 and is investigating whether piRNA promotes OVTC by maintaining cancer stem cell/progenitor populations.

3. Protocol development: (a) Developed a machine learning based miRNA-target prediction tool.

Publications

1. Liu J, Masurekar A, Johnson S, Chakraborty S, Griffiths J, Smith D, Alexander S, Dempsey C, Parker C, Harrison S, Li Y, Miller C, Di Y, Ghosh Z, Krishnan S and Saha V (2015) Stromal cellmediated mitochondrial redox adaptation regulates drug resistance in childhood acute lymphoblastic leukemia. *Oncotarget,* DOI: 10.18632/oncotarget.5528 (impact factor 6.359).

Conference proceedings

1. Sarkar A, Maji RK and Ghosh Z (2015) PIWI interacting RNAs- Role in Ovarian Teratocarcinoma, EMBL symposium *"The Non-coding Genome"*.
2. Sarkar A, Maji RK and Ghosh Z (2016) Elucidating the role of piRNAs in ovarian teratocarcinoma, *8th RNA Group meeting*.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Micro-regulatory networks in leukemia stem cells	DBT-RGYI
Jointly with Dr. Sudipto Saha Systematic identification of regulatory networks in pluripotent cells integrating coding and noncoding world	ICMR

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Presented on "PIWI interacting RNAs- Role in Ovarian Teratocarcinoma" at EMBL symposium "The Noncoding Genome" in Heidelberg, Germany during October 18 – 21, 2015.

Group member

Arijita Sarkar presented on "Elucidating the role of piRNAs in ovarian teratocarcinoma" at 8th RNA group Meeting at CCMB, Hyderabad during January 8 – 10, 2016.

Awards/Honours Received

Editorial Board Member, Current Bioinformatics.

Socially Relevant

Cancer stem cells (CSCs) have been reported to be responsible for tumor initiation, therapy resistance, progression, relapse, and metastasis. Despite their potential clinical importance, their mode of regulation at the molecular level is poorly understood. Regulatory noncoding RNAs (rncRNAs) are emerging as new players in the CSC paradigm. They contribute towards maintaining the CSC niche. (a) Focus of my lab is to elucidate the role of the putative novel biomarkers i.e these rncRNAs like miRNA, piRNA etc towards modulating CSCs. These can act as novel therapeutic targets for this deadly disease. (b) Another focus of my lab is to figure out the transcription/gene regulatory programs which goes disrupted in CSCs as compared to that in the normal pluripotent cells. The first work regarding our study towards characterizing the different pluripotent states is mainly to approach this goal. This will possibly help to frame better therapeutic strategy for tackling CSCs.

Dr. Debjani Roy

Assistant Professor

Scientific Reports

Epigenetic drug repositioning for Alzheimer's disease

Epigenetics has emerged as an important field of study that identifies the influence of external and environmental factors on the expression of cellular genes. The approval of epigenetic drugs for the

treatment of cancer has opened the avenue for the development of new epigenetic drugs for other disorders including AD. To identify repositioning drugs for AD, we have developed a novel pipeline that refines drugbank drugs and their epigenetic targets from human interactome. The proposed epigenetic repositioning drugs may represent new opportunities for the epigenetic therapeutic intervention of this disease.

Computational Systems Biology approaches to study Huntington's Disease from Next Generation Sequencing Data

Huntington's disease (HD) is a PolyQ class of neurodegenerative disease result of the occurrence of a stretch of CAG (glutamine) repeat in the coding region of the disease-causing gene. Our research methodology includes identification of all proteins, SNPs and non-coding RNAs associated with HD. Further analyses in terms of molecular modeling, virtual screening, and molecular dynamics simulations will provide structural insight into this disease.

In Silico Chemogenomic approaches to predict unknown drug-target interactions of Amyotropic Lateral Sclerosis

In silico statistical chemogenomic approaches are being employed to predict unknown drug-target interactions from chemical information about drugs and genomic information of target proteins of Amyotropic Lateral Sclerosis (ALSD).

Publications

Conference proceedings: (Oral)

1. Chatterjee P**,** Rathi N and Roy D (2015) MicroRNAs and epigenetics in Alzheimer's disease : Study from the whole human genome***; 6th World Congress on Biotechnology 2015***, organized by Omics Conference, Delhi, India, *Scientific Tracks Abstracts: J Biotechnol Biomater*, DOI: 10.4172/2155-952X.C.1043.
2. Chatterjee P and Roy D (2015) From Protein expression data to Molecular Dynamic Simulation - Analysis of GRIP1 PDZ6 domain in AD***; 6th World Congress on Biotechnology 2015,*** organized by Omics Conference, Delhi, India, October 2015; *Scientific Tracks Abstracts*: *J Biotechnol Biomater*, DOI: 10.4172/2155-952X.C1.043.

Dr. Sudipto Saha

Assistant Professor and Ramalingaswami Fellow

Scientific Reports

Computational framework for prediction of peptide sequences that may mediate multiple protein interactions in cancer-associated hub proteins

A considerable proportion of protein-protein interactions (PPIs) in the cell are estimated to be mediated by very short peptide segments that approximately conform to specific sequence patterns

known as linear motifs (LMs), often present in the disordered regions in the eukaryotic proteins. These peptides have been found to interact with low affinity and are able bind to multiple interactors, thus playing an important role in the PPI networks involving date hubs. For case studies, PPI data and de novo motif identification based method (MEME) were used to identify such peptides in three cancer-associated hub proteins-MYC, APC and MDM2. The peptides corresponding to the significant LMs identified for each hub protein were aligned, the overlapping regions across these peptides being termed as overlapping linear peptides (OLPs). These OLPs were thus predicted to be responsible for multiple PPIs of the corresponding hub proteins and a scoring system was developed to rank them. Several OLPs were predicted in MYC and MDM2 and were proposed for further experimental validation. In summary, a computational framework has been designed to predict and rank the peptide regions that may mediate multiple PPIs and can be applied to other disease-associated date hub proteins for prediction of novel therapeutic targets of small molecule PPI modulators.

Identifying Asthma Biomarkers using LC-MS/MS data from patient samples: *in collaboration with Prof. Swati Gupta Bhattacharya*

Asthma is now a public health problem across the globe. It is characterized by a specific pattern of inflammation in the airway mucosa which involves the infiltration of eosinophils, increased numbers of TH2 cells relative to TH1 cells and increased numbers of activated mast cells. Generally, asthma is of two types: Atopic (Extrinsic or Allergic) and Non atopic (Intrinsic or Non allergic). Although there is avariation of the disease from system to system, but theoverall symptoms of atopic and non-atopic asthma are same, thus making it difficult to distinguish the two types of asthma. Besides this, asthma and COPD (Chronic Obstructive Pulmonary Disorder) exhibit overlapping symptoms making them difficult to diagnose. We have collected blood samples from atopic/non-atopic patients along with healthy volunteers and removed the six-abundant plasma proteins followed by 1-D separations and LC-MS/MS. The quantitative analysis of plasma MS data were performed using Scaffold software. We have observed a few proteins like apolipoproteins (A1 and C1 precursors) to be differentially expressed in atopic asthma patients as compared to healthy volunteers.

Proteomic profiling and pathway analysis of West Nile virus (WNV) and Japanese encephalitis virus (JEV) infected Cell lines using LC-MS/MS: *in collaboration with Dr. Resmi G* and *Prof. M. Radhakrishna Pillai from Rajiv Gandhi Centre for Biotechnology* (RGCB)

West Nile Virus (WNV) and Japanese Encephalitis Virus (JEV) can cause neurological disease and death in people. Infection and pathogenesis caused by these neurotropic Flaviviruses is a product of a series of complex interactions between the virus and nervous and epithelial tissues.Thus, it is necessary to identify those host cellular factors affecting neurotropic Flaviviruses infection and the increasingly frequent appearance of neurological symptoms stemming from these viruses.In our initial experiments, the epithelial (HeLa) cells were infected with WNV and JEV in two different doses: low (1moi) and high (10moi). We identified approximately 1100 proteins in each set of

experiments using MASCOT search, out of which 10% of proteins were significantly differently expressed (p-value <0.01).The significant set of proteins were uploaded in Ingenuity Pathway Analysis for JEV low dose and high dose studies and it was observed many pathways were down regulated upon high/low doses of JEV and WNV infections. Most interestingly, EIF2 pathway was downregulated whereas Interferon pathway was upregulated in both low and high doses of infection. Similar pattern were observed in WNV pathway studies. In addition, there were a few new pathways observed to be downregulated significantly only in high dose infection (ILK signaling and Virus Entry via Endocytic Pathways) as shown in Fig 1. We are setting up similar experiments in IMR neuronal cells for identifying host factors and pathways perturbed upon WNV and JEV infection.

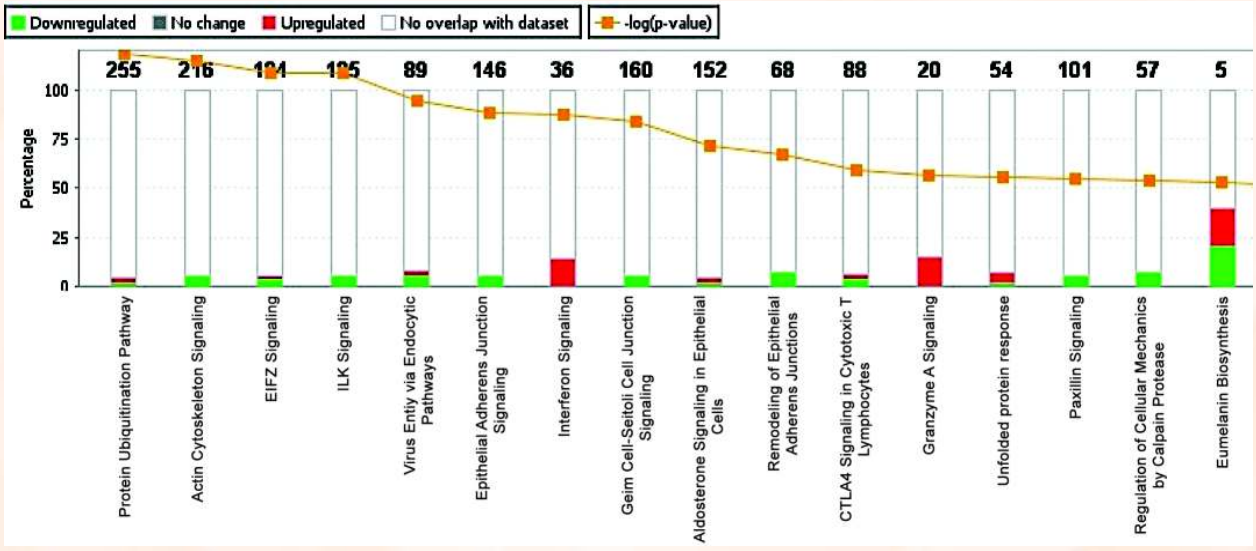


Fig 1. Pathways upregulated (red) and down regulated (green) in host cells upon high dose of JEV infection (JEV high dose vs Control)

Publications

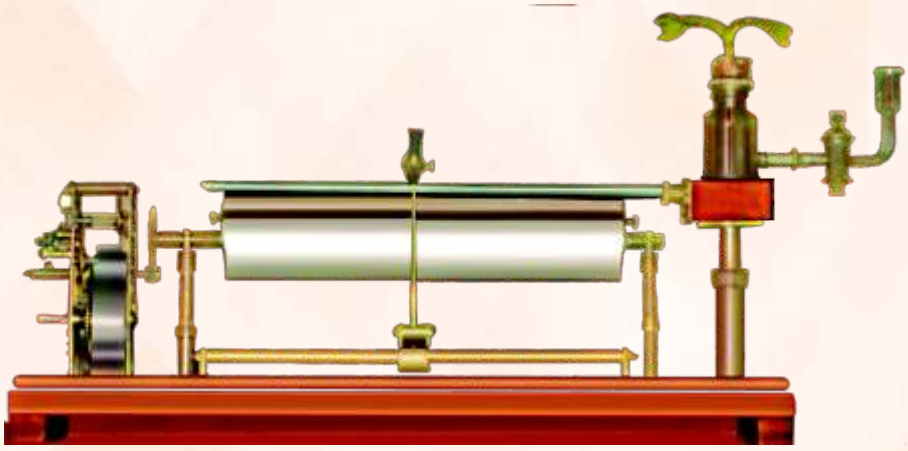
1. Barman R K, Jana T, Das S and Saha S (2015) Prediction of Intra-Species Protein-Protein Interactions in Enteropathogens Facilitating Systems Biology Study. *PLoS One*,10(12):e0145648. doi: 10.1371/journal.pone.0145648.

2. Mandal R S, Saha S and Das S (2015) Metagenomic surveys of gut microbiota. *Genomics Proteomics Bioinformatics*, 13(3):148-58. doi: 10.1016/j.gpb.2015.02.005.

3. Sircar G, Saha B, Mandal R S, Pandey N, Saha S and Gupta Bhattacharya S (2015)Purification, Cloning and Immuno-Biochemical Characterization of a FungalAspartic Protease Allergen Rhi o 1 from the Airborne Mold Rhizopusoryzae. *PLoS One*,10(12):e0144547. doi: 10.1371/journal.pone.0144547.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Systematic discovery of novel motifs mediating Protein-protein interactions	DBT-Ramalingaswami Fellow
With Prof. Swati Gupta Bhattacharya (Joint PI)	
Systematic diccovery of biomarkers of asthma caused by common environmental allergens using plasma proteomics, cytokine profiling and network biology- a systems approach to drug discovery	ICMR
A multi-institutional project with Rajiv Gandhi Centre for Biotechnology (RGCB)(Joint PI)	
Identifying Systems-level Cellular Networks Involved in Neurotropic Flavi Virus-Host Intercation	DBT



SCIENTIFIC REPORTS

| IV |
Molecular Medicine

Participation in Institutional Projects for the 12th Five-year Plan (2012-2017)

Dr. P. C. Sil (Coordinator), Dr. P. C. Sen, Dr. Subrata Majumder, Dr. Tanya Das, Dr. Gaurisankar Sa, Dr. N. N. Mandal, Dr. Atin Mandal, Dr. Kuladip Jana, Dr. Anup Kr. Misra, Dr. Mahadeb Pal, Dr. Kaushik Biswas

Introduction

The primary focus of the division is to study molecules related to health and diseases and manipulating those molecules to improve diagnosis, prevention and treatment of diseases like Cancer, Diabetes, Cardiovascular problems, Leishmaniasis, Tuberculosis etc. The division has initiated programme for developing drugs, i.e. synthetic, from natural source, protein based etc. specific to one or more of the above diseases. With the induction of a few new faculty members having experiences in one or more of the above mentioned areas it is expected that the division will be able to achieve its mandate more effectively in the coming years.

Dr. Kaushik Biswas

Associate Professor

| Scientific Reports |

Molecular mechanisms of tumorigenesis: Understanding the role of gangliosides in tumor growth, progression and metastasis

We have taken multidirectional approach towards understanding the basis of aberrant ganglioside expression in various tumors as well as studying the consequence of such an abnormal expression in carcinogenesis. In order to assess the role, tumor derived glycosphingolipids play in tumor growth and progression, siRNA mediated knockdown of GM2/GD2-synthase gene expression and consequently GM2 expression in 3 different tumor cell lines, CCF52, SK-RC-26B and A549 resulted in significant reduction in migration of the tumor cell lines, suggesting a plausible role of GM2 in tumor cell migration *in vitro*. Molecular cloning and over-expression of GM2/GD2- synthase gene in a minimally GM2 expressing cell line, SK-RC-45 resulted in increased GM2 expression and consequent tumor cell migration thereby confirming the pro-migratory role of GM2. Gene expression profiling by DNA microarray analysis of siRNA silenced CCF52 cells displayed a

number of differentially expressed genes involved in migration. Validation by western blot analysis confirmed the role of integrin mediated signaling in GM2 mediated tumor cell migration. Data shows that over-expression of select gangliosides like GM2 in tumor cells results in enhanced interaction with membrane bound integrin receptors resulting in activation of the integrin mediated signaling cascades eventually leading to rearrangement of the actin cytoskeleton thereby enhancing directional migration in tumor cells. With an aim to translate these *in vitro* findings in an *in vivo* mouse tumor model, TALEN mediated genome editing was done on a GM2 over-expressing variant of mouse kidney cancer cells, Renca-v. We have been able to successfully design and construct TALEN pairs for GM2/GD2-synthase, and subsequently generate a stable and permanent GM2/GD2-synthase knockout mouse cell line (Renca-v$^{GM2syn-/-}$), which is syngeneic to Balb/c mouse. GM2-synthase knockout clones exhibit significant reduction in anchorage independent growth (AIG) by reducing anoikis resistance of tumors. With the help of these cells, we have demonstrated the tumor promoting ability of GM2 *in vivo* using a syngeneic mouse tumor model. Further, using genetic knockouts for GM2-synthase, we are now finding evidences which might suggest that GM2 mediated epithelial-mesenchymal transition (EMT) involves the Hippo signaling pathway in tumorigenesis. Finally, we have initiated a study to find out the basis of over-expression of several ganglioside synthase genes in cancer, currently focusing on the regulation of GM2-synthase gene. Preliminary data suggests that there may be a plausible epigenetic role in the regulation of GM2-synthase gene in cancer, since increased histone acetylation (H3K9 and H3K14) associated with the transcription start site (TSS) of GM2-synthase gene was found to be significantly higher in the tumor cell versus a normal cell. Recent data suggests that in cell lines over-expressing GM2-synthase, a highly acetylated environment prevents binding of SP1 (which acts as a transcriptional repressor in this context) at the TSS, which results in less recruitment of HDAc1, thereby leading to enhanced transcription of GM2-synthase. On a different note, we have very recently undertaken a collaborative study (recently sanctioned DBT project), to screen and identify potential anti-inflammatory compounds from natural sources, those by virtue of being anti-inflammatory may be able to protect against chronic inflammation induced disease pathogenesis, like cancer.

Publication

1. Mahata B, Banerjee A, Kundu M, Bandyopadhyay U and Biswas K (2015) TALEN mediated targeted editing of GM2/GD2-synthase gene modulates anchorage independent growth by reducing anoikis resistance in mouse tumor cells. *Scientific Reports,* 5, 9048.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Role of c-Jun N-terminal kinase (JNK) in tumor derived soluble factor mediated T cell apoptosis	DBT

Dr. Tanya Das

Senior Professor

Scientific Reports

To delineate the molecular mechanisms regulating metastasis of non-small cell lung carcinoma stem cells: An approach towards a combinatorial therapy

Conventional chemotherapeutic regimens are unable to stop the incidence of metastasis and therefore are making cancer incurable with time. The origin behind this are considered to be a small sub-population of cells with self-renewal property, categorized as cancer stem cells (CSCs). We have fopund that both Slug/E-cadherin signalling pathway as well as Integrin signalling pathways play major role in regulating CSC migration. Non-steroidal anti inflammatory drug aspirin, by perturbing the expression of mTOR, accelerates the capability of cisplatin to retard migration in CSCs derived from non-small cell lung carcinomas (NSCLCs). In-depth analysis revealed that aspirin abrogates p300 binding at TATA- box as well as Initiator (INR)-region of mTOR promoter thereby repressing mTOR gene transcriptionally by impeding the binding of RNA polymerase II at those sites of mTOR promoter. As a consequence, mTOR down-regulation causes deactivation of Akt, which in turn activates Gsk3β to destabilize Snail, Slug and β-catenin thereby reverting epithelial to mesenchymal transition (EMT). Surprisingly, aspirin does not affect Intigrin/FAK signalling pathway and therefore, fails to retard migration of lung CSCs. Cisplatin co-treatment of aspirin-pre-treated lung CSCs down-regulates Integrin signaling thus retarding migration significantly. It can thus be concluded that aspirin shifts the tumor micro-environment towards anti-migration to aid cisplatin in halting migration. Cumulatively, our findings raise the possibility that aspirin might emerge as a promising drug in combinatorial therapy with the existing chemotherapeutic agents that fail to impede migration of lung CSCs. This will consequently lead to the advancement of remedial outcome for the metastatic lung carcinomas.

To manipulate ROS-NEIL2 cross-talk in favor of breast cancer stem cells apoptosis

Reactive oxygen species (ROS) have long been identified as crucial modulators in the progression as well as prevention of cancer. Generation of ROS at low levels, either endogenously or exogenously, triggers mutagenic lesions which when unrepaired may lead to genomic instability. NEIL2, a mammalian base excision repair (BER) protein, has been found to be involved in transcription-coupled DNA repair by assisting the excision of oxidized DNA lesions from bubble or single-stranded structures. It is a potent candidate in repairing ROS-induced DNA damage. Nevertheless, higher levels of ROS can induce severe oxidative stress resulting in apoptosis of cancer cells. This property can, therefore, be exploited for therapeutic benefits. Our aim for altering ROS status in human breast cancer cells unveiled a positive link between low ROS levels and repairable DNA damage through NEIL2, while higher levels of ROS impaired DNA damage repair mechanism, thereby directing the cell fate towards p53-dependent apoptosis. Further exploration showed that, at low ROS conditions, transcription factor SP1 binds to the NEIL2 promoter and facilitates its transcription. In contrast, higher ROS levels leads to oxidative degradation of SP1 thereby down-regulating NEIL2 and impairing the repair mechanism. In such an environment, the cells strategically switch to the p53-dependent apoptosis. This crucial revelation about the role of

NEIL2 in directing the fate of cancer cells upon altering ROS levels paved way for exploring its role in highly resistant cancer stem cells (CSC) that escape ongoing treatment regimens. We observed significantly higher expression level of NEIL2 and lower level of intracellular ROS in CSCs when compared to their non-stem counterparts. These findings are providing insights into a complex interplay between ROS and NEIL2 in CSCs as well. Studies are in progress to delineate the critical role played by NEIL2 and ROS in modulating resistant CSCs, which may further pave way for the development of efficient therapeutics against cancer.

Mechanics of tumor cell migration and underlying molecular cross-talks in local 3-dimensional durotactic environment

Durotaxis, the initiating phenomena of cancer metastasis, helps cellular migration by remodeling their 3-dimensional (3D) extracellular matrix (ECM). However, there is hardly any report describing durotaxis in 3D matrix of variable stiffness. We have designed and developed a 3D durotactic interphase system that comprises matrices of lower and higher stiffness separated by a durotactic interphase. This system offers monitoring of the dynamic alterations in morphological, biomechanical and biochemical parameters of human breast adenocarcinoma cells during durotaxis. We report that within a 3D collagen-I ECM micro-environment, tumor cells exhibit morphological plasticity, i.e., from bleb-based round morphology in soft matrix to lobopodia-based phenotype at durotactic junction and finally pseudopodia-based elongated morphology in stiff matrix. Multi-parameter analyses revealed cytoskeletal contractility, integrin-mediated mechanocoupling, MT1-MMP-mediated matrix breaching and their interdependency as key events in matrix-probing and matrixmodulation of cancer cells in local durotactic matrix environment. These results unveiling the mechanics of tumor cell migration and the underlying molecular interactions in 3D local durotactic environment may help designing therapeutic intervention to confine cancer cells within their local tissue thereby preventing them from metastasizing to new sites.

To identify and study stochastic phenotypic states of cancer cell population in a tumor mass

In recent years, there is a paradigm shift in the concept of the characteristics of different cell populations in a heterogeneous cancer tissue. New hypothesis focuses on the stochasticity of different phenotypic states in a total tumor mass in which all the cells are plastic in nature and can be either differentiated or de-differentiated in other cell types. Aim of this project was, therefore, to identify and study stochastic phenotypic states of cancer cell population. Using live cell video-micrography we have found that while given sphere forming environment, i.e., low attachment surface and serum free media with growth supplements, non-stem cell population, i.e., CD24 high expression, gradually converts to stem-like cells, i.e., CD44 high expression, and within 3 days most of the cells acquire stem like states. By tracking the fluorescence intensity of multiple cells, it has also been revealed that shifting of cells from CD44 to CD24 state is random with time. Moreover, the pattern of intensity variance with time confirms the randomness of the state shifting. To understand the role of one cell-state on the above-mentioned cell-state conversion of the other cell-state, we sorted cells with CD44 high expression and CD24 high expression cells and cultured them separately. Interestingly, our live cell imaging and fluorescence tracking show that in both the cases, from a single state, the cell population (either CD44 high or CD24 high cells) reaches an equilibrium state in which both the states are present. These results indicate that within a cancer

cell population, stem like state and non-stem state interconvert randomly with time. But still it is elusive to us whether the stem-like states converts to non-stem states and vice versa to attain equilibrium or any intermediate state/factor plays the role in maintaining such equilibrium. We are currently working on that interesting question to find out the underlying mechanism.

Publications

1. Banerjee S, Bose D, Chatterjee N, Das S, Chakraborty S, Das T, Saha KD (2016) Attenuated Leishmania induce pro-inflammatory mediators and influence leishmanicidal activity by p38 MAPK dependent phagosome maturation in Leishmania donovani co-infected macrophages. *Scientific Reports* 6:22335. doi: 10.1038/srep22335.
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3. Mukherjee S, Manna A, Bhattacharjee P, Mazumdar M, Saha S, Chakraborty S, Guha D, Adhikary A, Jana D, Gorain M, Mukherjee S, Kundu GC, Sarkar DK and Das T (2016) Non-migratory tumorigenic intrinsic cancer stem cells ensure tumor metastasis by continuous generation of $CXCR4^+$ migrating cancer stem cells. *Oncogene* doi: 10.1038/onc.2016.26.
4. Mukherjee S, Saha S, Manna A, Mazumdar M, Chakraborty S, Paul S and Das T (2015) Targeting cancer stem cells by phytochemicals: A multi-modal approach to colorectal cancer. *Current Colorectal Cancer Rep.* (Ed. Anand Srikant) Springer Science, USA.
5. Saha S, Mukherjee S, Khan P, Kajal K, Mazumdar M, Manna A, Mukherjee S, De S, Jana D, Sarkar DK, Das T (2016) Aspirin Suppresses the Acquisition of Chemoresistance in Breast Cancer by Disrupting an NFκB-IL6 Signaling Axis Responsible for the Generation of Cancer Stem Cells. *Cancer Research* 76(7):2000-12. doi: 10.1158/0008-5472.CAN-15-1360.
6. Saha S, Mukherjee S, Mazumdar M, Manna A, Khan P, Adhikary A, Kajal K, Jana D, Sa G, Mukherjee S, Sarkar DK, Das T (2015) Mithramycin A sensitizes therapy-resistant breast cancer stem cells toward genotoxic drug doxorubicin. *Translational Research* 165:558-77.

Students Awarded Ph.D.

Name of Student (University/Year)	Title of Thesis
Dr. Shravanti Mukherjee (C.U., 2015)	Getting into the root of breast cancer metastasis: Role of cancer stem cells
Dr. Shilpi Saha (C.U., 2016)	Understanding the mechanisms of chemo-resistance in breast cancer stem cells: An approach towards molecular intervention
Dr. Abir K. Panda (C.U., 2016)	Epigenetic regulation of T-cell plasticity in tumor microenvironment

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Mapping the molecular mechanisms of resistance-to-apoptosis switch over of non small-cell lung carcinoma by curcumin: An approach towards chemo-sensitization	DST
Binning stochastic phenotypic states of cancer cell population in different color box	DBT
As Co-PI	
Targeted alteration of MAPK family members ERK and p38MAPK/JNK to channelize oncogenic *Ras*-induced proliferative-signaling into apoptotic-signaling	*DST*
As Co-PI	
Remodeling the cellular calcium homeostasis by ethyl-4-(3-nitro)-phenyl-6-methyl-2-oxo-1,2,3,4-tatra-pyrimidine-5-carboxylate (Nifetepimine): A mecha-nistic approach towards cancer regression and immune-rejuvenation.	DAE
As Co-PI	
miR 325: a Distinct miRNA that controls T regulatory cell development and function	**DST**

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(I) Chaired a scientific session and delivered an invited lecture in the *4th International Conference in Angiogenesis: Technology & Therapeutics*, at SASTRA University, Thanjavur, in 2015. (ii) Participated in the *6th International Conference on Stem Cells and Cancer*: *Proliferation, Differentiation and Apoptosis*, held at Pune in 2015, where she chaired a scientific session and delivered an invited lecture. (iii) Invited to deliver a talk in the National Conference on *Exploring the Modern Approach in Biological Science: From Genome to Organism* **at the** Department of Zoology, Sidho Kanho Birsha University, Purulia, in 2015. (iv) Participated and delivered invited lecture in *XVII All India Congress of Cytology and Genetics&International Symposium on "Exploring Genomes: The New Frontier"* jointly organized by CSIR-Indian Institute of Chemical Biology, Kolkata, in 2015. (v) Delivered an invited lecture at the *International Conference on Cancer Research: New Horizons*, at NCCS, Pune in 2015. She was also invited at the *Indian Society of Translational Research Meeting* organized at Bose Institute, Kolkata, to deliver an invited talk in 2015. (vi) Delivered invited lectures at the *National Conference on Frontiers in Translational and Regenerative Biology*"at CRNN, University of Calcutta; *Trends in physiological researches from Laboratory to community,* at Vidyasagar University, Midnapore; and *Consortium for an integrated research on molecular medicine: Search for novel biopharmaceuticals from natural*

resources at West Bengal State University, Barasat, in 2016. (vi) Delivered plenary lectures at the *National Conferences* at Adamas Institute of Technology, Barasat, and Serampore College, Hooghly, in 2016.

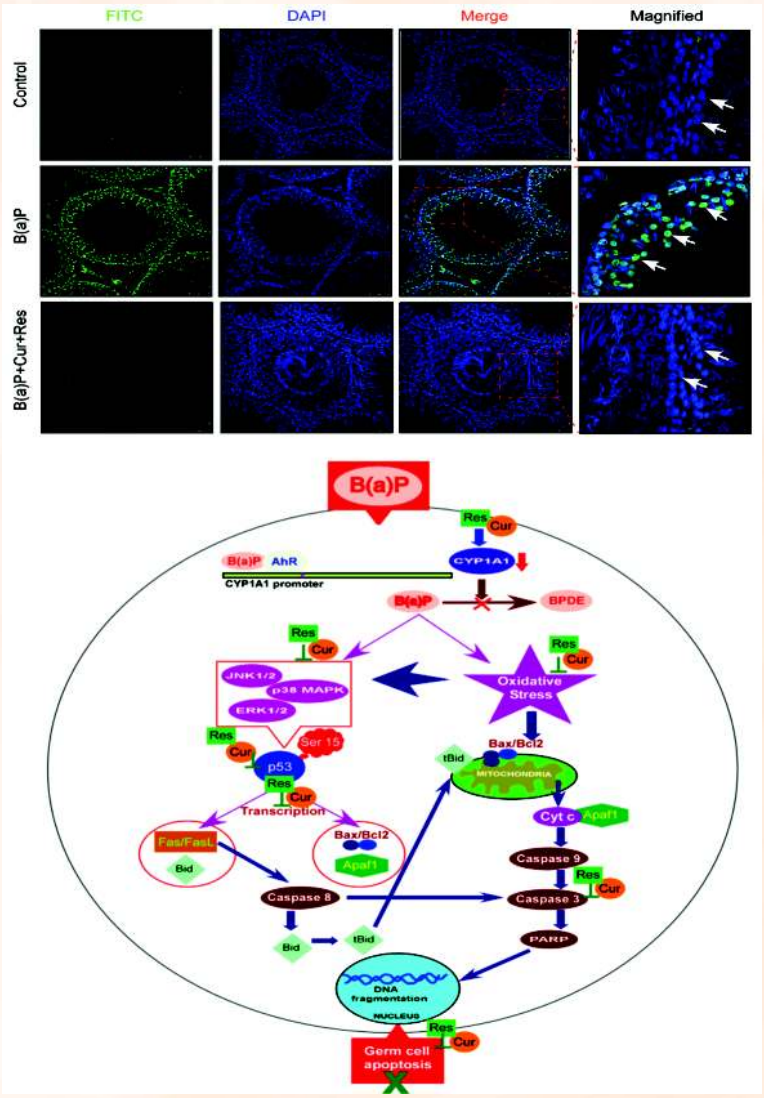
Dr. Kuladip Jana

Senior Scientist

Scientific Reports

(A) Molecular signalling involved in patho-physiological action of common air pollutant "Benzo(a)pyrene" in Germ cell DNA damage and apoptosis in connection to male infertility : possible protection by natural aryl hydrocarbon receptor antagonists: *in collaboration with Prof. P. C. Sen.*

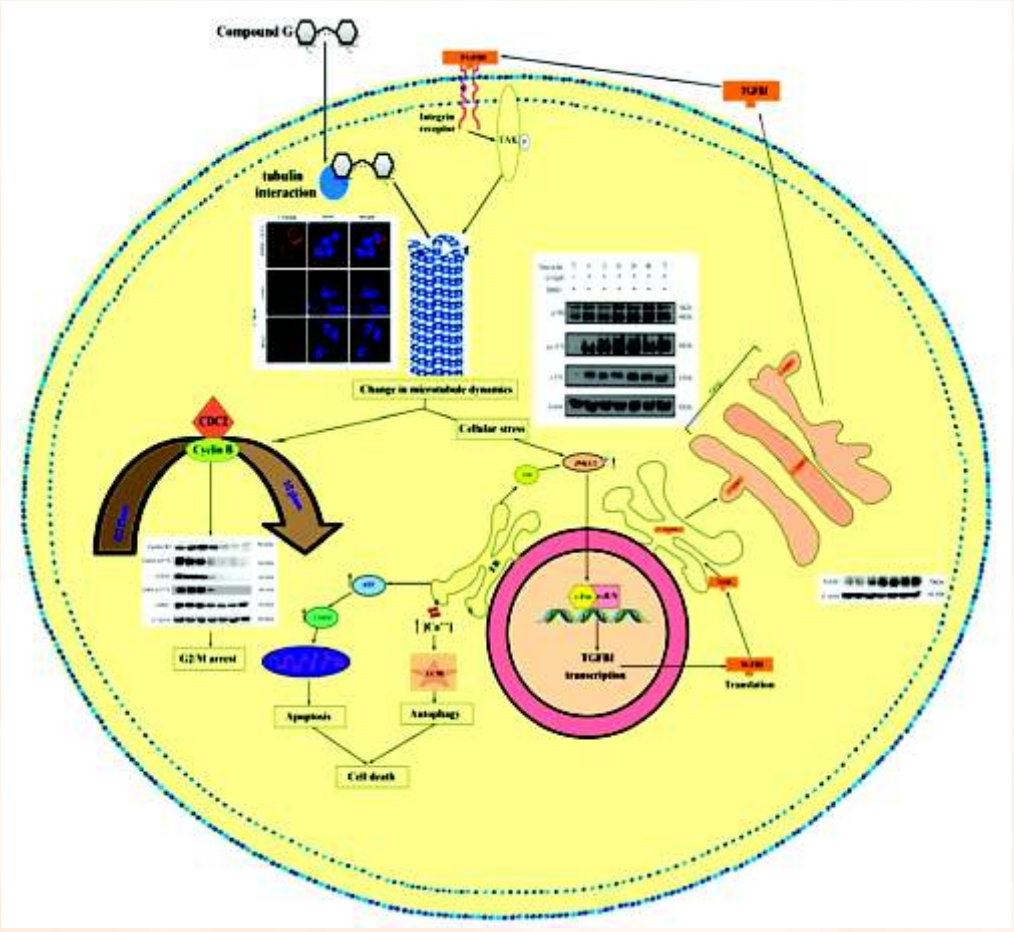
Benzo(a)pyrene (B(a)P) is an environmental toxicant that alters the steroidogenic profile of testis and induces testicular dysfunctions. In spite of the magnitude of the problem, the precise molecular and cellular mechanism of B(a)P mediated testicular damage and possible protective measures still remain unexplored. In the present study, we have investigated the molecular signaling of B(a)P and the ameliorative potential of the natural aryl hydrocarbon receptor (AhR) antagonist and antioxidant-3,5,4'-trihydroxy-*trans*-stilbene (Resveratrol) on B(a)P induced male reproductive toxicity. Studies carried out in adult male Wistar rats significantly showed that B(a)P treatment resulted in p38 MAPK activation and increased iNOS production along with testicular apoptosis and steroidogenic dysfunction. Our study also highlighted that resveratrol co-treatment maintained testicular redox potential, increased serum



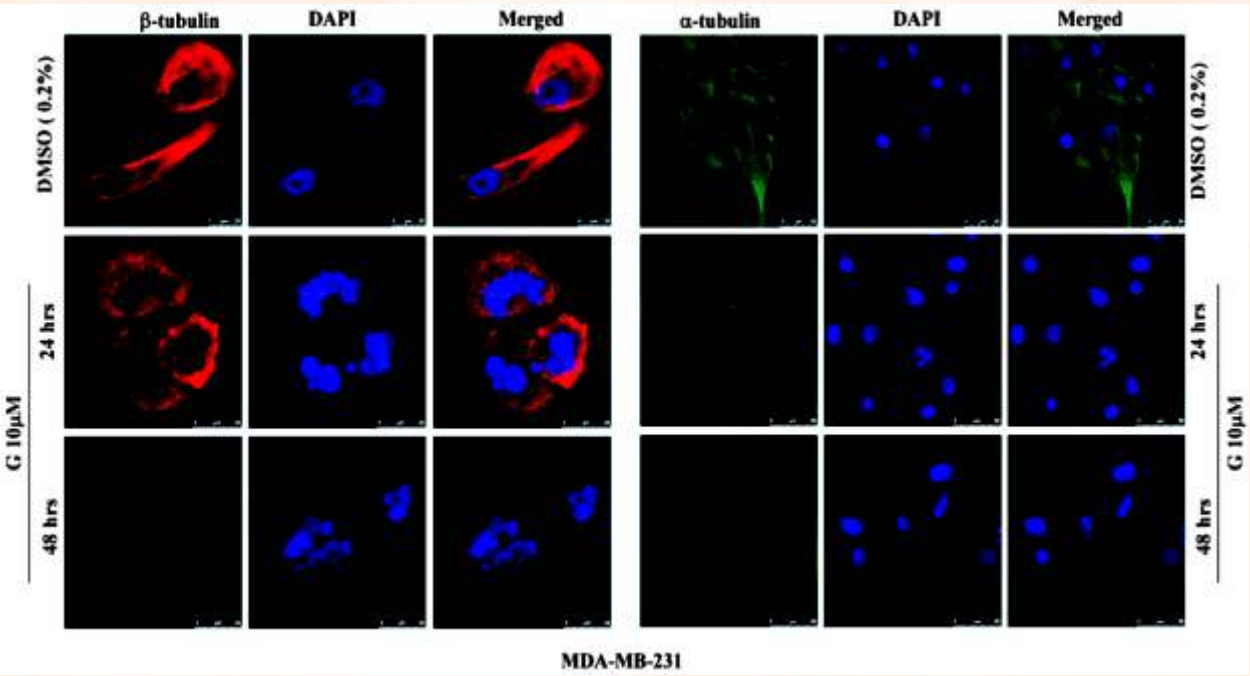
testosterone level and enhanced major testicular steroidogenic proteins (CYPIIA1, StAR, 3β HSD,17β HSD) expression and subsequent onset of apoptosis. Resveratrol co-treatment also showed significant inhibition of protein and mRNA levels of testicular cytochrome P4501A1 (CYP1A1), which is the major B(a)P metabolizing agent for BPDE-DNA adduct formation. Resveratrol also significantly decreased the B(a)P-induced AhR protein levels, its nuclear translocation and subsequent promoter activation, thereby decreasing the expression of CYP1A1. Resveratrol down-regulates B(a)P-induced testicular iNOS production through suppressing the activation of p38 MAPK and ATF2 thereby improving the oxidative status of the testis and inhibiting apoptosis. Our findings thus cumulatively suggest that resveratrol exhibits both anti-initiating effects of B(a)P by modulating the transcriptional regulation of CYP1A1 and acting as an antioxidant thus preventing B(a)P-induced oxidative stress and testicular apoptosis.

(B) Microtubule dynamics interfering agent drives apoptosis through Endoplasmic Reticulum stress pathway and increases paclitaxel sensitivity in breast cancer cells through AP1 mediated TGFBI over- expression: *in collaboration with Prof. A. K. Misra and Dr. K. Biswas.*

Microtubules play a critical role in the process of cell division, during which it helps in chromosomal segregation process. As cancer cells possess abnormal and uncontrolled cell division so targeting cell division through microtubule can be an important tool for cancer chemotherapy. We have identified a



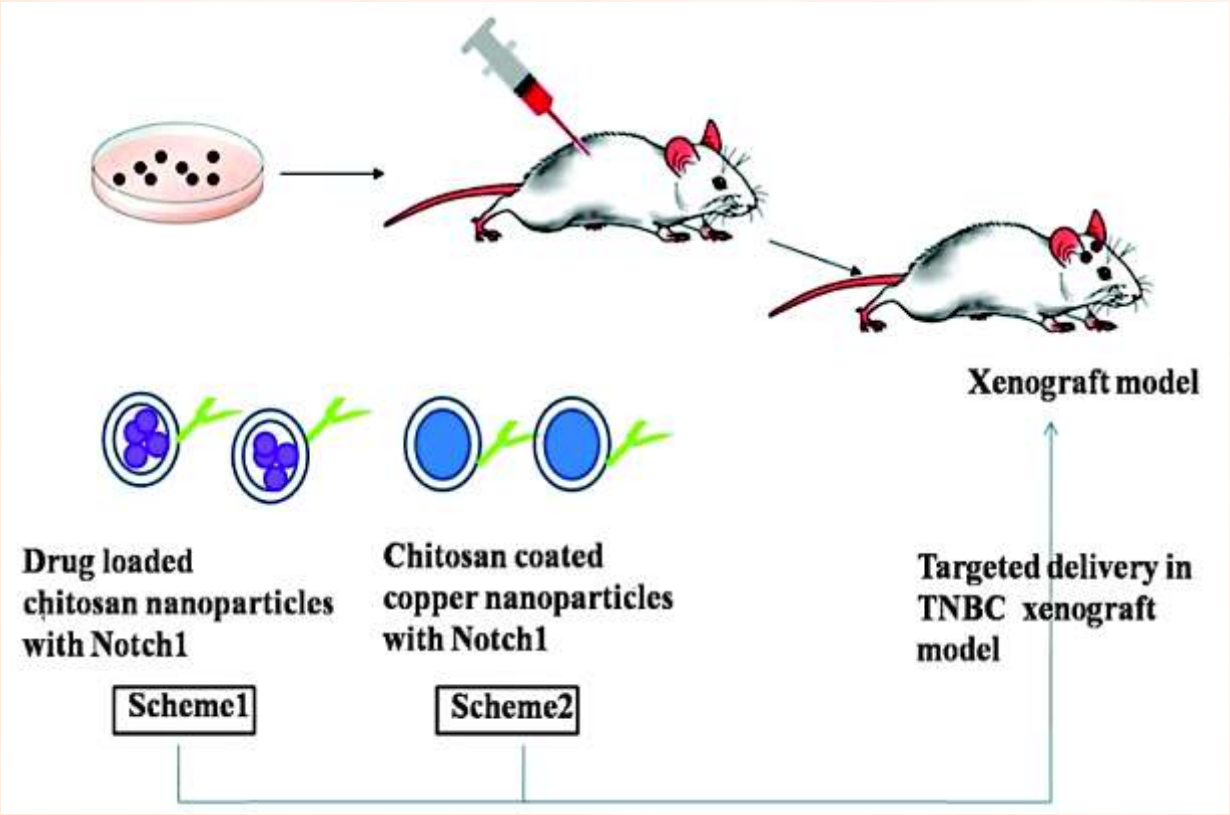
novel stilbene derivative (Z)-3-(3, 4-dimethoxyphenyl)-2-(3, 4, 5-trimethoxyphenyl) acrylonitrile (compound G) which causes microtubule depolymerization may leads to G2/M arrest. Several reports suggest that change in icrotubular dynamics leads to cellular stress including endoplasmic reticulum stress. Microtubule dynamic interfering agents such as paclitaxel (taxol), docetaxel (taxotere), vinblastine, vincristine, nocodazole, and colchicines have been involved in activation of the c-Jun N-terminal kinase/stress-activated protein kinase (JNK/SAPK) signaling pathway in a variety of human cells actually requires interactions with microtubules. A like other microtubule dynamic interfering agents compound G also activates JNK/SAPK pathway. Preliminary experiment in compound G treated condition we have found higher expression level of CHOP/DDIT3/GADD153, an important biomarker for ER stress. ER stress has been reported to be linked with activation of JNK/SAPK pathway. Thus, compound G mediated activation of JNK/SAPK pathway may have link with ER stress. So, in this project our first objective is to deduce whether the compound G mediated activation of JNK/SAPK is ER stress dependent or independent. Secondly, whether transforming growth factor-b-induced protein (TGFBI or keratoepithelin or βIg-h3), one of the ECM protein which has been implicated in a number of cellular disease processes including angiogenesis, tumor progression and metastasis has been found to be over-expressed at RNA and protein level in treated condition. TGFBI, a 68-kDa protein contains four conserved fasciclin-1 (FAS1) domains and a C-terminal RGD integrin-binding sequence. TGFBI mediates integrin binding to ECM proteins such as collagen, laminin and fibronectin. TGFBI binding to integrins has been related to the activation of cell proliferation, adhesion, migration and differentiation. This protein is up- regulated in human tumors of the colon, renal, pancreas, whereas it is down-regulated in breast cancer and lung cancer. TGFBI has conflicting roles in cancer progression. Depending on the tissue, TGFBI functions as an oncogene or tumor suppressor. Recent reports suggest TGFBI sensitizes ovarian cancers to paclitaxel via FAK- and Rho-dependent stabilization of microtubules by binding to integrin. Another interesting fact is that in benign to malignant breast



cancer the expression of TGFBI decreases drastically and acts as a biomarker for breast cancer progression. So, now question arises does TGFBI over-expression sensitize the cancer cells to compound G through integrin-FAK pathway? If not what is the role of TGFBI over-expression in relation to treatment of compound G? How compound G induces the over expression of TGFBI? As reports suggests that JNK signalling pathway activates during TGFBI over-expression and in our system c-JUN part of an important transcription factor (AP1), is highly expressed in treated condition so our third objective is to establish the role of AP1 and JNK pathway in relation to TGFBI over-expression in compound G treated condition.

© **Development of nanoparticle mediated treatment strategy to target NOTCH1 in triple negative breast cancer (TNBC) Xenograft model:** *in collaboration with Prof. Parimal Karmakar, Jadavpur University.*

The tumors with estrogen negative, progesterone negative and HER2-negative are known as triple-negative (TN) tumors and account for about 15% of breast tumors. These cells have poor prognostic outcome compared with other types of breast cancer. Treatment of TNBC limited due to the lack of a therapeutic target and as a result, these cells are chemo-resistance. As a matter of fact, Notch signalling pathway also have great role for chemo-resistance. These signalling pathway is a conserved pathway that has been involved in the determination of cell fate and self-renewal of a variety of cancer cells. This possible link between Notch signaling and breast cancer was established and Notch-1 exert an influence in tumor metastasis and proliferation in vivo. It was also shown that the expression of Notch 1 was enriched in triple negative breast cancer cells, where as



normal breast cells exhibited very low or no dateable noth1 expression. However, the increased expression of Notch-1 in triple negative breast cancer has been associated with malignant tumor behavior and poor prognosis.

To overcome this problem, nanoparticles may be used to deliver the drug in different cancer cells both in vitro and in vivo system. our focus is to delivery of drug loaded chitosan nanoparticles and copper coated chitosan nanoparticles tagged with Notch1 antibody for TNBC therapy. Due to its unique polymeric cationic character, chitosan has been extensively examined for the delivery system. We tried to load several anti-cancer drug such as doxorubicin and methoxtrate with chitosan nanoparticles or metal based nanoparticles such as Cu or Zn coated with chitosan. As mentioned before, there is very good strong correlation between the expression of Noth1 and TNBC. So, our target is to conjugate the Noth1 antibody with these nanoparticles. Initially, we examined the effect of these nanoparticles (both Noth1 conjugated or without Notch1 conjugated) on different sub type of breast cancer cells such as MDA-MB-231 (ER^-, PR^-, $HER2^-$), MCF-7 (ER+, PR+/–, $HER2^-$), BT-474 (ER^+, PR^+, $HER2^+$), MDA-MB-453(ER^-, PR^-, $HER2^+$). Next, we will try to focus on the exact molecular mechanism of cell death. The mouse models of human cancer are valuable tools for cancer research. So, we will also develop the TNBC xenograft model in immunodeficient mouse. The targeted drug or nanodrug delivery through chitosan nanoparticles tagged with Notch1 antibody will be therapeutic approach for treatment of chemo resistant triple negative breast cancer cells. Successful development of this kind of strategy for targeted delivery in TNBC xenograft model has tremendous application for overcome chemo-resistance of TNBC.

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2. Banerjee S, Kumar M, Alokam R, Sharma AK, Chatterjee A, Jana K, Singh R, Yogeeswari P, Sriram D, Basu J, Kundu M (2016) Targeting multiple response regulators of Mycobacterium tuberculosis augments the host immune response to infection. *Scientific Reports*; 6: 25851.
3. Halder P, Kumar R, Jana K, Chakraborty S, Ghosh Z, Kundu M, Basu J (2015) Gene expression profiling of Mycobacterium tuberculosis Lipoarabinomannan-treated macrophages: A role of the Bcl-2 family member A1 in inhibition of apoptosis in mycobacteria-infected macrophages. *IUBMB Life* 2015; 67:726-36.
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6. Roy P, Dhara D, Parida PK, Kar RK, Bhunia A, Jana K., Sinha Babu SP, Misra AK (2016) C-cinnamoyl glycosides as a new class of anti-filarial agents. *European Journal of Medicinal Chemistry*; 114:308-17.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Targeted delivery of nano-conjugated Methylglyoxal to cancer cells and understanding the bioenergetics difference between normal and malignant cells at molecular level.	DST
Assessment of the anti-cancer effect of Methylglyoxal in combination with conventional anti-cancer drugs at metronomic doses with special reference to cancer stem cells.	CSIR

Awards/Honours Received

Received Outstanding Scientist Award from Venus International Foundation, India on December 19, 2015.

Dr. Subrata Majumdar

Senior Professor

Scientific Reports

Early host-parasite interaction during lipid raft mediated entry of *Leishmania donovani* in mouse macrophages: *in collaboration with Dr. Suchandra Majumdar*

In Experimental Visceral Leishmaniasis, early host-parasite interaction involves Acid sphingomyelinase (Asmase) mediated ceramide generation leading to lipid raft microdomain formation on the membrane surface of the host macrophages facilitating *L. donovani* entry. *L.donovani* induces alterations of receptor crosstalk in the ceramide enriched lipid raft microdomains and PKC mediated downstream signaling pathway during early hour of infection in mouse macrophages.

Immunomodulatory role of a natural triterpinoid compound, ursolic acid against visceral leishmaniais: *in collaboration with Dr. Prasanta Saini*

Ursolic acid, a novel natural triterpinoid compound was isolated from the leaf of Nyctanthes arbortristis which shows the good antileishmanial activity against the amastigotes of *Leishmania donovani by in vitro study. It inhibits the parasitic burden at a concentration of 5µg/ml after 24 hours of incubations. Ursolic acid acts as a novel immunomodulator against visceral leishmaniasis by altering* the expression of IL-10, IL-12, IL-4 and TNF-α. In future this compound may be used as a good antileishmanial compound against visceral leishmaniasis.

Importance of sphingolipid metabolism in Ara-LAM mediated anti-leishmanial host immune response: *in collaboration with Bidisha Paul Chowdhury*

Leishmania donovani parasites disrupt the membrane architecture of the infected macrophages through ceramide generation resulting in infection establishment. Ara-LAM was found to reduce the ceramide level by inhibiting Ceramide synthase 2 and 5 and restored membrane integrity.

Consequently, PKCζ and PP2A activation was hindered leading to enhanced phosphorylation of Akt and P38MAPK. Simultaneously, we found an enhanced SphK1 level along with activated PKCα/βII in Ara−LAM pretreated infected macrophages. Thus, by regulating ceramide and sphingosine in a PKC dependent manner, Ara-LAM activated the macrophages for effective anti-leishmanial functions.

***Leishmania donovani* induced PGE2 generation is critically dependent on host TLR2-cPLA2 signaling:** *in collaboration with Amrita Bhattacharjee*

During VL, macrophage TLR2 plays an instrumental role in inducing PGE2 release from LD-infected macrophages. This PGE2 induction, mediated via the TLR2-PLC-PI3K signaling pathway, was found to be indispensible for activation of two major enzymes required for PGE2 generation; cytosolic phospholipase A2 (cPLA2) and cycloxygenase 2 (cox2). During infection cPLA2 activity increased >7 fold in a calcium-dependant and ERK-dependant manner, indicating that elevation of intracellular calcium and ERK mediated phosphorylation was necessary for LD-induced cPLA2 activation. For transcriptional upregulation of cycloxygenase 2 (cox2), activation of the calcium-calcineurin-NFAT signaling was required in addition to the TLR2-PLC-PI3K pathway.

***Mycobacterium inducus pranii (Mw)* mediated protection against visceral leishmaniasis by reciprocal regulation of host dual specific phosphatases:** *in collaboration with Shabina Parveen*

Mw, an immuinomodulator, reciprocally regulates DUSP1 and DUSP6 through TLR4 pathway. Association of PKCβ with DUSP6 increases by *Mw* treatment resulting into decreased IL-10, phosphorylation of ERK1/2 and Arginase1, whereas *Mw* treatment decreases association between PKCε and DUSP1 resulting into increased IL-12, phosphorylation of p38 and iNOS expression. Silencing of DUSP1 or over expression of DUSP6 in *L. donovani* infected BALB/c mice decreases parasitic burden by inducing IL-12 and reducing IL-10 production. We identify DUSP1 and DUSP6 as therapeutic targets, functions of which could be favorably modulated by *Mw*.

Dendritic cell mediated vaccination approach against experimental visceral leishmaniasis, critical role of TLR, NLR and PKCs: *in collaboration with Junaid Javed*

Leishmania donovani infection causes severe host immune-suppression through the modulation of pathogen recognition receptors (PRRs). In our study we have found that SLA-PGN stimulated dendritic cell based vaccination is showing promising results against *L. donovani* infection through TLR2 pathway and via the regulation of PKC β. Apart from TLRs recent studies focuses on the important contribution of NLR family member NOD1 and NOD2 as these receptors are capable of triggering host innate immunity. So in our study we are trying to explore the effect of NOD1 and NOD2 during *L. donovani infection.*

Mechanistic insight into tumor microenvironment regulation through ceramide: Role of immunomodulator(s) and protein kinases: *in collaboration with Sweta Ghosh*

Cisplatin, being a known anticancer drug is able to generate ceramide, which helps in the apoptosis of B16F10 melanoma cells. This still continues in PKCδ deficient cell by IRF1 mediated TNFα generation, which ultimately via ASMase and cPLA2 increases the ceramide. In another study, we found C2 ceramide can induce apoptosis in B16F10 cells, where PKCζ plays a major role. We also focused on the tumor microenvironmental regulation during MW treatment in

B16F10 containing tumor bearing mice. Initial results shows that there is no change in the percentage of Cancer stem cell due to treatment, which is majorly known as reason for tumor relapse.

Immunomodulatory role of *Mycobacterium indicus pranii* (MIP) against cervical cancer caused by Human Papilloma virus (HPV): *in collaboration with Priyanka Bhowmik*

Mycobacterium indicus pranii(MIP), previously known as *Mycobacterium w,* a saprophytic cultivable mycobacterium, has been found to be effective against leprosy, HIV infection, tuberculosis, Leishmaniasis and lung cancer. Heat killed MIP is reported to boost up the patient's immunity through the induction of a strong pro-inflammatory and CD4+ T helper 1 (Th-1) cells response. As induction of Th1 type of immune response is crucial in overcoming the immuno-suppressive tumor microenvironment, we sought to analyze the immunotherapeutic potential of MIP as an immunomodulator in cervical cancer caused by Human Papilloma Virus (HPV).

Publication

1. Banerjee S, Halder K, Ghosh S, Bose A and Majumdar S (2015) The combination of a novel immunomodulator with a Treg suppressing antibody (DTA-1) regress advanced stage B16F10 solid tumor by repolarizing tumor associated macrophages in situ; *Oncoimmunology*, Jan 30;4(3):e995559. eCollection 2015 Mar.PMID: 25949923.
2. Bandyopadhyay S, Bhattacharjee A, Banerjee S, Halder K, Das S, Paul Chowdhury B, Majumdar S (2015) Glycyrrhizic Acid Mediated Subduement of Myeloid Derived Suppressor Cells Induces Anti-Leishmanial Immune Responses In a Susceptible Host. *Infection and Immunity*. 83(12):4476-86.
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4. Bhattacharjee A, Majumder S, Bhattacharyya Majumdar S, Choudhuri SK, Roy S and Majumdar S (2015) Co-administration of Glycyrrhizic Acid with the antileishmanial drug Sodium Antimony Gluconate (SAG) cures SAG-resistant visceral leishmaniasis. *Int. J. Antimicrob. Chemother.* Mar;45(3):268-77. doi:10.1016/j.ijantimicag. 2014.10.023. Epub 2014 Dec 8.PMID: 25600891.
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6. Chowdhury BP, Bandyopadhyay S, Das S, Majumder S, Jha MK, Majumdar SB, Saha B, Majumdar S (2015) The Host-Protective Effect of Arabinosylated Lipoarabinomannan against Leishmania donovani Infection Is Associated with Restoration of IFN-γ Responsiveness. *PLoS One*. 2015 Feb 6;10(2):e0117247. doi:10.1371/journal. pone. 0117247. eCollection.

7. Das S, Bhattacharjee O, Goswami A, Pal N K, and Majumdar S (2015) Arabinosylated Lipoarabinomannan (Ara-LAM) mediated intracellular mechanisms against Tuberculosis infection: Involvement of Protein Kinase C (PKC) Mediated Signaling. *Tuberculosis*. Mar, 95(2):208-16. doi: 10.1016/j.tube.2014.11.007. Epub 2014 Dec 11. PMID: 2554431.

8. Das S, Halder K, Goswami A, Paul Chowdhury B, Pal N and Majumdar S (2015) Immunomodulation in host-protective immune response against murine Tuberculosis through regulation of the T regulatory cell function. *J. Leuko. Biol.* 98(5):827-36 pii: jlb.3A0315- 114R.

9. Gangalum P R, de Castro Waldione, Vieira L Q, Dey R, Rivas Luis, Singh S, Majumdar S and Saha B (2015) Platelet-Activating Factor Receptor Contributes to Antileishmanial Function of Miltefosine *J. Immunol,* 194(12):5961-5967.

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Students Awarded Ph.D.

Name of Student (University/Year)	Title of Thesis
Sayantan Banerjee (2016)	Characterization of the host immune response against solid tumor by reconditioning the immune effector cells
Satyajit Trpathy (2016)	Antimalarial efficacy of Chitosan nanoparticles conjugated Chloroquine against Plasmodium berghei NK65 infection: A mechanistic study.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Identification of the host cell factors responsible for survival and death of leishmania	DBT
Host phosphatases and kinases participating in CD40-induced anti-leiahmanial Vs Pro-leishmanial pathways	DBT
TLR2 dependent engagement of the host cell kinases and phosphatses that dictates disease progression or resolution.	DBT

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(i) Invited as a Key note Speaker in National Conference "CME in Immunology" during April 16-18, 2015 (ii) invited speaker at All India Institute of Medical Sciences, New Delhi on July 14, 2015.

Dr. Atin Kumar Mandal

Associate Professor

Scientific Reports

Role of Hsp90 in CRAF kinase regulation

Mammalian CRAF kinase requires continuous chaperoning by Hsp90 for its stability and activity. But the underneath reason for continuous dependence on Hsp90 is not clear. Using both yeast and mammalian cell culture we find that chaperones Hsp90 and its co-chaperone Cdc37 aid in maturation of CRAF by assisting autophosphorylation of S621 residue which is essential for CRAF stability and activity. Disruption of any of these two chaperones by genetic impairment (temperature sensitive mutant of yeast or siRNA) or chemical inhibitors (geldanamycin, celastrol) leads to impairment of CRAF S621 phosphorylation and hence accelerates CRAF degradation. Surprisingly, Hsp90 is not dissociated from CRAF in presence of Hsp90 inhibitor, geldanamycin. Interestingly, Hsp90 or Cdc37 inhibition does not have any effect on CRAF when protein synthesis was blocked with cycloheximide. This result suggests that folded CRAF is insensitive to Hsp90 or Cdc37 inhibition. However, Hsp90 binding is essential for CRAF functioning. To track the role of Hsp90, we overexpressed Hsp90 in mammalian cell instead of its inhibition that affects CRAF stability and found that Hsp90 overexpression upregulates MAPK pathway by activating CRAF kinase. Co-immunoprecipitation shows increased Hsp90 binding with CRAF when cellular Hsp90 level is upregulated and either in presence of active RAS or EGF stimulation. Surprisingly, this enhanced Hsp90 binding during stimulation facilitates actin recruitment, but not tubulin to CRAF and forms a transportosome that drives CRAF translocation to membrane for efficient RAS-CRAF association. Quite contrary, this function of Hsp90 does not require its ATPase activity. Thus, our finding establishes the bipartite role of Hsp90 that helps CRAF maturation during folding and actin recruitment to CRAF during mitogenic stimulation for its membrane translocation and interaction with RAS.

Structure determination of phospho-S621 CRAF peptide in presence of 14-3-3 protein

14-3-3 protein binds to the regulatory phosphorylation site S259 and autophosphorylation residue S621 of CRAF and regulates the activity of CRAF kinase. C-terminus of CRAF (aa 610-648) which contain the autophosphorylation S621 residue plays an important role in stability as well as activity of CRAF. But no structural information is available since C-terminus is flexible in nature. We took the strategy to obtain the structure of highly flexible C-terminus of CRAF in presence of purified 14-3-3 protein. Human 14-3-3ξ was cloned in bacterial vector and the protein was purified in homogeneity. Getting the structure of 38 mers synthetic phospho-S621 peptide in presence of 14-3-3 protein by solution NMR was unsuccessful due to overlapping peak in NMR. But, 16 mers phospho-S621 peptide interacted well with 14-3-3 protein but not with nonphospho-S621 peptide which establishes the specific interaction of phospho-S621 CRAF with 14-3-3 protein. We have obtained the random coil structure of the surrounding residue of phospho-S621 using NMR in presence of 14-3-3 protein. This work has been done in collaboration with Dr. Anirban Bhunia, Biophysics Department, Bose Institute.

Publication

1. Ghosh A, Ratha BN, Gayen N, Mroue KH, Kar RK, Mandal AK, Bhunia A (2015) Biophysical Characterization of Essential Phosphorylation at the Flexible C-Terminal Region of C-RAF with 14-3-3ζ Protein. *PLoS One* ,Aug 21;10(8).

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Group Member:

Joydeep Roy presented poster at 9th International Conference on Yeast Biology December 09-12, 2015, Kolkata on Triage decision of Hsp70 in clearing misfolded proteins for cell survival.

Dr. Nripendranath Mandal

Professor

| Scientific Reports |

Objectives

The major objectives of our laboratory is to concentrate on disease management in shrimp and human systems through two independent research programs, Marine Biotechnology and Medical Biotechnology, respectively, for the welfare of common people with the help of modern science and technology.

Achievements from Marine Biotechnology research

Identification and characterisation of a novel microsatellite DNA markers to identify disease resistant/ susceptible populations of marine giant black tiger shrimp, *Penaeus monodon:*

Giant black tiger shrimp, *Penaeus monodon* (Fabricius), a captured and cultured marine shrimp species has suffered persistent destruction due to pandemic diseases caused by several viral pathogens across the globe. Among these viral pathogens, white spot syndrome virus (WSSV) causative agent of white spot disease (WSD) creates severe destruction in shrimp production. Despite various efforts against WSD, the problem remains and continues to damage this industry, therefore, development of disease-resistant DNA marker is an alternative strategy to identify the disease-resistant broodstocks. Up till now, two DNA markers (71 bp microsatellite DNA marker and 457 bp RAPD-SCAR DNA marker) had been reported in *P. monodon* to identify the disease-resistant populations. Recently, 442 bp and 236 bp microsatellite DNA markers had been identified in *P. monodon* to recognize the disease susceptible population. These DNA markers were sequenced and found to be novel and thus were submitted to NCBI nucleotide database. Post challenge data showed that the rate of mortality among WSSV susceptible shrimps were significantly higher than the WSSV resistant shrimps which was further confirmed by quantitative real-time PCR data. WSSV prevalence and disease resistance prevalence using these two microsatellite DNA markers also suggests that Chennai and Port Blair followed by Vasco-Da-Gama (Goa), can be good places for collection of gravid females for further seed generation for sustainable WSSV resistant aquaculture. The strong positive correlation between these

two microsatellite DNA markers indicates that they can be regulated by similar mechanism and may be present in same QTL.

Achievements from Medical Biotechnology research

The Medical Biotechnology program is primarily oriented towards developing orally administrable drugs from various medicinal plants/algae/lichens against hepatotoxicity, inflammation and cancer. Moreover, we have also initiated studies on the anti-proliferative efficacies of BODIPY based organometallic fluorescent compounds.

Iron is one of the essential metals needed in our animal kingdom as it acts as the most common cofactor within the oxygen handling biological machinery. However, iron in excess, induced the overproduction of various free radicals which are not always effectively normalized by the internal antioxidant defense machinery, thereby causing oxidative stress induced disorders.No cost effective drug prevails in the market which could efficiently cure the iron overload induced diseases without casting any side effects. So, our approach in the Medical Biotechnology research is to develop some orally administrable medicine from natural resources for protection against iron-induced toxicity by chelating iron or by trapping free radicals (antioxidant). In addition to endogenous antioxidant systems, consumption of antioxidants rich natural supplements alters the redox environment thereby lowering risk of many oxidative stress-related diseases. Leaves of *Clerodendrum colebrookianum*, fruits of *Emblica officinalis* and *Prunus nepalensis* and an insectivorous plant, *Drosera burmannii*, exhibited excellent iron chelation as well as hepato-ameliorating potentials which can be used as sources of *orally administrable drugs* in the pathological sequence of iron-overload-linked liver disease and fibrosis.

The role of inflammation in cancer initiation and progression is well known and the relevant molecular mechanisms have been dissected widely. Moreover, evidence shows that inflammation also affects the effectiveness of cancer chemotherapy. Hence, the search for efficient anticancer agents of natural origin having potential anti-inflammatory activity, is the need of the hour. Flow cytometric and Western blot studies done in our lab proposed that 70% methanol extract of D. burmannii (DBME) selectively induced G2/M arrest and apoptosis in MCF-7 cells through upregulation of p53 and Bax/Bcl-2 ratio. Moreover, DBME also displayed a potent anti-inflammatory activity in murine macrophages by targeting the vital genes involved in inflammation.

Supramolecular metal-based complexes have been a hot topic of research owing to their capability of manipulating redox states in biological systems that opens enormous possibilities for utilizing metal-based compounds against various ailments like cancer. Moreover, when organometallic compounds are synthesized with BODIPY ligands, the resultant metallarectangles displayed fluorescence due to the co-existence of monomeric and aggregated species. The characteristic green fluorescence in Ru(II) and Ir(III) metalla-rectangles $[1]^{4+}$–$[4]^{4+}$containing such a BODIPY-based linker was used as a tracking tool by our laboratory under a confocal microscope to investigate the intracellular regions where the compounds were localized. Some compounds showed better toxicities against breast, cervical and glioblastoma cells than normal lung fibroblast cells and some showed activities even better than cisplatin against MCF-7 and U87 cell lines.

This wide field research contributes to our search for better and safer drugs against non-communicable diseases.

Publications

1. Chakrabarty U, Dutta S, Mallik A, Mondal D and Mandal N (2015) Identification and characterisation of microsatellite DNA markers in order to recognise the WSSV susceptible populations of marine giant black tiger shrimp, *Penaeus monodon*. *Veterinary Research* 46: 110. DOI: 10.1186/s13567-015-0248-2. (Impact factor: 2.982).

2. Chaudhuri D, Ghate N B, Panja S, Das A and Mandal N (2015) Wild edible fruit of *Prunus nepalensis* ser. (steud), a potential source of antioxidants, ameliorates iron overload-induced hepatotoxicity and liver fibrosis in mice. *PLoS ONE* 10(12): e0144280. DOI:10.1371/journal.pone.0144280. (Impact factor: 3.057).

3. Das A, Chaudhuri D, Ghate N B, Panja S, Chatterjee A and Mandal N (2015) Protective effect of *Clerodendrum colebrookianum* leaves against iron-induced oxidative stress and hepatotoxicity in Swiss albino mice. *Indian Journal of Experimental Biology* 53:281-291. (Impact factor: 1.165).

4. Ghate N B, Chaudhuri D, Das A, Panja S, and Mandal N (2015) Anantioxidant extract of the insectivorous plant *Drosera burmannii* vahl. alleviates iron-induced oxidative stress and hepatic injury in mice. *PLoS ONE* 10(5): e0128221. DOI:10.1371/journal.pone.0128221. (Impact factor: 3.057).

5. Ghate N B, Das A, Chaudhuri D, Panja S and Mandal N (2016) Sundew plant, a potential source of anti-inflammatory agents, selectively induces G2/M arrest and apoptosis in MCF-7 cells through up regulation of p53 and Bax/Bcl-2 ratio. *Nature-Cell Death Discovery* 2, 15062. DOI:10.1038/cddiscovery.2015.62.

6. Gupta G, Das A, Ghate N B, Kim T H, Ryu J Y, Lee J, Mandal N and Lee C Y (2016) Novel Bodipy-based Ru (ii) and Ir (iii) metalla-rectangles: cellular localization of compounds and their antiproliferative activities. *Chemical Communications* 52, 4274-4277. DOI:10.1039/C6CC00046K. (Impact factor: 6.567).

7. Sarkar R, Hazra B and Mandal N (2015) Amelioration of iron overload induced liver toxicity by a potent antioxidant and iron chelator, *Emblica officinalis* Gaertn. *Toxicology and Industrial Health* 31 (7): 656-669. DOI: 10.1177/0748233713483195. (Impact factor: 1.859).

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Molecular characterization of developed DNA markers linked to disease resistance/ susceptibility in giant black tiger shrimp, *Penaeus monodon*	DST-SERB
Identification and characterization of micro RNAs (miRNAs) in *Penaeus monodon*	DBT
Exploration of Lichens from Barak Valley of Southern Assam and Arunachal Pradesh (North East India) and Isolation of Phytochemicals and Bioprospecting of some selected Lichens species	DBT-NER Twinning

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(i) Attended the national seminar on the "New Education Policy (NEP) of the government of India", held on 7-8 November 2015 at RK Mission Institute of Culture, Golpark, Kolkata organized by Vidyarthi Vikash, RK Mission Institute of Culture, RK Mission Vivekananda University, Belur Math, Howrah, and AICTE, New Delhi, India; (ii) delivered an invited lecture on "Role of DNA markers to control white spot disease (WSD) in marine shrimp aquaculture" at the International Conference on "Aquatic Resources and Sustainable Management" held on February 17 - 19, 2016 at Science City, Kolkata organized by Central Calcutta Science and Culture Organization for Youth (CCSCOY), Kolkata, India; (iii) delivered a special invited lecture on "Sundew plant: Source for drug against multiple non-communicable diseases" at the International Conference on "Innovative Approaches in Applied Sciences and Technologies" held on February 01-05, 2016 at Kasetsart University, Thailand organized by Scientific Educational Research Society (SERS), Meerut, India and Kasetsart University, Bangkok,Thailand; (iv) delivered a special invited lecture on "Role of Biotechnology based research in the field of disease management" at the National conference on "Bioresources & Bioproducts: Ancient to Recent" held on January 20, 2016 organized by Dept. of Zoology, University of Gour Banga, Malda, India; (v) *delivered a special invited lead lecture on "A tropical lichen, Parmotrema reticulatum,* could be a source for better medicine to combat cancer and inflammatory diseases" at the National Conference on Cryptogam Research in India: Progress and Prospects held on September 28 – 29, 2015 organized by Indian Lichenological Society (ILS) NBRI, Lucknow.

Symposia and Seminar Organized

Arranged a seminar, on November 24, 2015 at 12:00 (Noon) at annex building seminar room where Dr. Grant Lewison, Kings College, London delivered a lecture on "New Methods to Evaluate the Quality and Impact of Biomedical Research".

Awards/Honours Received

1. Elected Fellow of Scientific and Educational Research Society (SERS), Meerut, 2015 for outstanding contribution in the field of Cancer Research.
2. Delivered invited lecture, felicitated, presided over as Chairperson of a technical session and Patrons in the International conference on Innovative Approaches in Applied Sciences and Technologies held on February 01-05, 2016 at Kasetsart University, Bangkok, Thailand.

Socially Relevant

The laboratory, has been involved in two major fields of research viz., Marine and Medical Biotechnology that play extensive roles in addressing the crucial socio-economic problems in the field of disease management in shrimp as well as human systems.

To address a permanent remedy of white spot disease (WSD) in a cost-effective way, the Marine Biotechnology program is persistently working to develop various molecular biomarkers which could recognize the disease resistant populations among black tiger shrimps. DNA marker assisted selective breeding among disease resistant shrimps would be a very effective commercial strategy for long term disease control and a platform for understanding the molecular pathogenesis of WSD. This study will open a new arena for the generation of specific pathogen resistant (SPR) broodstock through marker

assisted selection (MAS) to give a new lease of life to the aquaculture industry and to prevent the huge economic devastation caused by WSD.

Combating various non-communicable diseases resulting from failure of anti-oxidant defence in humans is another basic problem in the society. Iron overload in a human body leads to oxidative stress induced diseases like anemia, heart failure, liver cirrhosis, fibrosis, diabetes, arthritis, depression, impotency, infertility and cancer. Despite the advancement in anticancer drug discovery, the rate of cancer incidences worldwide are astonishing, thereby highlighting the need for new therapies focusing on cancer cell and its microenvironment, including inflammation. There is a substantial scarcity of cheap, effective but safe drugs in the market which a common man could afford for a deserving treatment.

To address these vital issues, Prof. Mandal's **Medical Biotechnology** research program is constantly involved in finding prospective sources of orally administrable anti-inflammatory and anticancer drugs, and also the ones that ameliorate iron-overload induced hepatotoxicity. Four different natural resources were recently discovered to be excellent iron chelators and promising sources of drugs which significantly treat iron overload induced hepatic damage. The beauty of an effective anticancer drug resides in its ability to selectively kill cancer cells, while sparing the normal ones. *D. burmannii* was found to be a potential source of anti-inflammatory drug that selectively induces apoptosis in breast cancer cells. Moreover, Prof. Mandal's group has successfully screened out certain BODIPY based metal complexes which displayed selective toxicities against breast, cervical and brain cancer cells. Some of these organometallic compounds showed even better activity than cisplatin. Prof. Mandal's socially beneficial research would lead to the development of safer, cheaper and effective drugs against the deadly diseases, which would be easily available especially to the economically backward people.

Dr. Anup Kumar Misra

Professor

Scientific Reports

Synthesis and bioevaluation of organic small molecules and complex oligosaccharides of microbial origin

(a) Our laboratory is actively involved in the synthesis of medicinally relevant organic small molecules and their biological screening in different drug development program (e.g. cancer, enzyme inhibitors, antioxidant etc.) in collaboration with biologists of Bose Institute and other research institutes (Visva Bharati University, Tezpur Univ., JNU, SINP, NICED, CDRI).

(b) Our laboratory has also been engaged in developing chemical synthesis of several complex oligosaccharides found in the cell-wall of pathogenic bacteria for their use in the preparation of glycoconjugate derivatives. Glycoconjugates have emerged as successful synthetic vaccine candidates to control microbial infections. In collaboration with biologists, immunochemical studies with the synthetic glycoconjugates are ongoing (sponsored by DST and CSIR, New Delhi).

Publications

1. Dhara D, Misra AK (2015) Convergent Synthesis of Oligosaccharide Fragments Corresponding to the Cell Wall *O*-Polysaccharide of *Salmonella enterica* O53, *Chemistry Open* 4, 768-773.
2. Ghosh T, Misra AK (2015) Facile synthesis of the heptasaccharide repeating unit of the cell wall *O*-polysaccharide of enterotoxigenic *Escherichia coli* O139, *Chemistry Open* 5, 43-46.
3. Harale K R, Dumare N B, Singh D, Misra A K, Chhikara M K (2015) Synthesis of a tetrasaccharide and its glycoconjugate corresponding to the capsular polysaccharide of *Neisseria meningitidis* serogroup X and its immunochemical studies, *RSC: Adv.*; 5, 41332-41340.
4. Jana M, Misra A K (2015) Synthesis of trisaccharide and a tetrasaccharide repeating unit corresponding to the O-antigen of Shiga toxin producing *Escherichia coli* O177. *Tetrahedron*; 71, 3960-3965.
5. Misra AK, Bokor É, Kun S, Bolyog-Nagy E, Kathó Á, Joó F, Somsák L (2015) Chemoselective hydration of glycosyl cyanides to C-glycosyl formamides using ruthenium complexes in aqueous media, *Tetrahedron Letters,* 56, 5995-5998.
6. Mukherjee N, Parida P K, Santra A, Ghosh T, Dutta A, Jana K, Misra A K, Sinha B, Santi P (2016) Oxidative stress plays major role in mediating apoptosis in filarial nematode Setaria cervi in the presence of trans-stilbene derivatives, *Free Rad. Biol. Med.* 93, 130-144.
7. Roy P, Dhara D, Parida P K, Kar R K, Bhunia A, Jana K, Sinha B, Santi P, Misra AK (2016) C-Cinnamoyl glycosides as a new class of anti-filarial agents, *Eur. J. Med. Chem;* 114, 308-317.
8. Santra A, Ghosh T and Misra AK (2015) Synthesis of di- and trisaccharides related to the *O*-polysaccharide of *Shigella dysenteriae* type 8, *J. Carbohydr. Chem.* 34, 501-513.
9. Si A, Misra AK (2016) Expedient synthesis of the pentasaccharide repeating unit of the polysaccharide *O*-antigen of *Escherichia coli* O11, *Chemistry Open;* 5, 47-50.

Students Awarded Ph.D.

Name of Student (University/Year)	Title of Thesis
Manas Jana (C.U., 2016)	Synthesis of Oligosaccharides and Development of Synthetic Methodologies

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Synthesis of polysaccharide fragments of *Streptococcus pneumoniae* strains for the preparation of glycoconjugate derivatives	**DST SERB**
Synthesis of oligosaccharide fragments corresponding to *Salmonella* strains and their use in the preparation of glycoconjugate derivatives	**CSIR**

Dr. Mahadeb Pal

Associate Professor

Scientific Reports

Identification and purification of modulators of transcription factors from medicinal plant extracts and study their mode of actions

India is a rich source of plants with unique medicinal values. Plant extract containing various medicinal values have been known and methodically in use in various branches of traditional medicine. We have been carrying out projects to screen plant extracts for small molecules modulators of activity of transcription factors that are involved in various human diseases such as in cancer as well as neurodegenerative diseases. By using cell based reporter responsive to a transcription factor we have found two compounds from methanolic extracts of neem that activates heat shock factor 1 by unique mechanism. This compound ameliorates polyQ disease associated toxicity fly.

In parallel we are purifying activities from plant extracts carefully selected by literature study specific to a particular type of cancer such as colon cancer and prostate cancer. The project is progressing towards identifying mode of action which include target signalling network that is specifically modulated by the activity only in the cancer cells but not in the normal cells. We are also close to purification of an activity to possible single molecule level.

Understanding the role of promoter proximally positioned nucleosome in stress induced gene expression in human cells

In a healthy cell the majority of cellular stress-induced genes including the targets of various oncogenes and tumour suppressor genes carry transcriptionally engaged RNA polymerase II (pol II) but paused at promoter proximal location. An advantage of this preparatory phase is that pol II proceed to elongation mode soon after an activation signal is encountered without going for searching for the target gene promoter. A project in the lab is being pursued in understanding how the promoter proximal nucleosome is remodelled during transcription activation of the gene. We have results that support the idea that removal of the promoter proximal nucleosome is removed by a unique mechanism. We are now in the process to test how close a nucleosome to the promoter to be to be entitled to this unique mechanism. We are addressing as well if this mechanism varies with activators.

Understanding molecular mechanism of transcription control of heat shock protein chaperone upon thermal shock in human cells

Inducible form of heat shock proteins such as HSP70A1A and HSP70A1B play important role in maintaining cellular protein homeostasis. Over expression of these proteins have been correlated with different human pathologies such as inflammation, cancer and cardiovascular diseases. Relatively more is known on the association of the proteins with different diseases than

mechanisms that control it transcription. A project in the lab is to unravel mechanism of over expression of these proteins such as Hsp70A1A. Relatively less has been explored on the molecular mechanism of induction of Hsp70A1A under different stressors including heat shock. Also, it remains to be understood how transcription factors other than heat shock factor 1 (HSF1) control upregulation of Hsp70A1A transcription under a proteotoxic. Studies reveal association as well as cooperation of DNA break repair complex with transcription factor that executes cellular proliferative signal in the regulation of cellular heat shock response.

Understanding molecular mechanism of control of pro-inflammatory gene expression by heat shock factor 1 (HSF1) in human cells

For a healthy cell heat shock response is a protection mechanism and is upregulated as required basis to challenge an unfavourable extra and intra cellular stressful environments. The HSR is down regulated to basal level as the stress signal is removed. Various pathologies including cancer, and neurodegenerative diseases associate with inefficient regulation of proteotoxic stress response. It has been found that the inefficient regulation of HSR in these disease conditions is partly due to uncontrolled function of its central regulator heat shock factor 1 (HSF1). We are studying a potential direct link of HSF1 with key pro-inflammatory mediator to obtain insight into proteotoxicity induced inflammation.

Publications

1. Dhar G, Chakravarty D, Hazra J, Dhar J, PoddarA, Pal M, ChakrabartiP, Surolia A, Bhattacharyya B (2015) Actin-curcumin interaction: insights into the mechanism of actin polymerization inhibition; *Biochemistry* 54,1132-43.
2. Leonova KI, Brodsky L, Lipchick B, Pal M, Novototskaya L, Chenchik AA, Sen GC, Komarova EA, Gudkov AV (2013) p53 cooperates with DNA methylation and a suicidal interferon response to maintain epigenetic silencing of repeats and noncoding RNAs. ***Proc Natle Acad Sci (USA)*** 110-89-98.
3. Pal S, Bhattacharjee B, Mandal N C, Mandal S C and Pal M (2014) Chronic inflammation and cancer: potential chemoprevention through nuclear factor kappa B and p53 antagonism. *J Inflamm (Lond)* 11, 23. Review.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Role of DNA-dependent protein kinase in transcription control in human cells	DBT
Molecular mechanism of HSF1 mediated chromatin remodeling during transcriptional induction of human hsp70 by different stressors	DST

Dr. Gaurisankar Sa

Senior Professor

Scientific Reports

A. Intervention of oncogenic RAS-induced proliferative-signaling results activation of apoptotic-signaling

Although active-mutant *RAS* is primarily attested with potent transforming ability, the *RAS* oncogene has, in addition to its mitotic potential, an apoptogenic activity still yet poorly-understood. So, exploring the signaling circuit for the shift of RAS signals from pro-proliferative to death-effector pathways may provide us the molecular clue for the missing-link. Our systems biology and experimental approaches unveil that intervention of oncogenic RAS-induced RAF/ERK pro-proliferative pathway channelizes signal towards p38MAPK/JNK1 pro-death circuitry. Such apoptogenic signal ensures phosphorylation of p53 at transactivation domain for optimal activation. Cumulatively, our findings delineate hitherto unexplained but critical mechanisms in the role of active-mutant RAS as a signal-switch molecule that oscillates between survival and apoptogenic cascades. Our findings thus constitute a specific novel approach to tumor regression through the differential regulation of different MAP kinase family members downstream of RAS, may have a critically potential for therapeutic significance.

B. G-actin guides p53 nuclear transport: potential contribution of monomeric actin in altered localization of mutant p53

p53 preserves genomic integrity by restricting anomaly at the gene level. Till date, limited information is available for cytosol to nuclear shuttling of p53; except microtubule-based trafficking route, which utilizes minus-end directed motor dynein. The present study suggests that monomeric-actin (G-actin) guides p53 traffic towards nucleus. Histidine-tag pull-down assay using purified p53(1-393)-His and G-actin confirms direct physical association between p53 and monomeric G-actin. Co-immunoprecipitation data also supports the same. Confocal imaging explores intense peri-nuclear co-localization between p53 and G-actin. Furthermore, to address the atomistic details of the complex, dynamic model of p53:G-actin complex was generated based on crystal structure for both p53 and G-actin. The docked complex was undergone all atom molecular dynamics simulation using Schrodinger LLC molecular modelling suite in implicit solvent. Simulation revealed that p53 DNA-binding domain arrests very well the G-actin protein. Considering these findings, we hypothetized that point mutation in p53 structure, which destabilizes p53:G-actin complexation, results in mutant p53 altered sub-cellular localization. Three "hot-spot" p53 mutants (R273H, R175H and R249S) have been selectively chosen, to experimentally validate the predicted hypothesis. Our study suggests p53Arg249 form polar-contact with Glu152 of G-actin, which upon mutation, destabilizes the p53:G-actin interaction and results in cytoplasmic retention of p53R249S

C. Clonal deletion of anti-tumorogenic $IFN^{+}FOXP3^{-}CD8^{+}$ Treg cells confine tumor immunosurveillance

$Cd8^{+}$ T-regulatory cells are progressively emerging as crucial components of immune system. However, the functional diversity of $CD8^{+}$ Treg cells in tumor microenvironment remain obscure. The

scanty report suggests the presence of FOXP3-positive CD8+ Treg cells in tumor patients similar to CD4+ Tregs. At an early stage of tumor development, we identified a subset of FOXP3-negative $CD8^+CD25^+CD127^-$ Treg cell which is essentially IFN-positive. Unlike $CD8^+$ T-effecter cells, this Treg cell is equipped with other $CD8^+$ Treg cell signatures *viz;* KIR, CD122, EOS and can selectively target HLA-E-positive tumor cells. Contrasting to FOXP3-positive $CD8^+$ Tregs, this subset plays a divergent role in the tumor microenvironment. Adoptive transfer of this Treg subset detained tumor growth and inhibited $CD4^+$ Treg generation in tumor milieu. At the late stage of tumor development, when $CD4^+$ Treg cells dominate tumor-microenvironment, $CD4^+$ Tregs mediate the clonal deletion of this anti-tumorigenic $FOXP3^-IFN^+CD8^+$ Treg cells and ensures tumor immune evasion. This clonal deletion dictates a negative correlation between the $FOXP3^+CD4^+$ and $FOXP3^-CD8^+$ Treg cells in both experimental tumor models and clinical samples. Our findings suggest that this IFN-producing FOXP3-negative $CD8^+$ Treg subset can potentiate immune surveillance at an early stage of the tumor and hence maneuvering their profile can open up a new avenue in cancer immunotherapy.

D. Transcriptional regulation of FOXP3 requires integrated activation of both promoter and CNS regions in tumor-induced $CD8^+$ Treg cells

T-regulatory cells are upsurge in tumor microenvironment and induce immune-evasion. $CD4^+$ Treg cells are well characterized whereas the role of $CD8^+$ Tregs in cancer has recently started to crease attention. Here we report an augmentation $CD8^+FOXP3^+$ Tregs in breast tumor microenvironment. FOXP3, the lineage-specific transcription factor, is a dominant regulator of Treg cell development and function. FOXP3 is induced preferentially by divergent signalling in $CD4^+$ Treg cells. But how *FOXP3* is induced and maintained in tumor-$CD8^+$ Tregs is the Cinderella of investigation. We observed that RUNX3, a $CD8^+$ lineage-specific transcription factor, binds at the *FOXP3*-promoter to induce its transcription. In addition to promoter activation involvement of *cis*-elements CNS1 and CNS2 in the transcriptional regulation of *FOXP3* was also evident in these cells. SMAD3 binds to CNS1 region and acts as transcription inducer, whereas GATA3 plays a temporal role in the *FOXP3* transcription by differential chromatin modification in CNS regions. In CNS1 region, GATA3 acts as repressor for *FOXP3* in naïve $CD8^+$ T cells. Whereas in $CD8^+$ Tregs GATA3 binds directly at CNS2 region and persuaded the maintenance of *FOXP3*. Therefore, intervention of these concerted transcriptional machineries may have a therapeutic potential in immunotherapy of cancer.

Publications

1. Bose, S, Panda AK, Mukherjee S & Sa G (2015) Curcumin and tumor immune-editing: Resurrecting the immune system. *Cell Division,* 12;10:6. doi: 10.1186/s13008-015-0012-z. e-Collection.
2. Chakraborty S, Sarkar T, Roy D, Bhattacharya A, Chakraborty D & Sa G (2015) Multi-edged sword against cancer: ancient exotic spice. *Indian journal of Physiology & Allied Sciences.* 68(4): 129-150.
3. Panda AK, Bose S, Banerjee S, Chakraborty S, Kajal K & Sa G (2015) *Intratumoral immune landscape: Immunogenicity to* tolerogenicity *Austin J Clinical Immunol.* 2(1), 1025.
4. Saha T, Kar RK & Sa G (2015) Structural and Sequential context of p53: A review of experimental and theoretical evidence. *Progress Biophy. Mol. Biol.* 117,250-263.

5. Saha S, Mukherjee S, Majumder M, Manna A, Khan P, Adhikary A, Kajal K, Jana D, Sa G, Mukherjee S, Sarkar DN and Das T (2015) Mithramycin A sensitizes therapy-resistant breast cancer stem cells towards genotoxic drug doxorubicin. *Translational Res*. 165, 558-577.

6. Saha S, Bhattacharjee P, Guha D, Kajal K, Khan P, Chakraborty S, Mukherjee S, Paul S, Manchanda R, Khurana A, Nayak D, Chakrabarty R, Sa G, Das T (2015) Sulphur alters NFκB-p300 cross-talk in favour of p53-p300 to induce apoptosis in non-small cell lung carcinoma. *Int. J. Oncol*. 47,573-582.

Students Awarded Ph.D.

Name of Student (University/Year)	Title of Thesis
1. Dr. Shravanti Mukherjee Calcutta University (2015)	Getting into the root of breast cancer metastasis: Role cancer stem cells.
2. Dr. Shilpi Saha Calcutta University (2016)	Understanding the mechanisms of chemo-resistance in breast cancer stem cells: An approach towards molecular Intervention.
3. Dr. Abir K. Panda Calcutta University (2016)	Epigenetic regulation of T-cell plasticity in tumor microenvironment.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
(As Co-PI) Mapping the molecular mechanisms of resistance-to-apoptosis switch over of non-small-cell lung carcinoma by curcumin: An approach towards chemo-sensitization.	DST
(As Co-PI) Binning stochastic phenotypic states of cancer cell population in different color box.	DBT
(As PI) *Targeted alteration of MAPK family members ERK and p38MAPK/JNK to* channelize oncogenic *Ras*-induced proliferative-signaling into apoptotic-signaling.	DST
(As PI) miR 325: a Distinct miRNA that controls T regulatory cell development and function.	DST

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(I) Invited to deliver a talk at Immunology Network (SIgN) at Agency for Science, Technology, and Research (A*STAR), Singapore in February 2016 (ii) chaired a scientific session and delivered an invited lecture in the *4th International Conference in Angiogenesis: Technology & Therapeutics*, at SASTRA University, Thanjavur, in 2015 (iii) chaired a Scientific Session and delivered an invited talk at the *6th International Conference on Stem Cells and Cancer*: *Proliferation, Differentiation and Apoptosis*, held at Pune in 2015 (iv) Invited to deliver a talk in the National Conference on *Exploring the Modern Approach in Biological Science: From Genome to Organism* at the Department of Zoology, Sidho Kanho Birsha University, Purulia, in 2015 (v) gave an invited lecture in *XVII All India Congress of Cytology and Genetics & International Symposium on "Exploring Genomes: The New Frontier"* held at CSIR-Indian Institute of Chemical Biology, Kolkata, in 2015 (vi) delivered an invited lecture and chaired a scientific session at the *International Conference on Cancer Research: New Horizons*, at NCCS, Pune in 2015 (vii) delivered invited lectures at the *National Conference on Frontiers in Translational and Regenerative Biology*" at University of Calcutta in 2016 (viii) delivered invited lecture on *Trends in physiological researches from Laboratory to community,* at Vidyasagar University, Midnapore. (ix) delivered invited lecture on *Consortium for an integrated research on molecular medicine: Search for novel biopharmaceuticals from natural resources* at West Bengal State University, Barasat, in 2016 (x) attended and delivered an invited talk in the 32th Annual Convention of Indian Association for Cancer Research in 2015 at Jaipur.

Seminar organized

Organized a *Conference of Indian Society of Translational Research* at Bose Institute, Kolkata in 2015.

Dr. Parimal C. Sen

Senior Professor

Scientific Reports

Synthesis and antitumorigenic activities of nanoencapsulated nifetepimine: A promising approach in treating triple negative breast carcinoma: *in collaboration with Dr. Mrinal K. Ghosh, IICB, Kolkata and Dr. Arijit Chakraborty, Maulana Azad College, Kolkata*

Triple-negative breast cancer (TNBC) is one of the most common invasive malignancies among women, associated with very poor prognosis. Over the past few decades standard chemotherapy nonspecifically targets all dividing cells, resulting in dose-limiting toxicities. In this study, we demonstrated a strategy of encapsulating a water insoluble synthetic compound, nifetepimine, shown to exert anticancer properties, in *poly (lactic-co-glycolic acid*) (PLGA) nanoparticles by a modified emulsion diffusion evaporation method to increase selectivity of drug to cancerous cells with minimum toxicity towards normal cells. Nanoencapsulated nifetepimine (nanonifetepimine) was successfully internalized inside breast cancer cells resulting in apoptosis up to 85% through mitochondria dependent pathway which also involved an overload of calcium triggered by reactive oxygen species (ROS) generation. Moreover, following cellular uptake, nanonifetepimine was shown

to be transported inside the nuclei of cells thereby regulating cell growth, proliferation and ultimately apoptosis. The nanoformulation showed dose-dependent cytotoxicity to breast cancer cells and significantly lower cytotoxicity against normal mammary epithelial cells. An *in vivo* bio-distribution study indicated that nanonifetepimine selectively accumulated into breast tumor sites of mice treated with nanonifetepimine, primarily due to prolonged circulation in the blood and binding to a receptor (EGFR) that remains over expressed in most of the TNBC cells. In addition, following nanonifetepimine administration, we observed significant reduction in tumor size in breast tumor bearing mice with improved survival rate till 60 days implying high tumor targetability. However, treatment with native nifetepimine showed no significant changes in tumor size and all the mice died within a month.

Phemindole, a novel synthetic di-indole derivative maneuvers the store operated calcium entry to persuade potent anti-carcinogenic activity in human triple negative breast cancer cells: *in collaboration with Dr. Arghya Adhikary, CRNN, Calcutta University and Dr. Anup K. Misra, Bose Institute*

Triple-negative breast cancer (TNBC), is a special subtype of breast tumor which is characterized by lack of, three "receptors" estrogen receptors, progesterone receptors and human epidermal growth factor receptor 2 (HER2). This represents an important clinical challenge because these cancers do not respond to most of the available chemotherapeutic agents. Dietary indole and its derivatives have gained prominence as anti-cancer agents and new therapeutic approaches are being developed to target them against TNBC. But a major drawback with 3,3'di Indolyl methane (DIM) is their poor bioavailability and high effective concentration against TNBC. In the current study we report the synthesis of a novel synthetic analog of DIM, named as Phemindole as an effective anti-tumor agent against TNBC cells. In the present study, we enumerated that phemindole caused ROS mediated mitochondrial-dependent apoptosis in MDAMB-231 cells. Furthermore, phemindole mediated Store Operated Calcium Entry (SOCE) retardation favored inactivation of STIM1 and henceforth activated ER stress to induce apoptosis in TNBC cells. Simultaneously, phemindole was also found to restrict the *in-vitro* cell migration through its anti mitotic property and pFAK regulation. Studies extended to *ex-ovo* and *in-vivo* mice models further validated the efficacy of phemindole. Thus our results cumulatively propose phemindole as a new chemotherapeutic regime which might be effective to target the deadly aspects of the TNBC.

Publication

1. Ghosh A, Bhowmik A, Bhandary S, *Putatunda S*, Lashkar A, Biswas A, Dolui S, Banerjee B, Khan R, Das N, *Chakraborty* A, Ghosh M K and Sen P C (2016) Antitumorogenic function of nanoencapsulated nifetepimine: A promising approach in treating triple negative breast carcinoma; *Nanomedicine: Nanobiotechnology, Biology and Medicine*. 12,1973-1985.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
With Dr. Tanya Das as Co-PI Remodeling the cellular calcium homeostasis by ethyl-4-(3-nitro)-phenyl-6-methyl-2-oxo-1,2,3,4-tetrahydro-pyrimidine-5-carboxylate (Nifetepimine): A mechanistic approach towards cancer regression and immune rejuvenation	DAE

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Delivered a talk and Chaired a Session at the National Seminar on "Science, Technology and Innovation: Its Impact on Communities of N.E. India" during September 10-11, 2015, Guwati University.

Dr.Parames C Sil

Senior Professor and Coordinator

Scientific Reports

Studies on the mechanisms of bio-active molecules in organ pathophysiology

Main objectives

Research in our laboratory encompasses several major areas of organ pathophysiology (hepatotoxicity, gastropathy, neurotoxicity, and nephrotoxicity), diabetes, cancer and its protection via bio-active molecules.

However, special emphasis is placed upon

- To understand the mechanisms of antioxidant potentials of phytochemicals.
- Chemical and drug induced mechanisms of cell injury/death (both in vivo and in vitro).
- Studies on the signal transduction mechanism of cell death and survival.
- To understand the anti-cancer potential of different phytochemicals and synthesized derivatives.
- Targeted drug delivery through different nanoparticles to enhance the efficiency.

Curcumin provides protection to spleen from inflammation and ER dependent apoptosis in diabetic pathophysiology

Spleen is a secondary lymphoid organ and plays an active role in the immune system by producing various antibodies. Chronic hyperglycemic state in diabetes leads to damage of various organs including spleen due to oxidative stress. Present study has been conducted to explore the role of polyphenolic curcumin on spleen tissue in diabetes. For this purpose adult male Wistar rats were made diabetic by injecting them with a single intraperitoneal dose of streptozotocin (STZ, at a dose of 65 mg/kg body weight). Animals with blood glucose level above 300 mg/dL were considered as diabetic. Consistent with our previous studies we observed reduction in the body weight as well as serum insulin level and increment in the oxidative stress related parameters in the type-1 diabetic model. In addition, damage spleen anatomy with depleted white pulp has also been found in the same group. Investigation of the cellular mechanism for the oxidative stress dependent and inflammation mediated splenic damage in diabetes showed upregulation in the level of different proinflammatory cytokines (TNF-α, IL-1β and IL-6), chemokine (MCP-1), adhesion molecules (ICAM-1 and VCAM-1) and translocation of

transcription factor NF-κB in the nucleus. Activation of the downstream signaling molecules of NF-κB like COX-2 and iNOS were also observed in diabetes. Moreover, upregulation in the expression of phospho-eIF2κ, GRP-78, CHOP, calpain-1, caspases (12 and 3) and phospho JNK has been found in case of endoplasmic reticulum (ER) dependent apoptotic death of the spleen cells under hyperglycemic state. However, curcumin at oral dose of 100 mg/kg body weight ameliorate all the changes to a significant extent near to control. This study suggests curcumin provide protection to spleen in diabetes by attenuating the upregulation of various proteins related to inflammation and cell death. Therefore, it could be a probable candidate for the treatment of oxidative stress mediated splenic damage in diabetes. Data of this study is about to publish.

Silymarin attenuates thioacetamide induced liver injury

Silybum marianum, commonly known as milk thistle has been used for long for the treatment of liver and gallbladder disorders, including hepatitis, cirrhosis, jaundice etc. Silymarin is a mixture consisting of flavonolignans and flavonoids and the remaining 20-30% consisting mainly of polyphenolic compounds. Silymarin has been shown to possess a wide range of biological and pharmacological effects, including antioxidant activity, cell regeneration ability, anticancer effects, antidiabetic activity, cardioprotection, anti-inflammatory, hypolipidemic, neuroprotective, and immune modulative effects. Thioacetamide (TAA) is a well-documented liver toxin. To elicit its hepatotoxic effects, TAA requires oxidative bioactivation, leading first to its S-oxide (TASO) and then to its chemically reactive S,S-dioxide (TASO2) form, which ultimately modifies amine-lipids and proteins. Our study has been designed in a TAA exposed mice model to investigate whether silymarin could protect liver cells against TAA exposed cellular damage and oxidative stress and if so, what molecular pathways it utilizes for its protection.

For this study, we have performed western blot analysis to detect different proteins. We have also performed flow cytometric analysis and DNA fragmentation analysis. We have measured the activity of different antioxidants and mitochondrial membrane potential and also measured the intracellular ROS level. We also have performed RT-PCR analysis to detect different genes at transcript level.

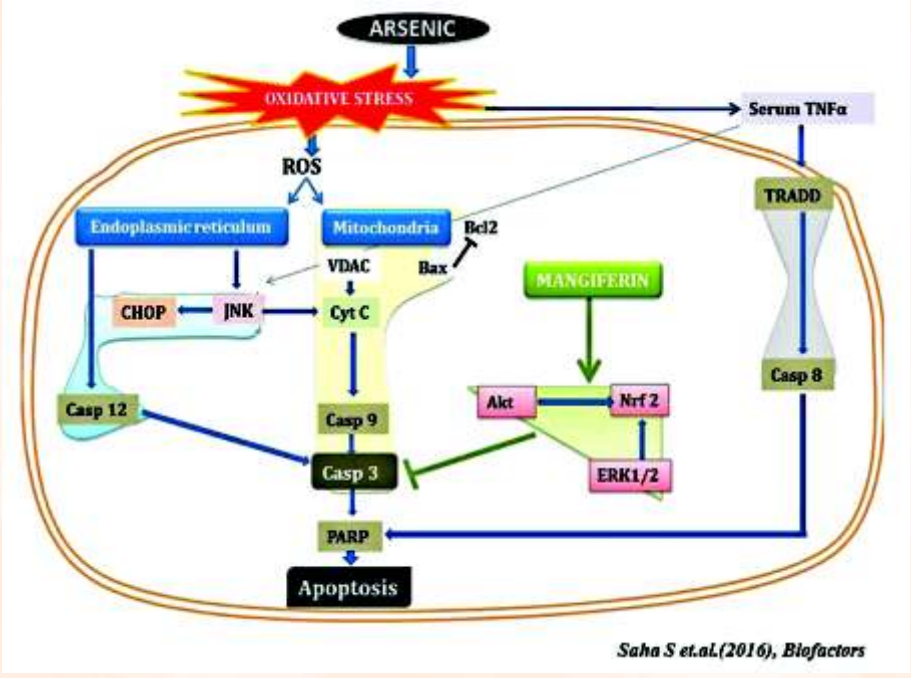
Improving the bioavailability of curcumin by pegylation and the administration of Mesoporous silica nanoparticles

Curcumin (obtained from *Curcuma longa*) has been found to be effective against many diseases like diabetes, cancer, etc. In spite of its wide range of pharmacological and therapeutic effects, its poor solubility as well as low bioavailability remains a major drawback.

Mesoporous Silica Nanoparticles (MSN) is one of the major emerging drug delivery systems. We have loaded curcumin into the MSNs and studied its effect in breast cancer cell lines. Results showed that MSN mediated delivery of curcumin not only enhance the bioavailability of curcumin thereby showing its therapeutic activity at a relatively lower dose. Study showed that at the same concentration there was a threefold increase in the percentage of apoptotic cells in case of MSN-Cur compared to free curcumin. In vivo studies also showed improved bioavailability of MSN-Cur. Then we have modified MSN by pegylation and loaded with curcumin. The distribution of this conjugate has been shown by in vivo imaging.

Prophylactic role of mangiferin in oxidative stress-mediated liver dysfunction in arsenic intoxicated murines

Mangiferin, a natural xanthone derived mainly from mangoes, possesses great potentials, antioxidative being a primary one. The present study has been carried out to investigate the hepatoprotective role of mangiferin, against arsenic-induced oxidative damages in the murine liver. Arsenic, a well-known toxic metalloid, is ubiquitously found in nature and has been reported to negatively affect nearly all the organs of the human body via oxidative injury. Administration of As in the form of sodium arsenite (NaAsO2) at a dose of 10 mg/kg body weight (3 months) abruptly increased reactive oxygen species (ROS) level, led to oxidative stress and significantly depleted the first line of antioxidant defense system in the body. Moreover, arsenic caused apoptotic cell death in hepatocytes. Treatment with mangiferin at a dose of 40 mg/kg for body weight for 30 days simultaneously and separately after NaAsO2 administration decreased the ROS production and attenuated the alterations in the activities of all antioxidant indices. Mangiferin also protected liver against the NaAsO2-induced apoptosis and disintegrated hepatocytes, thus counteracting with arsenic-induced toxicity. It could significantly inhibit the expression of different proapoptotic caspases and upregulate the expression of survival molecules such as Akt and Nrf2. On inhibiting Akt (by PI3K inhibitor) and ERK1/2 (by ERK1/2 inhibitor) specifically, caspase 3 got activated abolishing mangiferin's protective role on arsenic-induced hepatotoxicity. So here, we have briefly elucidated the signaling cascades involved in arsenic-induced apoptotic cell death in the liver and also the detailed cellular mechanism by which mangiferin provides protection to this organ.

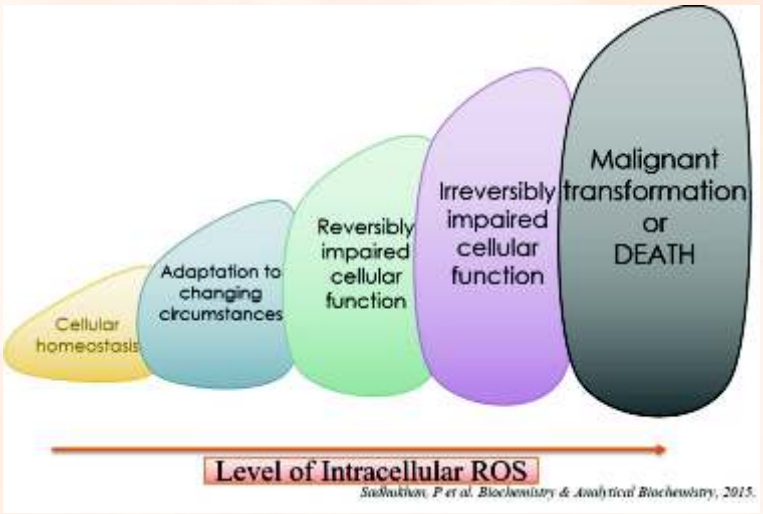


Selective anticancer activity of naturally occurring polyphenolic compounds and synthetic derivatives mediating oxidative stress

Cancer is one of the leading cause of death in most of the countries. Cancer develops when somatic cells mutate and escape the restraints that normally restrict them in their problematic expansion. Many signaling pathways that are linked to tumorigenesis can also regulate the metabolism of ROS through direct or indirect mechanisms. High ROS levels are generally detrimental to normal cells, but the redox status of cancer cells usually differs from that of normal cells. Because of metabolic and signaling aberrations, cancer cells exhibit elevated ROS levels. On the contrary, it is also accepted that cancer

cells are more vulnerable to exogenous insult of ROS, therefore manipulation of the ROS level may be a way in specifically killing the cancer cells without harming the normal cell.

Selective induction of apoptosis in cancer cells barring the normal cells is considered as an effective strategy to combat cancer. In a present study, a series of bis-lawsone derivatives and bis-coumarin were assayed for their pro-apoptotic activity in different cancerous and normal cell lines using different cytotoxicity assay. These test compounds, were found to be effective in inducing apoptosis in many cells (such as CCF-4 cells and HeLa cells) among the different cancerous cell lines used in the study. The activity of these compounds, were again compared to a popular anticancer drug cisplatin, having limitation usage because of its nephrotoxic nature. In a study, with a bis-lawsone derivatives, 1j derivative showed very less toxicity to the normal kidney cells compared to cisplatin, thus, indicating the superiority of 1j as a possible anticancer agent. This compound was observed to induce apoptosis in the glioma cells by inducing the caspase dependent apoptotic pathways via ROS and downregulating the PI3K/AKT/mTOR pathway. Estimation of different oxidative stress markers also confirms the induction of oxidative stress in 1j exposed cancer cells. The toxicity of 1j compound toward cancer cells was confirmed further by different flow-cytometrical analyzes to estimate the mitochondrial membrane potential and cell cycle. The sensitivity of malignant cells to apoptosis, provoked by this synthetic derivative in vitro, deserves further studies in suitable *in vivo* models. These studies not only identified a novel anticancer drug candidate but also help to understand the metabolism of ROS and its application in cancer treatment. Different other projects are currently under progress where anticancer activity of different polyphenolic compounds such as mangiferin, genistein, gerberinol were tested and detailed molecular mechanism will be investigated.



Moreover, we intend to study the detailed mode of action of different effective compounds found in other cancer cells. Moreover, we would like to identify more active compounds, designed and synthesized with desired bioactive compounds. We would also like to extend this study on *in vivo* cancer models, and establish the molecular pathway by which these compounds induces cytotoxicity on tumor cells without affecting normal physiological conditions.

Role of carnosine in chemotherapeutic drug induced toxicity of spleen

cis-Diamminedichloroplatinum (cisplatin) is a widely used chemotherapeutic agent used to treat various types of solid tumors. Biodistribution of cisplatin to other organs due to poor targeting towards only cancer cells constitutes the backbone of cisplatin-induced toxicity. Although cisplatin-induced nephrotoxicity is well studied the adverse effect of this drug on spleen is not well characterized so far. Therefore, we have set our goal to explore the mechanism of the cisplatin-induced pathophysiology of

the spleen and whether carnosine, can ameliorate the pathophysiological response of spleen. We found a dose and time-dependent increase of the pro-inflammatory cytokine, TNF-α in the spleen tissue of the experimental mice exposed to 10 and 20 mg/kg of cisplatin. The increase in inflammatory cytokine leads to the activation of the transcription factor, NF-κB which aids in the transcription of other pro-inflammatory cytokines and cellular adhesion molecules. ROS production and oxidative stress also lead to the activation of NF-κB further augmenting inflammatory response. Cisplatin administration also leads to increased expression of iNOS that causes nitrosative stress. The additive effect of inflammation, oxidative stress and nitrosative stress results in activation of cellular stress-related MAP Kinase, JNK. Eventually, the persistence of inflammatory response and oxidative stress leads to apoptosis through extrinsic pathway via the activation of caspase 8. Carnosine has been found to restore the expression of inflammatory molecules and antioxidant to normal level through inhibition of pro-inflammatory cytokines, oxidative stress, NF-κB and JNK. It also protected the spleen from apoptosis induced by cisplatin. For the first time, our study elucidated the detailed mechanism of cisplatin-induced spleen toxicity and use of carnosine as a protective agent against this cytotoxic response. Future work will involve the investigation of the role of mitochondria and endoplasmic reticulum in cisplatin induced immunotoxicity.



Studying the pathophysiology of lungs under oxidative stress and screening of phytochemicals for their protective effects in lungs

Reactive oxygen species (ROS) acts as secondary messengers. They are produced by normal cellular metabolism. A balance between in the production and removal of ROS is required which is also termed as 'redox homeostasis'. This homeostasis is maintained with the help of several antioxidant enzymes like SOD, catalase, etc. In addition to these molecules vitamins, minerals and other such molecules also acts as scavenging agents and help to maintain the balance in the amount and production of ROS.

Under stressed conditions, the cells or the tissues have two options to either 'fight' i.e., generation of oxidative stress conditions and inflammation or 'flight' i.e., induction of apoptosis. Apoptosis is the last option left for a cell in order to fight a stressed situation. Thus generation of oxidative stress is a positive response to stimulate the defensive system of our body. However, the alteration in this homeostasis condition i.e., increased production of ROS, can lead to various pathophysiological conditions and diseased state. Increased production of ROS has been reported to promote cancer, gastrointestinal diseases, etc.

The role of ROS in the pathophysiology of lung diseases is well reported. Oxidative stress can lead to many diseased conditions like acute lung injury (ALI), chronic obstructive pulmonary disease (COPD), asthma, etc.

Therefore, we aim to explore the pathophysiology of lung under oxidative stress conditions. We will be establishing an oxidative stress model using agents like tBHP in both *invitro* (normal lung cell line) and *invivo* conditions (mice model). The aim is to screen for phytochemicals and other bioactive molecules that provide maximum protection under such stress conditions in lungs, both in *invitro* system and proceed with the treatment of the most effective one, in *invivo* model. Thereafter, a preliminary study of the molecular markers of oxidative stress will be screened first followed by biochemical studies. Thereafter, changes in the levels of marker proteins both at transcriptional and translational level both in-vitro and *invivo* will be monitored. Finally, histological sections will be analyzed to study the effective protection provided by the selected bioactive molecule.

Studies on the protective effects of some natural antioxidants against rotenone induced parkinson's disease in rat model

Parkinson's disease (PD) is a neurodegenerative disorder associated with motor dysfunctions. It is induced by the selective loss of dopaminergic neurons in the substantia nigra of the brain. Deposition of mutated α-synuclein protein in various parts of the brain along with the accumulation of neuromelanin and iron leads to the generation of Lewy bodies. In 2013, Parkinson's disease was reported amongst 53 million people and was the cause of 103,000 deaths worldwide. India is a country with varied ethnicity and an enormously large gene pool. Therefore, the susceptibility of different populations living in various regions of this country to different diseases is also varied. The prevalence of Parkinson's disease in India is nearly half of that reported in the western countries. In India, 70 per 100,000 people are affected by this disease but owing to the huge population of the country, the number of affected individuals is estimated to be about 7 million. The prevalence of this disease has been found to be quite common amongst the Parsi community of the country.

Pesticide exposure is a major environmental factor for the induction of neuronal disorders. Rotenone is one such pesticide which is reported to be a major causative agent for the induction of Parkinsonism. It is a complex I inhibitor which causes selective dopaminergic degeneration and α -synuclein accumulation. The use of rotenone as a pesticide and an organ pesticide is quite common in India. It is used for fishing in the villages. It also finds its applications in treatment of scabies, head lice, mites etc. As an organ pesticide, rotenone in its powdered form is applied in the vegetable gardens for killing the beetles, cabbage worms and other arthropods. However, bioaccumulation of this compound in fishes and vegetables and their subsequent entry into the human body when such contaminated food is being consumed induces toxicity.

The natural antioxidants help in reducing oxidative stress associated with different disease manifestations. Owing to their easy commercial availability, cheap price and practically no side-effects, natural antioxidants can be considered as potent therapeutic agents for the treatment of different diseases. Therefore, we want to preliminarily screen for the most potent neuro-protective effects of different natural antioxidants in maintaining viability of rotenone treated SH-SY5Y cells (Human neuroblastoma cells).

Following this study, we want to investigate the pathophysiological manifestations and signaling pathways associated with rotenone induced Parkinson's disease in rat model and their amelioration by the most potent protective molecule.

Neuroinflammation plays an important role in the progressive loss of nigral dopaminergic neurons. Inflammatory responses manifested by the increased release of pro-inflammatory cytokines, glial reactions and infiltration of T cells are important features of PD. Therefore, we want to study the role of inflammatory markers in the manifestation of rotenone induced toxicity.

Apoptosis, necrosis and autophagy are important cell death pathways associated with the pathogenesis of the disease. Therefore, we want to perform elaborate experimentations to determine the therapeutic effects provided by the most potent protective molecule against such cell death pathways in rotenone induced Parkinson model.

Publications

1. Banerjee S, Ghosh J, Sil PC (2016) Drug Metabolism and Oxidative Stress: Cellular Mechanism and New Therapeutic Insights. *Biochem Anal Biochem*, 5 (255), 2161-1009.1000255.

2. Das J, Sarkar A, Sil PC (2015) Hexavalent chromium induces apoptosis in Human Liver (HepG2) cells via redox imbalance. *Toxicol Rep* 2, 600-608.

3. Ghosh S, Banjerjee S, Sil PC (2015) The beneficial role of curcumin on inflammation, diabetes and neurodegenerative disease: A recent update. *Food Chem Toxicol* 83, 111-124.

4. Pal S, Ghosh M, Ghosh S, Bhattacharyya S, Sil PC (2015) Atorvastatin induced hepatic oxidative stress and apoptotic damage via MAPKs, mitochondria and ER dependent pathways. *Food Chem Toxicol* 83, 36-47.

5. Pal S, Sarkar A, Pal PB, Sil PC (2015) Protective effect of arjunolic acid against atorvastatin induced hepatic and renal pathophysiology via MAPK, mitochondria and ER dependent pathways. *Biochimie* 112, 20-34.

6. Saha S, Sadhukhan P, Sinha K, Agarwal N, Sil PC (2016) Mangiferin attenuates oxidative stress induced renal cell damage through activation of PI3K induced Akt and Nrf-2 mediated signaling pathways. *Biochem Biophys Rep* 5,313–327.

7. Sinha K, Sadhukhan P, Saha S, Pal PB, Sil PC (2015). Morin protects gastric mucosa from nonsteroidal anti-inflammatory drug, indomethacin induced inflammatory damage and apoptosis by modulating NF-κB pathway. *Biochim. Biophys. Acta [General Subjects]* 1850,769-783.

SCIENTIFIC REPORTS

| V |
Basic and Applied Microbiology

Participation in Institutional Projects for the 12th Five-year Plan (2012-2017)

Dr. Sujoy K. Das Gupta (Coordinator), Dr. Pradeep Parrack, Dr. Subrata Sau, Dr. Tapan Datta, Dr. Wriddhiman Ghosh, Dr. Joyoti Basu, Dr. Manikuntala Kundu, Dr.Srimonti Sarkar, Dr. **Abhrajyoti** Ghosh

Introduction

The objective of Plan Program V is to investigate microbes using various molecular as well as genomic tools. The microbes being investigated include those which cause diseases, such as *Mycobacterium tuberculosis*, those that can be used to degrade complex environmental pollutants and finally those that are found in various environmental niches such as geothermal vents. A major component of our research is to trace the evolutionary origins of microbes and their genes, particularly those that are associated with novel functions. Using methods that include sequencing of genomes and metagenomes considerable insight into complex metabolic pathways that are environmentally and evolutionary important have been unraveled.

Dr. Joyoti Basu

Senior Professor

| Scientific Reports |

Genome-wide analysis for the identification of transcription factor MtrA binding genes of *M. tuberculosis*: *in collaboration with Dr. Manikuntala Kundu*

MtrA is an essential response regulator of two component systems of *M. tuberculosis* (Mtb). In order to obtain a comprehensive map of the genome-wide MtrA binding sites, ChIP-seq experiments were performed. Analysis of the sequencing data suggested that MtrA may regulate the transcription of at least 5 genes in exponentially growing Mtb. Functional classification showed that 23% of the total targets identified belonged to cell wall and cell processes, while 4 percent were classified under virulence, detoxification and Information pathway. Q-PCR analysis confirmed enrichment of genes associated with information pathway (*rpoB*); virulence, detoxification, adaptation (*relF*); regulatory proteins (*whiB4*) and cell wall and cell processes (*rpfA* and *rpfC*). Using electrophoretic mobility shift assays (EMSA), we have been able to show the presence of MtrA binding sites in the upstream promoter regions of the above mentioned genes. We also

observed that either overexpression of MtrA or knock down of MtrB in Mtb led to modulation in the transcription of *relF*, *whiB4*, *rpfA* and *rpfC* in vivo.

MicroRNA 26a regulates *Mycobacterium tuberculosis* (Mtb) mediated autophagy in a KLF4 dependent manner: *in collaboration with Dr. Manikuntala Kundu, Dr. Kuladip Jana and Dr. Umesh Gupta, CJIMOD, Agra.*

Microarray analysis of Mtb infected macrophages showed modulation of several miRNAs including miR 26a which was down regulated in both RAW 264.7 cells and bone marrow derived macrophages after Mtb infection. Downregulation of miR26a was also observed in the lungs of mice infected with Mtb for 12 weeks. 3'UTR analysis confirmed that KLF4 (a transcription factor) is a target of miR26a and expression of miR26a was increased in the infected cells. Upregulation of KLF4 is linked to the modulation of autophagy as well as bacterial survival in macrophages. Further elucidation of the signalling pathway linked to autophagy is in progress.

Publications

1. Gupta S, Banerjee SK, Chatterjee A, Sharma AK, Kundu M, Basu J (2015) Essential protein SepF of mycobacteria interacts with FtsZ and MurG to regulate cell growth and division, *Microbiology,* 161, 1627-38.
2. Kumar R, Sahu SK, Kumar M, Jana K, Gupta P, Gupta UD, Kundu M, Basu J (2016) MicroRNA 17-5p regulates autophagy in *Mycobacterium tuberculosis*-infected macrophages by targeting Mcl-1 and STAT3; *Cell Microbiol;* 18,679-691.
3. Sharma AK, Chatterjee A, Gupta S, Banerjee R, Mandal S, Mukhopadhyay J, Basu J, Kundu M (2015) MtrA, an essential response regulator of the MtrAB two-component system, regulates the transcription of resuscitation-promoting factor B of *Mycobacterium tuberculosis*; *Microbiology*, 161,1271-1281.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
With Dr. Manikuntala Kundu (Co-PI) The role of the secreted antigens Rv0009 of *Mycobacterium tuberculosis* in modulating signalling in macrophages (24.10.2015 – 23.10.2017)	DAE

Dr. Sujoy K Das Gupta

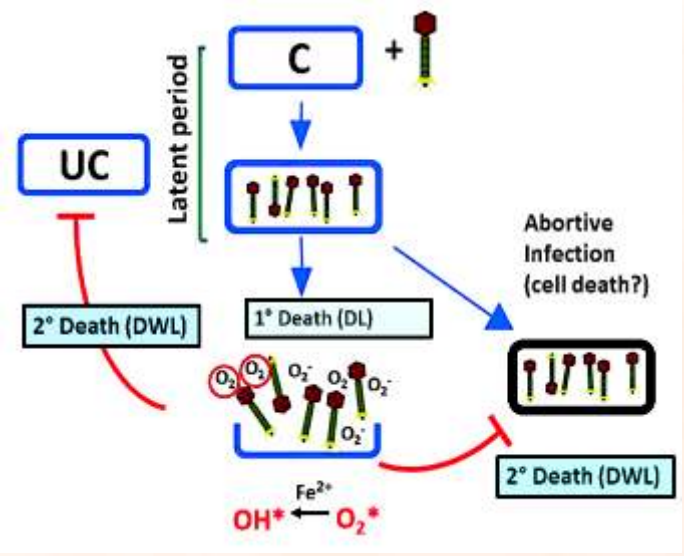
Senior Professor and Coordinator

Scientific Reports

Mycobacterial death without lysis induced by bacteriophage D29

Conventional drug-based strategies to eradicate the mycobacterial disease tuberculosis (TB) has had limited success, owing to the emergence of resistance strains. Conceptually, phage therapy using

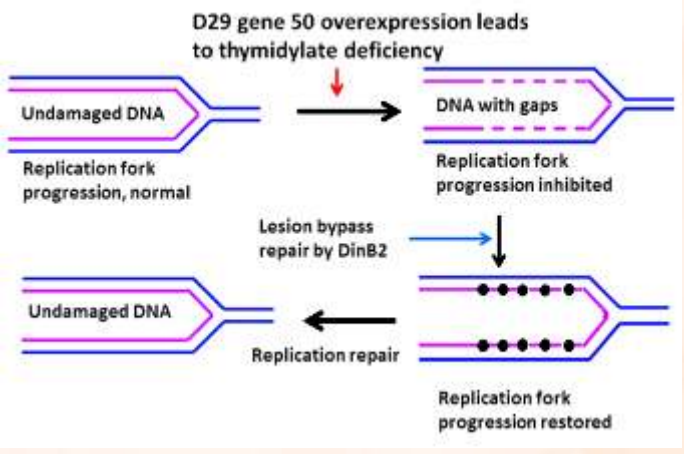
mycobacteriophages is an attractive alternative, which needs to be aggressively pursued. Using mathematical modeling and experimental methods, we have demonstrated that in addition to lysis, mycobacteria-specific phage D29 can bring about a significant reduction in the host cell viable count through a secondary mechanism involving the generation of reactive oxygen species (ROS). The information presented can potentially accelerate further development of phage-based therapeutics for TB.



A model to describe phage induced killing of host cells. Following phage infection a fraction of the host cells (C) are killed due to lysis (DL). This is the primary mechanism (1°) of cell death. Following lysis progeny viruses are liberated along with superoxide radicals which act on un-infected cells (UC) resulting in death without lysis (DWL).

A role for DinB2, a Y-family DNA polymerase, in mycobacterial survival under dTTP limiting conditions

We report that expression of a phage D29 derived gene encoding a class II ribonucleotide reductase in DinB2 deficient mycobacteria results in growth arrest. The observed effect was due to induction of a



Proposed model to illustrate the mode of action of the mycobacterial DNA repair enzyme DinB2. It helps mycobacteria to survive under thymine deficient conditions. The dark circles stand for uracil residues which are incorporated in place of thymine.

thymidylate limiting state in the affected cells and that ectopic expression of the gene for DinB2 reversed the phenotype. The information obtained indicates that DinB2 plays a crucial role in sustaining mycobacterial DNA replication under thymidylate deficient conditions. We have therefore unraveled an important function of the enigmatic DNA repair related mycobacterial protein DinB2.

Publications

1. Bhowmik P and Das Gupta SK (2015) Biochemical Characterization of a Mycobacteriophage Derived DnaB Ortholog Reveals New Insight into the Evolutionary Origin of DnaB Helicases. *PLoS One*. 10(8),e0134762.
2. Ghosh S, Samaddar S, Kirtania P, Das Gupta SK (2016) A DinB ortholog enables mycobacterial growth under dTTP limiting conditions induced by the expression of a mycobacteriophage derived ribonucleotide reductase gene. *J. Bacteriol* 198 (2), **352-362.**
3. Samaddar S, Grewal RK, Sinha S, Ghosh S, Roy S, Das Gupta SK (2015) Dynamics of Mycobacteriophage-Mycobacterial host interaction - evidence for secondary mechanisms for host lethality. *Appl Environ Microbiol* 82,124–133.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Understanding the evolutionary origin and mechanism of action of a putative primase polymerase encoded by the Mycobacterial plasmid pAL5000	CSIR

Dr. Tapan K. Dutta

Professor

| Scientific Reports |

Biochemical and molecular characterization of bacterial catabolic potential

An exhaustive biochemical and genetic characterization of the metabolic pathway for the assimilation of mono-nitrobenzoic acids have been performed in a soil isolate *Cupriavidus* sp. ST-14. Moreover, in the degradation of other substituted aromatics, it has been found that strain ST-14 has a clear preference on carboxy-hydroxy-substituted single ring aromatic compounds. Recent findings from our laboratory suggested that *strain* ST-14 can utilize a wide array of toxic anthropogenic and lignin derived phenylalkanoic acids such as phenylacetic acid (PAA), 2-hydroxyphenylacetic acid (2HPAA), 3-hydroxyphenylacetic acid (3HPAA), 4-hydroxyphenylacetic acid (4HPAA), 3-phenylpropionic acid (PPA), 3-(3-hydroxy) phenylpropionic acid (3HPPA) and 3-(4-hydroxy) phenylpropionic acid (4HPPA). 2HPAA, 3HPAA and 4HPAA degradation pathways have been elucidated by standard biochemical analyses which showed that these compounds are degraded via homogentisic acid as the pathway intermediate. Elucidation of the metabolic pathway of PAA, PPA and 3HPPA is still in progress along with the identification of relevant genes/proteins responsible for their assimilation.

In *Burkholderia* sp., BC1, the genetic characterization of a novel 2-naphthol degrading *nol* operon has been revealed and the presence of a unique ring hydroxylating dioxygenase system capable of dioxygenating 2-naphthol has been observed. Functional characterization of the dioxygenase towards various polycyclic aromatic hydrocarbons as well as other aromatic compounds has been investigated. Furthermore, a three dimensional structural model of 2-naphthol dioxygenase has been constructed to identify the important amino acid residues responsible for substrate binding and catalysis. Site directed mutagenesis studies to establish the importance of critical amino acid residues have been in progress.

In another study, regulatory mechanisms of catechol *ortho* and *meta*-cleavage pathway are being studied in *Sphingobium* sp. PNB. In strain PNB, degradation of phenanthrene proceeds *via* two distinct catabolic pathways involving 1-hydroxy-2-naphthoate and 2-hydroxy-1-naphthoate as metabolic intermediates which in turn enter the TCA cycle via common central metabolite, salicylate and catechol. In phenanthrene and 1-hydroxy-2-naphthoate grown cultures, catechol is metabolized to 2-hydroxymuconaldehyde acid via *meta* cleavage by catechol 2,3 dioxygenase. While in 2-hydroxy-1-naphthoate and salicylate grown cultures, catechol is metabolized to *cis*, *cis*-muconic acid via *ortho* cleavage by catechol 1,2 dioxygenase, in addition to *meta* cleavage pathway. Thus to decipher the possible mechanism by which catechol *ortho* and *meta* cleavage pathways are regulated in strain PNB during the degradation of phenanthrene and its metabolic intermediates are investigated based on chromatographic analysis, spectral assays as well as real time RT-PCR studies.

In a quest for identification of eukaryotic and prokaryotic (Gram positive and Gram negative) constitutive promoters from soil metagenomic samples, metagenomic libraries were constructed in promoter trap vectors consisting of dual reporter genes (EGFP and mCherry) and maintained into *Saccharomyces cerevisiae*, *Staphylococcus aureus* and *Escherichia coli*. All kind of libraries were screened through FACS for detection of reporter signal which will indicate the presence of cloned promoter fragment. Attempts were also been made to identify constitutive promoters from some lab isolates like *Burkholderia* sp. BC1, *Sphingobium* sp. PNB and *Cupriavidus* sp. ST-14. Genomic libraries were prepared following the similar strategy as that employed for metagenomic libraries and screened by FACS.

Moreover, in order to study the regulatory regions of some previously studied genetic operons involved in the degradation of aromatic pollutants by our lab isolates, probable promoter regions amplified by PCR and analyzed through a 'bacterial promoter analysis tool' were cloned into reporter vector and screened for reporter (EGFP) gene expression by confocal microscopy, fluorimetric and spectrofluorimetric analyses. Identification and further manipulation of a constitutive promoter of the naphthalene degrading nag operon of *Burkholderia* sp. BC1 lead to the construction of a new bacterial expression vector that can be used for protein expression in both *E. coli* and wild type strains isolated from the environment.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Exploration of promoters of biotechnological importance from metagenomic DNA	DAE

Dr. Abhrajyoti Ghosh

Assistant Professor and DST-Ramanujan Fellow

Scientific Reports

Understanding protein translocation under extreme conditions

Protein translocation across biological membranes is a prerequisite for the survival of all living organisms. The process of protein translocation has been extensively addressed in bacteria and eukaryotes. Unfortunately, little information is available regarding protein translocation across the archaeal membranes. Analysis of the archaeal protein translocation machinery revealed its hybrid nature comprising of selected features of both bacterial and eukaryotic processes. However, certain aspects of the archaeal protein translocation pathway are apparently unique to the representatives of this domain of life, indicating the distinctive biological strategies developed by archaea during evolution. The Signal Recognition Particle (SRP), a ribo-nucleoprotein complex, is central to this protein translocation pathway in all three domains of life. During the past years, several interesting aspects with respect to the archaeal protein translocation have been documented. However, the lack of detailed biochemical analysis and limited availability of the genetic and cell-biological tools have restricted our progress in understanding the role of SRP in archaeal cells. Detailed *in-vitro* and *in-vivo* analyses are thus far an important pre-requisite to understand the exact nature of signal recognition particle (SRP) components in archaea and their roles in trafficking membrane and secretory proteins under variety of different environmental conditions. In the present work, we are able to characterize SRP components, SRP54 and SRP19 with respect to aiming at detailed understanding of the biochemical interactions between SRP-components in vitro as well as in vivo using *Sulfolobus acidocaldarius* as a model system.

Discovering the diversity, ecophysiology, and metabolic potential of novel archaeal species

We study the phylogenetic diversity, metabolic capabilities, and ecological role of archaea in diverse environments. We utilize, develop and evaluate a variety of procedures to achieve these goals. An integrative approach combining large scale culture-independent surveys, environmental genomics (metagenomics), and isolation/characterization of novel archaeal species is adopted. Our studies on the diversity and distribution of archaea in Sundarbans sediment revealed distinct anthropogenic intervention in the study area. Polyaromatic hydrocarbons (PAH) are found to play major role in shaping archaeal diversity and distribution in the sediment. To obtain further insight, we have successfully isolated and characterized number of haloarchaeal species.

Functional and structural studies on archaeal Actin-like protein: *in collaboration with Dr. Gautam Basu, Dept. of Biophysics, Bose Institute*

Crenactin is an actin ortholog identified in several crenarchaeal genomes, as well as in *Candidatus* Korarchaeum cryptofilum, and was shown to polymerize into cytoskeletal structure in the hyperthermophilic crenarchaeaon *Pyrobaculum calidifontis*. Immunofluorescence microscopy imaging revealed that crenactin formed helical filaments that traversed the length of the rod-shaped cells. In a cell subpopulation, these filaments had been remodeled into band-like structures, presumably in preparation for the cell division, in this respect resembling the bacterial MreB, which

belongs to the same ATPase superfamily as actin and crenactin. Identification of crenactin only in the genomes of rod-shaped archaea has led researchers to propose that this protein is involved in cell shape formation. Despite of its identification and preliminary studies; little is known about its biochemical and structural features. Recent structural analysis has confirmed that crenactin forms a helical filament and functions probably like actin/MreB in cytoskeletal assembly. Detailed biochemical analysis, however, an utmost requirement for better understanding of its role within 'Arcade' macromolecular assembly complex, which constitutes crenactin and other arcadin proteins. In the present project, we propose to explore the biochemical nature of crenactin and its interaction with arcadins. We believe that detailed understanding of the role of crenactin might shed light into its evolutionary significance especially in relation to eukaryotic actin.

Publications

1. Basak P, Pramanik A, Sengupta S, Nag S, Bhattacharya A, Roy D, Pattanayak R, Ghosh A, Chattopadhyay D, Bhattacharyya M (2016) Bacterial diversity assessment of pristine mangrove microbial community from Dhulibhashani, Sundarbans using 16S rRNA gene tag sequencing. *Genomics data*, 7,76-78.
2. Bhattacharyya A, Majumder N, Basak P, Roy D, Nag S, Haldar A, Chattopadhyay D, Mitra S, Bhattacharyya M, Ghosh A (2015) Shifts in archaeal community structure along the ecological gradient of the sediment of Sundarbans. *Archaea*, 968582.
3. Neiner T, Chaudhury P, D'Imprima E, Banerjee A, Reindl S, Hammel M, Ghosh A, Arvai A S, Mills D J, van der Does C, Tainer J A, Vonck J, Albers S V (2016) The Nucleotide-Dependent Interaction of FlaH and FlaI is Essential for Assembly and Function of the Archaellum Motor. *Molecular Microbiology*, 99(4), 674-85.
4. Saha S, Jana S, Gupta S, Ghosh A, Nayek H P (2016) Syntheses, Structures and Biological Activities of Square Planer Ni(II), Cu(II) Complexes. *Polyhedron*, 107, 183-189.
5. Sengupta S, Pramanik A, Ghosh A, Bhattacharyya M (2015) Characterization and phylogenetic analysis of potential antimicrobial metabolite producing actinomycetes from mangrove ecosystems of Indian Sundarbans. *BMC Microbiology*, 15:170.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Understanding protein translocation under extreme conditions	DST-Ramanujan Fellowship research grant, SERB, DST, Govt. of India
Investigation of the archaeal diversity and activity in Sundarbans mangrove	CSIR
Assessment of plant growth promoting bacteria in the mangrove rhizosphere and evolution of the plant growth promotion activity on rice	Dept. of Biotechnology West Bengal

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(I) Presented a poster entitled 'Mangrove Archaeal Diversity and the Impact of Hydrocarbon Contamination Revealed by 454-Amplicon Sequencing: Archaeal Proxies for Hydrocarbon Pollution in Sundarbans' at the 56th Annual Conference of Association of Microbiologists of India (AMI-2015) & International Symposium on "Emerging Discoveries in Microbiology" at Convention Center, Jawaharlal Nehru University (JNU), New Delhi, during December 7 – 10, 2015. (ii) Delivered an invited lecture entitled "Structural metagenomics in understanding microbial diversity" at the Faculty Improvement Programme on METAGENOMICS jointly organized by Department of Microbiology, Lady Brabourne College, Kolkata and World Bank ICZM project, Department of Biochemistry, University of Calcutta, Kolkata on July 9, 2015.

Dr. Wriddhiman Ghosh

Assistant Professor

Scientific Reports

Quest for the biophysical basis of habitability of hydrothermal vent ecosystems

While studying the microbial ecology of the hot springs of the Puga geothermal area of Ladakh we obtained new biophysical insights into the habitability of high temperature environments. High throughput metagenomic sequence data was used to characterize the distributions of bacterial populations along multiple trajectories of hydrothermal outflows (representing distinct hydrothermal gradients or thermoclines) from two prominent hot springs of Puga. The distribution of bacteria along the thermoclines revealed many such instances where phylum- as well as genus-level populations dispersed beyond the known temperature limits of laboratory growth of their member species. Thus more than 100 mesophilic genera (no laboratory growth at >45 °C) were detected at sites >50 °C.

In the hot springs of Puga, the presence and/or prevalence of most bacterial phyla and genera became progressively-constrained at around 40, 50, 60 and 70 °C, as compared to their 30 or 20 °C levels. This trend was the converse of that observed by other researchers in NaCl-dominated hypersaline habitats where biomass and biodiversity can increase at elevated salt concentrations, but consistent with changes in the microbial community of chaotropic, $MgCl_2$-dominated haloclines where diversity is constrained as salt concentration increases. For instance, in one Puga hot spring habitat, microbial diversity at 66°C was half of that observed at 46°C, a finding which corroborates the trend reported at high $MgCl_2$ concentrations where halophilic diversity is almost-halved between 1 and 2 M $MgCl_2$.

One primary mechanism by which thermal stress acts on living systems is via entropic changes in biomacromolecules, which become disordered at high temperatures. Heat imposes a high energetic cost on the microbial cell and the entropic destabilization of biomacromolecules caused thereby



leads to cell-system failure. Analogous to the action of heat, activities of various solutes known as chaotropes also modulate the stability of biomacromolecular systems by entropically disordering them. The presence of high levels of chaotropic compounds, such as ethanol, $MgCl_2$ etc. reduce intracellular water activity and decrease the strength of hydrogen bonding and other electrostatic interactions and thereby perturb the structure and function of hydrated macromolecules, including nucleic acids, proteins, and lipids. Chaotropes may thus be utilized to extend the growth windows for key microbes, such as saprotrophs, in cold ecosystems and manmade biomes (as they impart the necessary flexibility to cold-rigidified biomacromolecules). Counter to the chaotropes, there is another category of solutes known as kosmotropes, for example NaCl, glycerol, etc., which stabilize, structure, and impart rigidity to biomacromolecules, and thereby mitigate against the inhibition of cellular systems by chaotropic agents. Incidentally, the hydrothermal discharge of Puga hot springs are characterized by significant concentrations of potent kosmotropic solutes such as borates, biocarbonate, sodium, thiosulfate, sulfate, sulfite and sulfide ions. Collating all these information we have hypothesized that *in situ* abundance of kosmotropes could be mitigating high temperature-induced chaotropicity in the Puga hot spring habitats, and thereby enabling colonization of high temperature sites by phylogenetic relatives of mesophilic bacterial taxa in unusually high numbers.

Publication

Roy C, Alam M, Mandal S, Haldar P K, Bhattacharya S, Mukherjee T, Roy R, Rameez M J, Misra A K, Chakraborty R, Nanda A K, Mukhopadhyay S K and Ghosh W **(2016)** Global association between thermophilicity and vancomycin susceptibility in Bacteria. *Frontiers in Microbiology* **7**: 412. doi: 10.3389/fmicb.2016.00412.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Vertical profiling of the sedimentary microbiome of the Arabian Sea OMZ with special reference to carbon and sulfur cycles	MoES

Dr. Manikuntala Kundu

Senior Professor

Scientific Reports

Targeting multiple response regulators of two component systems of *Mycobacterium tuberculosis*: *in collaboration with Dr. Joyoti Basu and D. Sriram, BITS Pilani*

The genome of *M. tuberculosis* (Mtb) encodes eleven two component systems (TCSs). Each TCS consists of a sensor kinase (SK) and a response regulator (RR). We demonstrate that a conserved motif "LRXK" present in the C-terminal domain of at least three RRs (MprA, RegX3 and MtrA) regulates the DNA binding functions of Mtb. In collaboration with BITS Pilani, we identified two molecules (by in silico docking to the DNA binding pockets) with a thiazolidine scaffold capable of targeting these RRs. Using knock out mutants of MprA and RegX3, we confirmed the inhibitory role of these compounds on DNA binding activity of RR as well as inhibition of bacterial survival in macrophages. The changes in bacterial transcriptome led to increased autophagy and nitric oxide production from infected macrophages. The results of ex vivo studies clearly indicate the potential of the development of new therapeutics targeting multiple RRs of Mtb in future.

Publications

1. Gupta S, Banerjee SK, Chatterjee A, Sharma AK, Kundu M, Basu J (2015) Essential protein SepF of mycobacteria interacts with FtsZ and MurG to regulate cell growth and division, *Microbiology,* 161, 1627-38.
2. Kumar R, Sahu SK, Kumar M, Jana K, Gupta P, Gupta UD, Kundu M, Basu J (2016) MicroRNA 17-5p regulates autophagy in *Mycobacterium tuberculosis*-infected macrophages by targeting Mcl-1 and STAT3; *Cell Microbiol;* 18,679-691.
3. Sharma AK, Chatterjee A, Gupta S, Banerjee R, Mandal S, Mukhopadhyay J, Basu J, Kundu M (2015) MtrA, an essential response regulator of the MtrAB two-component system, regulates the transcription of resuscitation-promoting factor B of Mycobacterium tuberculosis; *Microbiology*,161,1271-1281.

Dr. Pradeep Parrack

Professor

Scientific Reports

Investigations into the Function of the ribosome binding GTPase HflX from *E. coli*

A. Characterisation of the autophosphorylation activity of HflX and its C-terminal fragment, HflX(C)

The HflX family of translation factor-related GTPases, despite being widely distributed across species, is a poorly characterized protein family. The E. coli HflX (EcHflX), a P-loop GTPase, is a

426-residue polypeptide (Mol wt. 48.3 KDa) and hydrolyses not only GTP but also ATP, and binds 50S ribosomes. We have found that EcHflX exhibits autophosphorylation activity, like several other P-loop bacterial GTPases. Recently, it has been shown that the N-terminal glycine-rich domain of HflX has a Rossman-like noncanonical NTPase motif, apart from the C-terminal canonical P-loop NTPase nucleotide binding motif (G-domain). These nucleotide binding domains of HflX influence each other's NTPase activity.

To check the individual autophosphorylation properties of the domains, we cloned, overexpressed and purified the N-terminal and C-terminal domains of HflX. While the C-terminal domain (HflX(C)) showed a strong autophosphorylation activity, no such activity could be detected for the N-terminal domain (HflX(N)). Further, unlike full length HflX, HflX(C) could use both Mn^{2+} and Mg^{2+} cofactors equally well for autophosphorylation. We also examined the nature of the phosphoamino acid by chemical stability assay and have shown that the autophosphorylation involves a serine residue of HflX, most likely Ser211, belonging to the P1-loop region.

We have characterised HflX(C) in terms of its GTPase property, and carried out biophysical studies on the protein using urea and guanidium chloride induced unfolding. Full-length HflX and HflX(C) were compared. The GTPase reactions followed the Michaelis-Menten equation. It was observed that V_{max} for HflX(C) (8.3 $\mu M.mg^{-1}min^{-1}$) was much higher than that for HflX (3.1 $\mu M.mg^{-1}min^{-1}$). Also, K_m for HflX(C) was lower (29.4 μM, compared to 55.8 μM for HflX). The nucleotide binding domains of HflX influence each other's NTPase activities. Therefore, it is possible that a crosstalk between the two GTP-binding domains in full length HflX leads to a decrease in its GTPase activity.

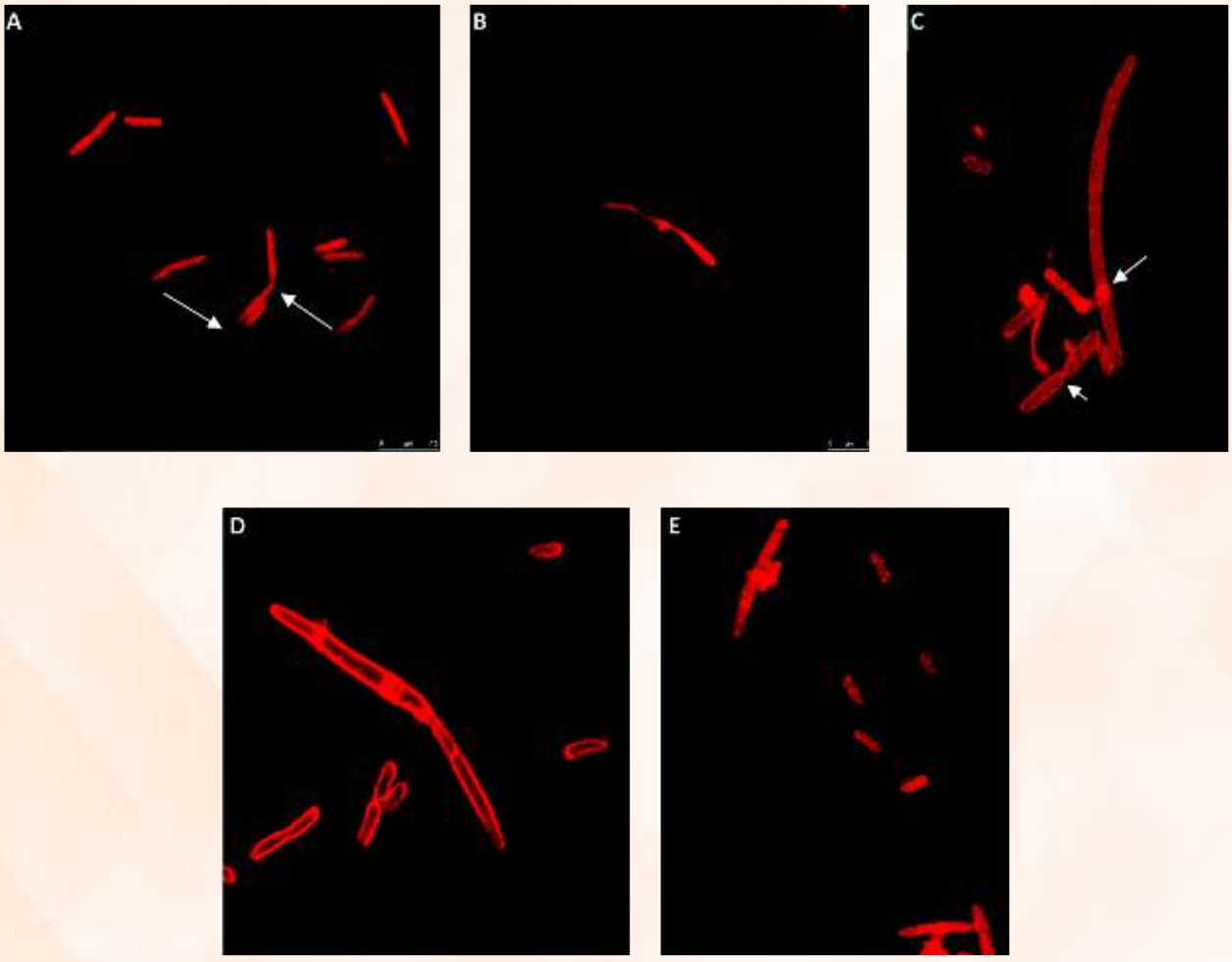
B. Unfolding studies on HflX and HflX(C)

During urea and GdnCl mediated unfolding studies, it was observed that in the case of HflX, the molar ellipticity and tryptophan fluorescence intensity increased at low denaturant concentration. This type of conformational change, leading to a compaction of protein structures at low concentration of denaturants has indeed been observed for certain proteins. It appears that HflX also belongs to this group of proteins that exhibit an initial disorder-order transition during unfolding. Probably native HflX is loosely packed in the experimental buffer condition. But in case of HflX(C), no such conformational change is observed at low denaturant concentration. HflX(C) shows only one intermediate at ~1.5M denaturant concentration, like HflX. So due to deletion of N-terminal part from HflX, the disorder-order transition at very low denaturant concentration disappeared. From this result, it can be inferred that the N-terminal part is not so compact.

C. Role of HflX in cell division

Although HflX is dispensable for growth under normal conditions, the deletion of *hflX* renders the bacterium to be extremely sensitive to manganese, characterized by arrested cell growth and filamentation of Δ*hflX* cells. We examined in detail the fate of such cells under Mn^{++} stress. We demonstrate that upon complementation by *hflX*, the Mn stress, which is probably linked to the autophosphorylation activity of HflX, is relieved. In phenotypic studies done in a Mn-rich environment, depletion of *hflX severly* sensitized the cells to antibiotics that bind the penicillin binding protein 3 (PBP3). This result suggests that the observed Mn-stress is due to impaired

peptidoglycan biosynthesis. By staining the bacterial membrane and nucleoids, we observed an irregular distribution of FtsZ along filaments, delocalization of FtsZ from midcell towards poles, lack of septum formation and arrested cell division in Mn-stressed Δ*hflX* cells. From confocal microscopy imaging and FACS studies it was found that chromosome replication and segregation of nucleoids were unaffected in Δ*hflX* cells in the presence of Mn^{++}. Therefore HflX serves as a regulator of the *E. coli* cell cycle under Mn-stress, at the cell-division event of the cell-cycle, probably by modulating the activity of the cell division protein PBP3 (FtsI), a major component of the divisome apparatus.



Confocal microscopic images of *ΔhflX cells alone (A-D) and complemented with pAX-01 (E) that expresses HflX,* in the presence of Mn^{++}. FM4-64-stained micrographs showing dark bands at midcell or polar regions (A), FtsZ ring at midcell with dark band at subpolar region (B), or irregularly distributed FtsZ rings (C, D). Upon complementation, FtsZ rings appeared only at the midcell regions in dividing cells, while many cells which have completed division and septation were also visible (E). FtsZ rings or dark bands are indicated by arrows

Students Awarded Ph.D.

Name of Student (University/Year) PhD awarded :	Title of Thesis
Abinit Saha (C.U., Feb 2016)	An Investigation into the Cyclic AMP dependent Properties of cyclicAMP Receptor Proteins (CRP) from *Escherichia coli* and *Mycobacterium tuberculosis*

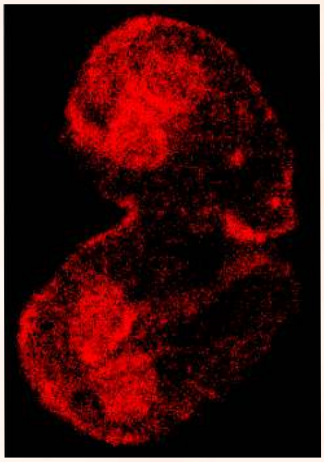
Dr. Srimonti Sarkar

Associate Professor

Scientific Reports

Is *Giardia*'s simplistic proteasome its Achilles heel?

The protist *Giardia lamblia* is a flagellated gut pathogen that causes the diarrhoeal disease giardiasis. It is one of the most common causes of water borne diseases worldwide, with estimated human infections of about one billion yearly; of these, about 200 to 300 million individuals develop giardiasis. The disease is particularly endemic in areas of poor sanitation, which is why it has a high rate of recurrance in ecomonically weaker sections of society of the developing world. Children are more liable to suffer from repeated infections and the long-term consequences include lower IQ and decreased growth. Although there are a handful of drugs to treat this disease, there is heterogeneity in patient response to a particular drug. Also, the emergence of drug-resistant strains of *Giardia* poses a threat. My research group is engaged in studying the cell biology of this protist with the goal of identifying new therapeutic targets.



Our focus: We are particularly interested in the proteasome-mediated protein degradation process of this organism. Our studies of the giardial proteasomal machinery indicate that it may be much simpler than that of the host as it is composed of fewer subunits. This lower complexity of the proteasome extends even to individual subunits. For example, the proteasomal ubiquitin receptor, GlRpn10, has a significant truncation in a domain called the VWA. The VWA domain arose early during the course of evolution as it is found in both prokaryotes and eukaryotes. Except for GlRpn10, no other protein, either prokaryotic or eukaryotic in origin, has such a truncation. In fact, the full-length VWA domain is found in three other proteins of *Giardia* itself. Modeling studies of the smaller VWA domain of GlRpn10 indicate that this truncation leads to the absence of a α-helix and two β-strands. We believe that such structural differences between the host and parasite proteasome makes GlRpn10 an excellent therapeutic target. We have also observed that GlRpn10 localizes to the flagellar pore regions and may be playing a role in flagellar

maintenance. This involvement in flagellar function makes GlRpn10 an even more attractive target as flagellar motility is crucial for the survival of this parasite inside the host.

Publications

1. Dutta S, Saha N, Ray A and Sarkar S (2015) **Significantly-diverged Did2/Vps46 orthologues from the protozoan parasite *Giardia lamblia*.** *Current Microbiology*; 71(3), 333-40 (DOI: 10.1007/s00284-015-0844-4).
2. Sinha A, Ray A, Ganguly S, Ghosh Dastidar S and Sarkar S (2015) Variation in the ribosome interacting loop of the Sec61α from *Giardia lamblia*. *Biology Direct*; 10(1), 56. (DOI: 10.1186/s13062-015-0087-0).

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Identification and characterization of a 19S proteasomal component of the early diverging eukaryote *Giardia lamblia*	Department of Biotechnology Govt. of India
Functional characterization of the lipid-binding FYVE protein from *Giardia lamblia*	CSIR

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(I) Delivered talk at the 26th National Congress of Parasitology held from 21st to 23rd January, 2016 at Benaras Hindu University, Varanasi; (ii) Invited talk at (1)Summer School in Basic Sciences organized by Indian Association for Cultivation of Science, Kolkata in May, 2015 and (2) Annual Science Meet of La Martiniere for Girls', Kolkata in July 2015.

Dr. Subrata Sau

Professor

Scientific Reports

Studies on the DNA/drug binding proteins of bacterial origin

FKBP22, an *Escherichia coli*-encoded peptidyl-prolyl *cis-trans* isomerase, shares considerable homology with the Mip-like virulence factors, carries a tentative V-shape, and forms dimers in the aqueous solution. FKBP22 monomer is composed of an N-terminal domain (NTD) and a C-terminal domain (CTD) those are assumed to be connected by a long α-helix designated α3. While NTD is involved in its dimerization, CTD binds substrate or inhibitor like FK506 or rapamycin. To understand the roles of α3 on the structure, function, and stability of FKBP22, we have studied a

recombinant FKBP22 (rFKBP22) and its three variants I65P, V72P and A82P using multiple tools. Each mutant bears a Pro substitution mutation at a distinct location in α3. The data show that the three mutants differ not only from each other but also from rFKBP22 in structure and activity. Their unfolding mechanism also varies from that of rFKBP22 in the presence of urea. Besides, the stabilities of the mutants, particularly I65P and V72P, are significantly different from that of rFKBP22. On the contrary, their rapamycin binding affinities were nearly similar to that of rFKBP22. Of the mutants, I65P lost the highest extent of structure/function and partly formed monomers in solution. The V-shape of I65P was also mostly lost possibly due to the anomalous movement of its CTDs. The α3 is, therefore, critical for FKBP22.

Expression of many proteins in *Staphylococcus aureus* are controlled by Triton X-100 (TX-100), a non-ionic surfactant. SarA, a global virulence regulator in *S. aureus*, is one of the TX-100-induced proteins in this pathogen. To delineate the roles of TX-100 on the structure, and function of SarA, we have studied a recombinant *S. aureus* SarA (rSarA) and its point mutant C9W in the presence of this surfactant using several tools. The results reveal that the DNA binding affinities of rSarA and C9W are nearly comparable in the absence of TX-100. Conversely, their DNA binding activities were significantly augmented in the presence TX-100. This surfactant changed their structures to an extent as well. Size of the rSarA-TX-100 complex was intermediate to those of rSarA and TX-100. In addition, we noticed a relatively modest interaction between C9W and TX-100. However, TX-100 bound to C9W by a cooperative manner particularly at the micellar and post-micellar concentrations of this surfactant. We together suggest that the TX-100-induced structural change of rSarA and C9W may be responsible for their higher DNA binding activity. TX-100 could, therefore, be useful for studying the relatively weaker SarA-DNA complex effectively.

Publications

1. Polley S, Chakravartya D, Chakrabarti G, Chattopadhyaya R, Sau S (2015) Proline substitutions in a Mip-like peptidyl-prolyl *cis-trans* isomerase severely affect its structure, stability, shape and activity. *Biochimie Open*. 1, 28–39.
2. Mandal S, Mahapa A, Biswas A, Jana B, Polley S, Sau K, Sau S (2016) A Surfactant-Induced Functional Modulation of a Global Virulence Regulator from *Staphylococcus aureus*. *PLoS One*. 11(3):e0151426.

Students Awarded Ph.D.

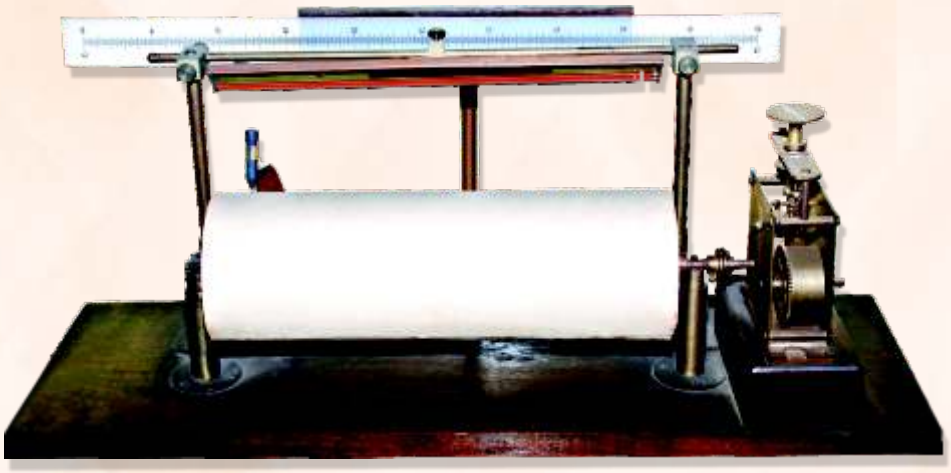
Name of Student (University/Year)	Title of Thesis
With Dr. P. K. Parrack (Co-supervisor)	
Mr. Rajkrishna Mondal (J.U., 2015)	Studies on the Major Sigma Factors of *Staphylococcus aureus*.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
With Dr. T. K. Dutta (Co-PI)	
Studies on the DNA binding mechanism of a global virulence regulator SarA of *Staphylococcus aureus*.	DAE

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Joint with Soumitra Polley presented a poster entitled "Determining the roles of a conserved tyrosine residue in a Mip-like peptidyl-prolyl *cis-trans* isomerase" at the Annual Meeting of The Indian Biophysical Society 2016, held at IISC, Bangalore, on February 7 – 10, 2016.



Response Recorder

SCIENTIFIC REPORTS

| VI |
Systems Biology

Participation in Institutional Projects for the 12th Five-year Plan (2012-2017)

Dr. Joyoti Basu (Coordinator), Dr. Indrani Bose, Dr. Manikuntala Kundu, Dr. Jayanta Mukhopadhyay, Dr. Suman Kr. Banik and Dr. Zhumur Ghosh

Introduction

In this programme scientists are working on various aspects of understanding disease processes and infections using Systems Biology approaches. Specifically, high throughput approaches have been taken to understand pathogen-tuned signaling networks in host cells. Mathematical modeling has been employed to understand stress responses in mammalian cells and in bacterial pathogens.

Dr. Suman K Banik

Associate Professor

| Scientific Reports |

Parameter sensitivity in two-component signaling pathway

To understand the switching of different phenotypic phases of *Bordetella pertussis*, we propose an optimized mathematical framework for signal transduction through BvgAS two-component system. The response of the network output to the sensory input has been demonstrated in steady state. An analysis in terms of local sensitivity amplification characterizes the nature of the molecular switch. The sensitivity analysis of the model parameters within the framework of various correlation coefficients helps to decipher the contribution of the modular structure in signal propagation. Once classified, the model parameters are tuned to generate the behavior of some novel strains using simulated annealing, a stochastic optimization technique.

Information transmission in a two-step cascade

We present a stochastic framework to study signal transmission in a generic two-step cascade $S \rightarrow X \rightarrow Y$. Starting from a set of Langevin equations obeying Gaussian noise processes we calculate the variance and covariance while considering both linear and nonlinear production terms for different biochemical species of the cascade. These quantities are then used to calculate the net synergy within the purview of partial information decomposition. We show that redundancy in information

transmission is essentially an important consequence of Markovian property of the two-step cascade motif. We also show that redundancy increases fidelity of the signaling pathway.

Publications

1. Biswas A and Banik S K (2016) Redundancy in information transmission in a two-step cascade, *Phys. Rev. E* 93, 052422.
2. Mapder T, Talukder S, Chattopadhyay S and Banik S K (2016) Deciphering parameter sensitivity in two-component signal transduction, *PLOS One* 11, e0147281.
3. Sarkar P, Shit A, Chattopadhyay S and Banik S K (2015) Profiling the overdamped dynamics of a nonadiabatic system, *Chem. Phys.* 458, 86.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
In Vitro study of input-output robustness of MprAB signaling pathway in *Mycobacterium tuberculosis*	DBT

Dr. Joyoti Basu

Senior Professor and Coordinator

Scientific Reports

Mycobacteria induced epigenetic modification of promoters of genes of host macrophages : *in collaboration with Dr. Manikuntala Kundu*

Epigenetic modification has served as an important mechanism in regulation of various cellular processes. Covalent post-translational modification of core histones constitutes a principle regulatory mechanism in eukaryotic chromatin. H3K4-methylation preferentially occurs at the transcription-start site (TSS) of active genes and plays a role in transcription activation, in particular, tri-methyl H3K4me3 (H3K4me3) occurs at the TSS of active genes. Here, we have used chromatin immunoprecipitation (Chip) and Chip-sequencing (Chip-seq) to characterize the modification of H3K4me3 in THP-1 macrophages infected with Mtb H37Rv (virulent) or H37Ra (avirulent) in a time dependent manner, in order to understand the host epigenetic architecture and subsequently altered cellular processes mediated by virulent and avirulent strains of mycobacteria respectively. H3K4 me3 was found to be highly enriched at 2 h infection in both H37Rv and H37Ra but global H3K4Me3 modification was greated following infection with Mtb H37Ra compared to infection with Mtb H37Rv. At 4 h, this was reversed. Validation of some of the Chip-seq data is in progress. We are focusing on genes established to be important regulators of the innate immune response.

Publication

1. Halder P, Kumar R, Jana K, Chakraborty S, Ghosh Z, Kundu M, Basu J (2015) Gene expression profiling of *Mycobacterium tuberculosis* lipoarabinomannan-treated macrophages: A role of the Bcl-2 family member A1 in inhibition of apoptosis in mycobacteria-infected macrophages; *IUBMB Life*, 67 ,726-736.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
With Dr. M. Kundu (Co-PI)	
Role of microRNAs in the immune response to mycobacterial infection	CSIR
With Dr. M. Kundu (Co-PI)	
Sys TB: A Network Programme for Resolving the Intracellular Dynamics of Host Pathogen Interaction in TB Infectio	DBT

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(I) Delivered a lecture in the INDO FRENCH WOMEN IN SCIENCE SEMINAR, held in the Indian Institute of Science, BANGALORE, INDIA from March 3 - 5 2015, organized jointly by CEFIPRA, the Indian Academy of Sciences, and the Embassy of France in India (ii) Delivered lecture in 27th International meeting of the Korean Society of Molecular and Cell Biology in Seoul from September 21 to 23, 2015.

Awards/Honours Received

(i) Member, Editorial Board, PLoS One

(ii) Member of the ICMR Expert Committee on Cellular and Molecular Biology

Dr. Indrani Bose

CSIR-Emeritus Scientist

Scientific Reports

Interdisciplinary Physics/Systems Biology

Natural populations can undergo catastrophic collapse in response to small changes in environmental conditions. This has recently been demonstrated in laboratory populations of budding yeast. A possible origin of the sudden collapse lies in a phenomenon known as the strong Allee effect in which the per capita growth rate of a population is negative at low densities, maximal at intermediate densities and reduced from the maximum value at high densities. The

negative growth rate is obtained for population density below a critical value, the so-called Allee threshold, resulting in the extinction (collapse) of the population.. We have provided a qualitative explanation of the various experimental observations, including the early signatures of a collapse transition at the "tipping point", using a model of population dynamics incorporating the Allee effect.

We have initiated a study of a one-dimensional (1d) reaction-diffusion (RD) model of tumour growth and propagation. The problem is studied from the perspective of biological invasion. The term biological invasion describes phenomena in which a new species, on being introduced into an ecosystem, has the ability to spread into the surrounding regions. In this context, one can envisage two possible regimes in the system dynamics: (i) biological invasion is successful and (ii) the invading species retreats rather than advances. The cells in a tumour constitute a new 'species' in the human ecosystem. A recent study has pointed out the similarity of cancer spread with the geographical expansion of an invasive species. We consider a 1d RD model of tumour growth and spread which incorporates the Allee effect. For population density less than a critical density, the growth rate of the population is negative resulting in the extinction of the population. It is possible that many tiny tumours are formed in different parts of the body during the lifetime of an individual. These tumours mostly become extinct because of their small sizes, indicative of a negative growth rate at low density as in the case of the Allee effect. Cooperativity, which provides a possible basis for the Allee effect to occur, may be at work in a population of cancer cells, which contribute jointly to a common pool of diffusible growth factors required for tumour proliferation or pro-angiogenetic growth factors like vascular endothelial growth factor A , needed for the recruitment of blood vessels to irrigate the tumour.We have already derived the conditions for the metastasis to be successful and we would like to extend the results to higher dimensions.

Publication

1. Pal M, Ghosh S and Bose I (2016) Functional characteristics of gene expression motifs with single and dual strategies of regulation, *Biomedical Physics & Engineering Express* 2, 025009, 12 pages.

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Delivered on invitation talk on (i) Cell Differentiation and Criticality" at SYMPHY-2015 organised by the Research Scholars' Association at the Physics Department, IIT, Mumbai during May 9-10, 2015; (ii) Dynamics of Cell Differentiation: A Statistical Physics Perspective at UGC Workshop on Statistical Physics of Soft Matter at Physics Department, BHU, Varanasi during November 26-30, 2015; (iii) Criticality in Cell Differentiation at Workshop on Mathematical and Computational Biology at IISER, Kolkata during January 9-10, 2016; (iv) Signatures of Criticality in Cell Differentiation at the K. S. Krishnan Symposium at IACS on January 12, 2016; (v) Signatures of Criticality in Cell Differentiation at Conference on Complex System Approach to Self-Organization at IIT, Chennai during February 1-5, 2016 (vi) Condensed Matter Physics: Its Diversity and Interdisciplinarity at Conference on Modern Trends in Condensed Matter Physics organized by West Bengal State University during March 11-12, 2016; (vii) Delivered on invitation a Special

Lecture on Quantum Information Theory and Man Body Physics at Summer School on Quantum Correlation: Foundation, Information Processing and Various Applications at the Indian Statistical Institute, Kolkata during June 22 – July 3, 2015; (viii) two lectures on "What exactly-solvable models can teach us about condensed matter systems" at Winter School on Condensed Matter Physics at Indian Statistical Institute, Kolkata during January 11-22, 2016.

Dr. Zhumur Ghosh

Assistant Professor

Scientific Reports

(a) Elucidating the key hubs that are different in metastatic state and cancer stem cell state

My lab has developed a high resolution network model (incorporating the concept of Shortest Path) that elucidates key gene drivers responsible for regulating the spatio-temporal progression of a cellular system (viz. cancer).

(b) Understanding the role of PPARγ in ManLAM induced macrophage cell signaling: in cpllaboration with *Dr. Joyoti Basu and Dr. Manikuntala Kundu*

Mannose-capped lipoarabinomannans (ManLAMs) are members of the family of Mycobacterium tuberculosis effectors that regulate signalling in host immune cells. Analysis of the global transcriptomic data suggests the role of LAM towards regulating apoptosis in J774A.1 macrophages. ManLAM regulates host cell apoptosis which likely favours survival of the pathogen and limits the proinflammatory response. Our *insilico* analyses suggest that PPARγ signaling likely influences pathways which are critical to infection, including phagocytosis, internalization and autophagy.

Publication

1. Halder P, Kumar R, Jana K, Chakraborty S, Ghosh Z, Kundu M and Basu J (2015) Gene expression profiling of Mycobacterium tuberculosis Lipoarabinomannan-treated macrophages: A role of the Bcl-2 family member A1 in inhibition of apoptosis in mycobacteria-infected macrophages. *IUBMB Life 2015*; DOI: 10.1002/iub.1430 (impact factor 3.143)

Dr. Manikuntala Kundu

Senior Professor

Scientific Reports

Global expression profile of mRNA and miRNA of *Helicobacter pylori* infected epithelial cells: *in collaboration with Dr. Jhumur Ghosh and Dr. Joyoti Basu*

Microarray analysis of miRNA and mRNA of Helicobacter infected epithelial cells was carried out after infecting AGS cell with *Helicobacer pylori* at different MOI. In silico analysis of microarray

data predicted putative targets of miRNA which were modulated by Helicobacter infection. We observed that matrix metalloproteases and the serine threonine phosphatase PHLPP1 was modulated after infection in a dose and time dependent manner. Moreover using 3'UTR construct of PHLPP1, we have been able to identify the miRNA responsible for the modulation of PHLPP1 in infected cells. PHLPP1 inactivates oncogenic kinase AKT and therefore offers a novel therapeutic target for the suppression of oncogenic pathways. Validation of miRNA and its target mRNA has also been carried out by q-RT PCR using RNA isolated from uninfected and infected cells.

Functional analysis of mycobacterial response regulator RegX3: *in collaboration with Dr. Joyoti Basu and Dr. Sudipta Saha*

One of the two component systems, SenX3-RegX3 of *Mycobacterium tuberculosis* (Mtb) is known to be responsible for the survival of bacteria under phosphate stress. Microarray data was generated using RNA isolated from Mtb (wild type or RegX3 knock out strain) grown in phosphate supplemented or depleted medium. Venn analysis clearly identified sets of genes which were differentially regulated between wild type and knock out strain under phosphate stress. In silico analysis predicted the presence of probable consensus sequence for RegX3 binding in the upstream promoter regions of differentially regulated genes. Among these genes, we validated the presence of RegX3 binding sites in two of the *WhiB* family of regulatory proteins which are associated with oxidative stress management and antibiotic resistance in mycobacteria. We also observed down regulation of WhiB proteins in the knock out strain compared to the wild type strain under phosphate stress. Further work on the delineation of the role of RegX3 mediated modulation of regulatory proteins is in progress.

Publication

1. Halder P, Kumar R, Jana K, Chakraborty S, Ghosh Z, Kundu M, Basu J (2015) Gene expression profiling of *Mycobacterium tuberculosis* lipoarabinomannan-treated macrophages: A role of the Bcl-2 family member A1 in inhibition of apoptosis in mycobacteria-infected macrophages; *IUBMB Life*, 67 ,726-736.

Students Awarded Ph.D.

Name of Student (University/Year)	Title of Thesis
Jointly with Dr. Joyoti Basu	
Priyanka Halder (C.U. 2015)	Modulation of host cell signaling by effectors of *Mycobacterium tuberculosis* and *Helicobacter pylori*

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
With Dr. Joyoti Basu (Co-PI) Regulation of the mycobacterial stress response by the two component system SenX3-RegX3 in *M. tuberculosis*	DST-SERB
With Dr. Joyoti Basu (Co-PI) The role of two component systems and cell division protein in mycobacterial physiology	DBT

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Arun Kumar Sharma, SRF, presented a poster in the conference "6th Congress of European Microbiologists" held in Maastricht, The Netherlands from June 7-11, 2015.

Srijon Kaushik Banerjee, SRF, presented a poster in the Gordon Research Conference "Microbial adhesion and signal transduction" held in Newport, Rhode Island, U.S.A. from July 26-31, 2015.

Dr. Jayanta Mukhopadhyay

Associate Professor

Scientific Reports

In vitro study of input-output robustness of MprAB signaling pathway in Mycobacterium tuberculosis:

One of the important functional aspects of living organisms is to respond to the sudden changes made in their environment, and to make appropriate changes in the cellular or sub-cellular level for survival. Direct manifestations of such changes at the sub-cellular level are the regulation of single or multiple genes controlling different functional behavior of an organism. The human pathogen *Mycobacterium tuberculosis*, causative agent for the disease tuberculosis, is no exception to this behavior. *M. tuberculosis* while responding to a particular external stimulus utilizes its machinery of two component systems (TCSs) each comprising a paired sensor kinase and its cognate response regulator. One of such TCS in *M. tuberculosis* is MprAB having the sensor kinase MprB and the response regulator MprA, encoded by the operon *mprAB*. In presence of external stimulus MprB shows bi-functional behavior by acting as kinase as well as phosphatase towards its cognate response regulator MprA. The pool of phosphorylated MprA acts as a transcription factor for expression of *sigE*. SigE, in turn, activates the operon *mprAB*. Measurement of *sigE* levels following the application of an external stimulus could therefore serve as an indirect measure of the pool of MprA-P generated due to induction. Considering the influx of the external stimulus and the consequent outflux via the formation of phosphorylated response regulator, one can define an input-output relation using the framework of bacterial TCS. This phosphorelay based signalling machinery is likely to be insensitive to the variation in systems components that eventually leads to a robust signalling framework. Keeping this in mind we plan to address validation of input-output

relation in MprAB TCS of *M. tuberculosis* utilizing the *in vitro* reconstitution of the signal flow network in *E. coli*.

In our preliminary work, we have cloned *M. tuberculosis mprA* and *mprB* gene and purified the recombinant proteins by expressing them in *E. coli*. For studying MprAB dependent gene expression *in vivo*, we have used the recombinant M. tuberculosis reporter assay in *E. coli*. For this assay, we have cloned the *mprAB* genes under an inducible promoter and in the same plasmid we have introduced a mCherry cassette under the control of a MprA dependent promoter DNA.

Publications

1. Prajapati RK, Sengupta S, Rudra P and Mukhopadhyay J (2016) Bacillus subtilis δ Factor Functions as a Transcriptional Regulator by Facilitating the Open Complex Formation. *J Biol Chem*. 291(3), 1064-75.
2. Rudra P, Prajapati RK, Banerjee R, Sengupta S and Mukhopadhyay J (2015) Novel mechanism of gene regulation: the protein Rv1222 of Mycobacterium tuberculosis inhibits transcription by anchoring the RNA polymerase onto DNA. Nucleic Acid Research, 43: 5855-67.
3. Sengupta S, Prajapati RK and Mukhopadhyay J (2015) Promoter escape with bacterial two-component sigma factor suggests retention of sigma region two in the elongation complex. *J Biol Chem*. 290(47), 28575-83.

Students Awarded Ph.D.

Name of Student (University/Year)	Title of Thesis
Rajdeep Banerjee (C.U., 2015)	Mechanism of Gene Regulation in *Mycobacterium tuberculosis*

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
In vitro study of input-output robustness of *MprAB* signalling pathway in *Mycobacterium tuberculosis*	DBT
Characterization and design of inhibitors of *Mycobacterium tuberculosis* transcription	DBT

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(I) Participated on Novel mechanism of gene regulation: the protein Rv1222 of Mycobacterium tuberculosis inhibits transcription by anchoring the RNA polymerase onto DNA; at 18th Transcription Assembly Meeting, IISER, Pune on March 12-15, 2015; (ii) Poster presented on Validation of 'proposed model for promoter escape' using two-component σ factor YvrI and YvrHa of Bacillus subtilis at 18th Transcription Assembly Meeting, IISER, Pune on March 12-15, 2015.

SCIENTIFIC REPORTS

VII
Basic and Applied Problems in Physical and Environmental Sciences

Participation in Institutional Projects for the 12th Five-year Plan (2012-2017)

Dr. D. Home (Coordinator), Dr. S. Raha, Dr. B. K. Chatterjee, Dr. Indrani Bose, Dr. Sanjay Kr. Ghosh, Dr. S. K. Saha, Dr. T. P. Sinha, Dr. Pradip Das, Dr. Somsubhro Bandyopadhyay, Dr. Dhruba Gupta, Dr. Rajarshi Ray, Dr. Achintya Singha, Dr. Abhijit Chatterjee, Dr. Supriya Das, Dr. P. S. Joardar and Dr. Soumen Roy, Dr. Probir Roy, Dr. Sanat Kumar Das, Dr. Sidharth Kumar Prasad, Dr. Saikat Biswas.

Introduction

The Institutional project VII contributes both to fundamental knowledge as well as applications relevant to industry and society in general. The Department's current research activities are in the areas of Atmospheric Sciences, Radiation Physics; Statistical Mechanics; Foundations of Quantum Mechanics and Quantum Entanglement; Astrophysics of Strongly Interacting Matter; Characterization of Detector Materials for Heavy Ions; Preparation and Characterization of Dielectric Materials, Condensed Matter Physics, Image processing and Differential networks, Nuclear and High Energy Physics, Astroparticle Physics and Cosmology, Physics Relativistic Heavy Ion Collisions. Recently, intense activities have also been initiated in Millimeter Wave and Microwaves.

Dr. Somshubhro Bandyopadhyay

Associate Professor

Scientific Reports

I. Theoretical Research

A. Entanglement as a resource for quantum information processing in many-body systems

Limitations on entanglement as a resource for multipartite state discrimination: *jointly with Saronath Halder and Michael Nathanson*

We explored the question of using an entangled state as a universal resource for implementing quantum measurements by local operations and classical communication (LOCC). We showed that for most systems consisting of three or more subsystems, there is no entangled state from the same space

that can enable all measurements by LOCC. This is in direct contrast to the bipartite case, where a maximally entangled state is a universal resource. Our results were obtained showing an equivalence between the problem of local state transformation and that of entanglement-assisted local unambiguous state discrimination.

Entanglement cost of distinguishing GHZ states: ***jointly with Saronath Halder***

We showed that a maximally entangled *m-qubit, m-partite* GHZ state as resource is sufficient to distinguish *any N -qubit, m-partite* maximally or non-maximally entangled GHZ basis. However, for non-maximally entangled GHZ basis, sometimes, it is possible to reduce the entanglement cost. An upper bound on the entanglement cost for a class of non-maximally entangled GHZ basis can therefore be obtained.

Entanglement as a resource for LOCC state discrimination: ***jointly with Saronath Halder***

It is shown that if multiple copies of a special class of entangled states are available then it is possible to optimally discriminate any multipartite basis. This is in direct contrast with bipartite systems.

B. Quantum Channels: *joint work with Rajarshi Pal, IIT Madras*

Quantum channels for which optimal singlet fraction is attained by using a non-maximally entangled state

To establish an entangled state of optimal fidelity between two distant observers when the available quantum channel is noisy is a central problem in quantum information theory. We consider an instance of this problem when only a single use of the channel and local post-processing by trace preserving operations are allowed. We show that for any dimension there is a channel for which the optimal singlet fraction is not obtained by sharing a maximally entangled state as intuition would suggest. A notable consequence of these results is that the ordering of states under an entanglement monotone can be reversed even when the states undergo the same local interaction via a trace-preserving completely positive map.

Optimal way to transmit a qudit though a single use of a noisy qudit channel

In this work we ask what is the best strategy for Alice and Bob to communicate a qudit with a single use of a quantum channel. There are two strategies which they can take: They can either use an encoding decoding scheme assisted by classical commounication, or, they can first share an entangled state through the channel and then use the shared entangled state for teleportation. We show that 'optimal teleportation' is always as good as the best encoding-decoding operation for the average channel fidelity.For any qubit channel, this allows us to provide a tight bound on the channel fidelity with respect to arbitrary trace-preserving LOCC encoding-decodings.

C. Quantum state discrimination by LOCC: *jointly with Saronath Halder*

There exist complete product basis in dxd Hilbert space that cannot be distinguished by LOCC. Recently, it has been observed that even a small subset of the whole basis can show the local indistinguishability. We have constructed a new class of bipartite nonlocal product basis for which it is shown that a smaller subset is nonlocal.

We have considered the structure of multipartite nonlocal product bases. It is shown that there exists a class of nonlocal product bases that remain locally indistinguishable across every bipartition.

II. Quantum Optics Laboratory

We are happy to report that our Integrated M.Sc. - Ph.D. students are doing basic experiments in quantum mechanics in this lab as part of their M.Sc. curriculum. We have also procedure new optimal elements for advanced experiments.

Publications

1. Banerjee A, Shukla C, Pathak A (2015). Maximal entanglement concentration for (n + 1)-qubit states, *Quantum Information Processing*, 14, 4523-4536.
2. Deb P (2016). Geometry of quantum state space and quantum correlations, *Quantum Information Processing*, 15(4), 1629–1638.
3. Deb P and Banik M (2015). Role of complementary correlations in the evolution of classical and quantum correlations under markovian decoherence, *Journal of Physics,* A: Mathematical and Theoretical, 48(18), 185303.
4. Margherita Z, Tanjung K, Tomasz P, Bandyopadhyay S, Banerjee A, Deb P, Halder S, Modi K, Paternostro M (2016). *Excessive distribution of quantum entanglement*, Physical Review, A 93, 012305.
5. Shukla C, Banerjee A and Pathak A (2015). Protocols and quantum circuits for implementing entanglement concentration in cat state, GHZ-like state and 9 families of 4-qubit entangled states, *Quantum Information Processing*, 14, 2077-2099.
6. Shukla C, Banerjee A, Pathak A and Srikant R (2016). Secure quantum communication with orthogonal states, *International Journal of Quantum Information,* 14.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Quantum entanglement and distributed quantum information processing (February 2013 –February 2016)	DST-SERB

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Delivered (i)several lectures on Basics of Quantum Information Theory at Summer School on Quantum Correlation; Foundation, Information Processing And Various Applications, 22nd June - 3rd July, 2015 held at the Indian Statistical Institute, Kolkata (ii) *delivered an invited talk at the* Discussion Meeting on Quantum Information Processing, Indian Institute of Science, Bangalore, 29-30 June 2015 (iii) attended International Conference *"Quantum Foundations 2015", NIIT Patna, December 2015 (iv)* delivered Colloquium at the Physics Department, IIT Madras, January 20, 2016 (v) visited Nanyang Technological University and delivered an invited talk at QLIPS, NTU, Singapore, Feb-March 2016.

Group Members

Prasenjit Deb i) presented a poster at International Workshop on Quantum Correlations and Many-Body Physics, University of York, UK ii) attended a conference on Quantum Information Processing and Communication, University of Leeds, UK.

Saronath Halder i) presented poster at the Young Quantum-2015 at HRI, Allahabad (Title: Entanglement cost of distinguishing GHZ basis ii) delivered a talk at the Physics and Applied Mathematics Researchers' Meet-2015 at ISI, Kolkata (Title: Entanglement cost of distinguishing GHZ basis).

Anindita Banerjee i) presented poster at the International Conference on Quantum Foundations 2015, National Institute of Technology, Patna, India, 30th November - 4th December, 2015 ii) presented poster titled "On the group-theoretic structure of a class of quantum dialogue protocols", at Quantum Physics and Logic(QPL), University of Oxford, UK, July 13- 17, 2015 iii) presented poster titled "Distribution of entanglement", Physics and Applied Mathematics Researchers' Meet (PAMRM), ISI, Kolkata, March 18-20, 2015 iv) delivered a talk titled "Symmetric and Asymmetric Multiparty Quantum Communication", International School and Conference on Quantum Information (ISCQI-2016) , Institute of Physics (IOP), Bhubaneswar, February 9 - 18 (2016) v) delivered a talk titled "Quantum conference", A meeting on Quantum Information Processing and Applications (QIPA-2015), Harish-Chandra Research Institute (HRI), Allahabad, India, 07 - 13 December, 2015 vi) delivered a Tutorial on "Experimental aspects of optical quantum information", Internationa School and Conference on Quantum Information (ISCQI-2016) , Institute of Physics (IOP), Bhubaneswar, February 9 - 18 (2016).

Socially Relevant

- Acted as a resource person in NESST-BEST, 2015 at Mayapuri, Darjeeling.
- Anindita Banerjee acted as a resource person for "Electronics associated with Data Acquisition System for Astroparticle Physics", 10th. Winter Workshop and School on Astroparticle Physics (WAPP 2015), Bose Institute, Mayapuri, Darjeeling during December 17 - 29, 2015

Dr. Saikat Biswas

Assistant Professor

Scientific Reports

R&D of gaseous detectors for experimental high energy physics: *with Mr. Rama Prasad Adak, Dr. Supriya Das, Prof. Sanjay Kumar Ghosh, Mr. Dipanjan Nag, Dr. Sidharth Kumar Prasad, Prof. Sibaji Raha.*

We are actively working on the ALICE experiment at CERN, Geneva and CBM experiment of FAIR, Germany. I am working to build a detector laboratory for experimental high-energy physics at Bose

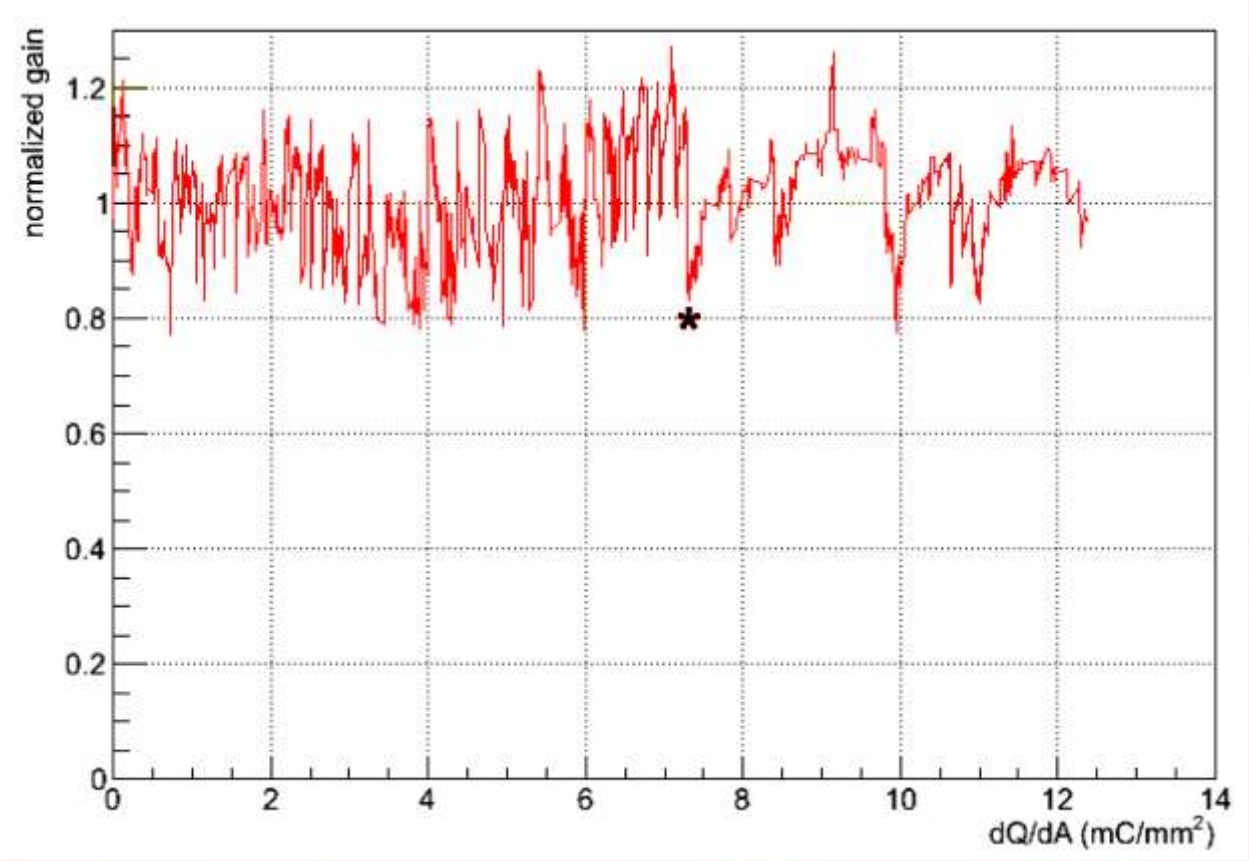
Institute. A gas detector laboratory started functioning at CAPSS, Bose Institute. Triple GEM (Gas Electron Multiplier) detector prototype is built and tested with a gas mixture of Ar/CO_2 of 70/30-volume ratio. The long-term stability test of this detector is performed using Fe^{55} X-ray source. The gain is measured and normalized for the T/p effect. Only a fluctuation about 1 in the normalized gain is observed after T/p correction. No ageing is observed till an accumulation of charge per unit area $>$ 12.0 mC/mm^2. From these results it can be concluded that triple GEM detector can safely be used in high-energy physics experiments where a long-term stability of the detector is an essential criterion. This work is very much essential for both the ALICE-TPC upgrade and CBM Muon Chamber.



Experimental set-up for the long-term stability test of the triple GEM detector.

Publication(s)

1. Biswas S, Abuhoza A, Frankenfeld U, Garabatos C, Hehner J, Kleipa V, Morhardt T, Schmidt C J, Schmidt H R and Wiechula J (2015). Measurement of the spark probability of a GEM detector for the CBM muon chamber (MuCh); *Nuclear Instruments and Methods in Physics Research A* 800,93- 97; Impact Factor: 1.2



Normalized gain as a function of the charge per unit area.

Conference proceedings:

1. Biswas S, Abuhoza A, Frankenfeld U, Garabatos C, Hehner J, Kleipa V, Morhardt T, Schmidt C J, Schmidt H R, and Wiechula J (2015) Discharge probability measurement of the GEM detector for the CBM Muon Chamber. *Proceedings of the DAE Symposium on Nuclear,* 60, 910-911.

2. Bhardwaj A, Biswal K, Gupta R, Nag A, Nanda A, Patra R N, Rudra S, Sahoo S S, Bhattacharya P, Biswas S, Mohanty B, Nayak T K, Sahu P K and Sahu S (2015) Development of triple GEM detector for a heavy ion physics experiment; *Proceedings of the DAE Symposium on Nuclear Physics,* 60, 962-963.

3. Patra Rajendra Nath, Singaraju R N, Ahammed Z, Biswas S, Nayak T K (2015) Studies of characteristics of triple GEM detector for the ALICE- TPC upgrade; *Proceedings of the DAE Symposium on Nuclear Physics*, 60, 934-935.

4. Sahu S, Bhattacharya P, Biswas S, Mohanty B, and Sahu P K (2015) Development of a 4-channel TTL scaler for detector signal counting; *Proceedings of the DAE Symposium on Nuclear Physics,* 60, 958-959.

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(i) Poster presented at Frontier Detectors for Frontier Physics (13th Pisa meeting on advanced detectors), La Biodala, Isola d'Elba, Italy, May 24-30, 2015 on a) A simple technique for gamma ray and cosmic ray spectroscopy using plastic scintillator b) Characterizations of GEM detector prototype c) Systematic measurements of the gain and the energy resolution of single and double mask GEM detectors d) Building and Commissioning of a Setup to Study Ageing Phenomena in Gaseous Detectors.

(ii) Participated workshop on GEM detector development for CBM at GSI at FAIR Detector Workshop; during February 19-20, 2016, Puri, Odisha.

(iii) Delivered lecture on Advanced gaseous detectors for high energy physics experiments at National Science Day celebration, 29 February 2016, Maulana Azad College, Kolkata.

Symposia and Seminar Organized

Organized along with Dr. Supriya Das, CAPSS on FAIR Detector Workshop at Puri, Odisha during February 19-20 2016.

Social relevance

The work is very essential for basic science. The work will train Indian students on instrumentation for high-energy physics. The position resolution of the GEM detector is very good. It is a very good candidate for medical imaging in place of scintillator-based detector.

Dr. Abhijit Chatterjee

Assistant Professor

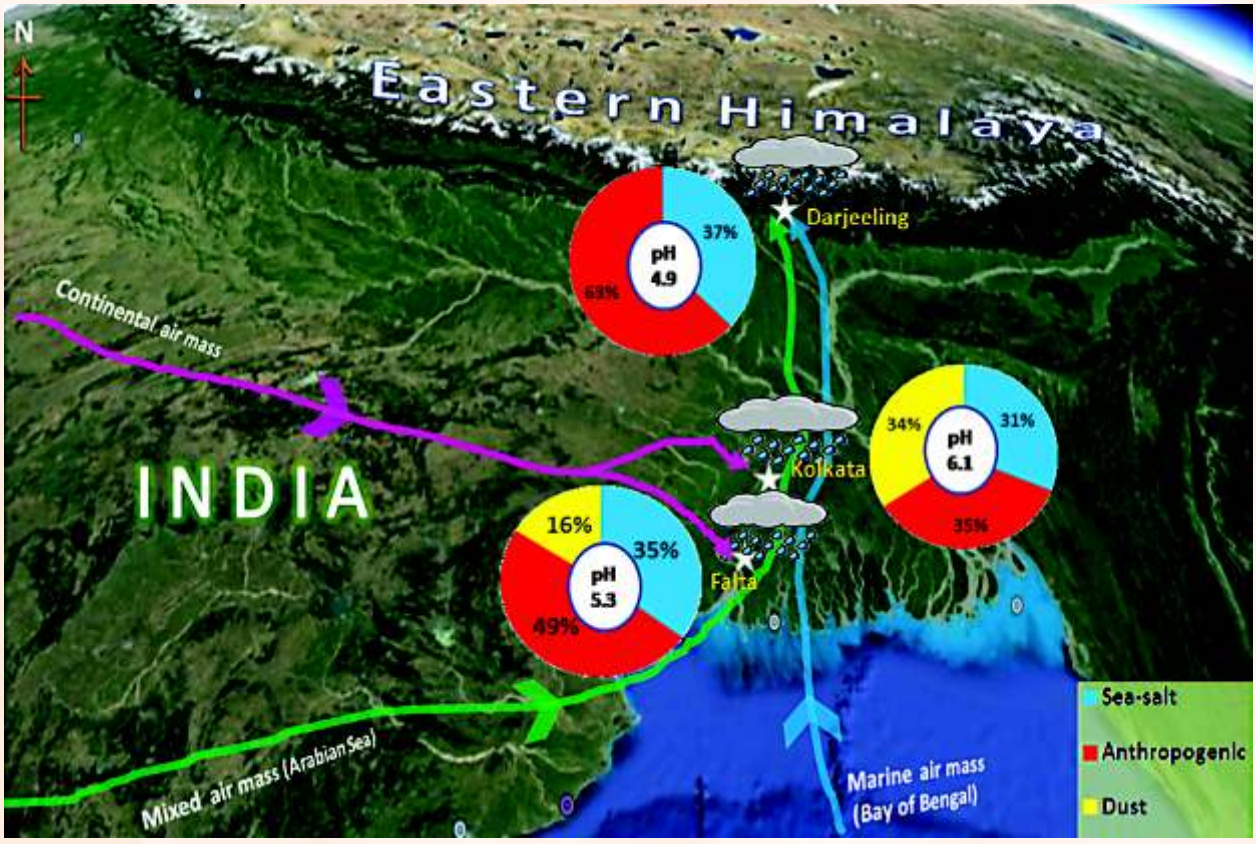
Scientific Reports

Studies on precipitation chemistry over urban, rural and high altitude Himalayan station in eastern India

A study was conducted on precipitation chemistry during monsoon (June-September) over Darjeeling, a high altitude station (2200 m asl) at eastern Himalaya; Kolkata, a typical metropolitan urban station and Falta, a rural station near Bay of Bengal. It was observed that the total ionic composition in rainwater was maximum over Kolkata (391 μeq l^{-1}) followed by Falta (204 μeq l^{-1}) and Darjeeling (64 μeq l^{-1}). The concentration of sea-salt species was highest near Bay of Bengal which got diluted by ~15 % over the mega-city i.e. moving towards north and further diluted by ~65 % over eastern Himalaya i.e. moving far north. It was observed that 85 % rain events were alkaline over Kolkata whereas 55 and 65 % events were acidic over Falta and Darjeeling respectively. Ca^{2+} was found to be the most potential species to completely neutralize the acidity over Kolkata whereas NH_4^+ was found to be the potential species to partially neutralize the acidity over Falta and Darjeeling.

Schematic diagram of how transport of air masses affected rainwater over Kolkata, Falta and Darjeeling

Positive matrix factorization model was used for the source apportionment of the ionic species scavenged by rain. High dust loading neutralized the rainwater acidity over Kolkata whereas very poor and negligible dust loading (compared to anthropogenic acidic species) increased the acidity over Falta and Darjeeling respectively. Anthropogenic and dust species increased by more than two times when air masses arrived from continental regions over Kolkata and Falta. It was observed that rainwater over Kolkata and Falta was alkaline under the influence of marine air masses. However under the influence of continental air masses, rainwater became acidic as transported anthropogenic ionic species had more acidic potentials than the neutralizing potentials of local and transported alkaline species whereas rainwater acidity did not vary with the air mass pathways over Darjeeling. Such high acidity of rainwater over Himalayan and coastal stations near Bay of Bengal is of paramount importance as acid rains could lead to deterioration of soil quality, agricultural growth, canopy cover, contamination of ground and surface water over these two ecologically important regions in India.



Characterization of winter-time aerosols over Sundarban mangrove forest

A field campaign was conducted over Chulkati, a remote and pristine island at Sundarban, north-east coast of Bay of Bengal for studying the effect of transport of anthropogenic polluted continental pollutants from Indo-Gangetic Plain regions to Bay of Bengal. It was observed that aerosols over Sundarban forest was mostly composed of locally generated sea-salt aerosols and carbonaceous and

other anthropogenic components. SO_4^{2-} was found to be the most abundant species amongst various water soluble ionic components. Chloride was found to be depleted by ~80 % from NaCl suggesting interactions between fresh marine sea-salt aerosols and other transported continental aerosol components. SO_4^{2-} and NO_3^- were the most efficient components depleting chloride ions from sea-salt particles. Strong westerly winds carried significant amount of carbonaceous aerosols like soot particles over Sundarban mangrove forest. These soot particles were found to be transported from the highly polluted Indo-Gangetic Plain regions. The huge transport of polluted aerosols could significantly affect the pristine marine environment at Sundarban.

Studies on Poly-nuclear Aromatic Hydrocarbon (PAH) over urban atmosphere of Kolkata and Himalayan high altitude station, Darjeeling

A first ever study of 14 polycyclic aromatic hydrocarbons (PAHs or polyaromatic hydrocarbons) intrinsic to the inhalable fraction (10µm or less) of particulate matters in ambient air, simultaneously carried out at Kolkata, a megacity on the Indo-Gangetic plain and at Darjeeling, an Eastern-Himalayan high altitude station in India, during three seasons, viz., post-monsoon (October and November, 2015), winter (December 2015 to February 2016) and pre-monsoon (March to May, 2016). The concentrations of total-PAHs during post-monsoon, winter and pre-monsoon were in the ranges of (83.42—113.52 ngm^{-3}), (78.08—146.71 ngm^{-3}), (37.65—109.27 ngm^{-3}) respectively at Kolkata and (5.12—22.72 ngm^{-3}), (8.52—28.43 ngm^{-3}), (5.45—13.34 ngm^{-3}) respectively at Darjeeling. The present work elucidates the distributions, sources of PAHs, meteorological influences and possible health effect: 1) PAHs concentrations at the two sites differ by a factor of five to one order of magnitude but similarity between PAHs profiles of the two sites indicated they had common sources, which was attributed to the effect of local emission. 2) At both sites, the profiles displayed obvious seasonal variations, as a result of the seasonality of sources and meteorological influences. The total-PAHs concentrations were in the order of winter > post-monsoon > pre-monsoon at Kolkata but post-monsoon > winter > pre-monsoon at Darjeeling. 3) Source apportionment by calculating diagnostic ratios and positive matrix factorization showed vehicle exhaust (~40%) was the greatest contributor in all seasons at Kolkata but coal and biomass combustion was the main contributor (~45%) at Darjeeling in all seasons. both sites. 4) Regarding meteorological parameters, a negative effect of temperature, wind speed, solar radiation and ozone concentration over PAHs was confirmed, with correlation coefficients of -0.84 ($p < 0.01$), -0.63 ($p < 0.01$), -0.81 ($p < 0.01$), -0.47 ($p < 0.05$) respectively for Kolkata and -0.61 ($p < 0.01$), -0.70 ($p < 0.01$), -0.78 ($p < 0.01$), -0.42 ($p < 0.05$) respectively for Darjeeling. 5) More than half of the quantified total-PAHs at both Kolkata and Darjeeling were comprising of probable human carcinogens (40–60%).

First ever studies on major Aldehydes and Ketones over eastern Himalaya

A first ever study was made on atmospheric carbonyl compounds over a high altitude hill station, Darjeeling (27.01°N, 88.15°E, 2200 masl) at eastern Himalaya in India. Temporal variation, meteorological influence, source apportionment and ozone formation potential etc were studied for acetaldehyde, formaldehyde, acetone, butanaldehyde, propanaldehyde, benzaldehyde, crotonaldehyde, valeraldehyde, isovaleraldehyde, hexanaldehyde, p-tolualdehyde and o-tolualdehyde. Acetone was found to have high concentrations (81.6 ± 63.5 μgm^{-3}) which could be

due to the higher photochemical production from its precursor volatile organic compounds emitted from tea plants and tea processing units. The concentration of acetaldehyde (20.7 ± 47.6 μgm^{-3}) and formaldehyde (11.6 ± 16.3 μgm^{-3}) were found to be comparable with metro cities of India and world. The average annual concentration of total carbonyl compounds was 174.2±184.6 μgm^{-3} with maximum during postmonsoon (456.9± 199.5 μgm^{-3}) and minimum during winter season (72.2 ± 42.9 μgm^{-3}). Meteorological parameters like surface reaching solar radiative flux and wind speed played the major roles for the seasonal variation of the carbonyl concentration over the hill station. The average ratio of formaldehyde to acetaldehyde over Darjeeling was found to be 1.64 ± 1.43 well representing a typical urban atmosphere at this part of Himalaya. Principal component analysis was performed for the source apportionment of the observed carbonyl compounds for the entire study period and three factors were identified. Secondary photochemical production and vehicular emission were the major contributors and biomass/coal burning or biogenic emissions were the minor contributors of carbonyl compounds over the hill station.

Role of local and transported submicron aerosols on the formation of Cloud Condensation Nuclie (CCN) over eastern Himalaya

A comprehensive study was conducted on how the submicron aerosols whether locally generated or transported from long-distant regions affect the formation of CCN over eastern Himalaya in India. Continuous monitoring was made for the measurement of aerosols and CCN during dry seasons in 2015-2016. It was observed that during summer and winter, aerosols over Darjeeling were mostly contributed by local vehicular activities as well as transported from plain land cities at Indo-Gangetic Plain (IGP). Winter and summer-time aerosols over Darjeeling were also contributed by huge crop residue burning occurred at the IGP regions like Uttar Pradesh, Himachal Pradesh, Punjab and Haryana. These aerosols were very active and efficient to form cloud condensation nuclei and hence cloud droplets in the atmosphere of eastern part of Himalaya.

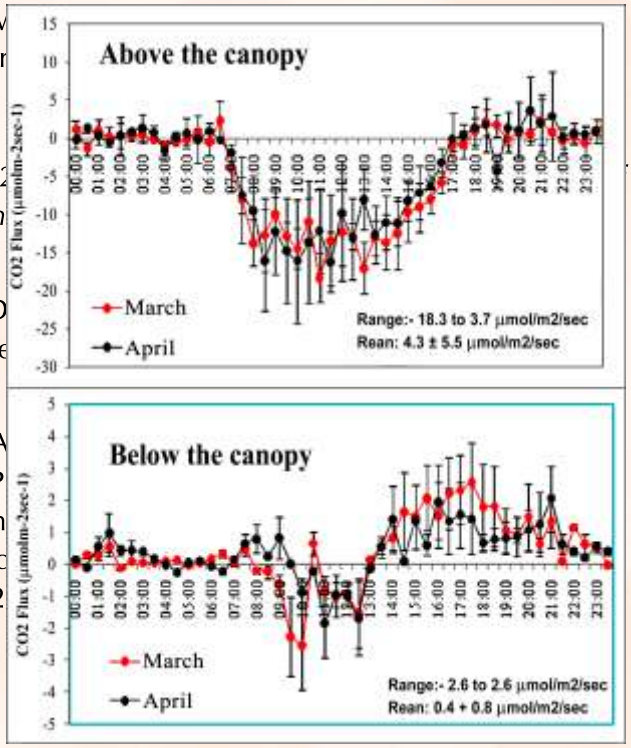
Exchange of Carbon-di-oxide between Himalayan biosphere and atmosphere in India

To understand the impact of Indian subcontinent and its natural resources on the regional and global environmental changes, an integrated national environmental network Indoflux was proposed few years back and has become operational sponsored by Indian Institute of Tropical Meteorology, Ministry of earth Sciences, Govt of India. This national comprehensive observation network integrates terrestrial, coastal and oceanic environments for the studies on exchange of greenhouse gases (GHG) for better understanding of the coupling of these different environments in India.

Among the various sites under this national network in India, Bose Institute, has started monitoring and observational studies over a high altitude Himalayan forest in eastern India. The study on exchange of CO_2, H_2O and Energy fluxes is being carried out based on Flux-tower Eddy Covariance method erecting a 50 meter tall tower in a typical Himalayan sub-alpine coniferous forest. The observational site (27.04 ºN, 88.08 ºE) is situated at an altitude of 2286 m above mean sea level at eastern Himalaya in India. The forest vegetation is comprised mainly of Cryptomaria Japonica with the average height of 25 m. The site is in a highly complex terrain of Himalaya and situated in an absolute remote area with no anthropogenic activities and almost at ridge-top with an aerial distance of ~13 km from main Darjeeling Township. Two CO2/H2O analyzers with co-located

near ground at night which started decreasing during day-time till ~20 m and then increased gradually. Overall we observed that ~18 g CO_2 was sequestered by the forest whereas ~2.5 g H_2O was emitted through evapo-transpiration from the forest per square meter area per day during summer, 2015.





Study of Cosmic ray interactions and Cosmic Ray – Aerosol – Cloud connection in the context of regional climate change	DST
Study on Biosphere-Atmosphere Exchange of Carbon dioxide, Water Vapor and Energy in a Tropical High Altitude Forest Canopy at Eastern Himalaya, India	MoES
National Carbonaceous Aerosol Program (NCAP) (*Project to be started from October 2016*)	MoEFCC

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(i) Delivered invited talk on solving the mystery of carbon tetrachloride; organized by Swiss Federal Laboratories for Materials Science and Technology, Zurich, Switzerland, Universities Space Research Association, USA and NASA, USA and funded by United Nation Environment Program (UNEP) held at Zurich, Switzerland during October 5-6, 2015. (ii) Delivered talk in "13th AsiaFlux Workshop" held at Indian Institute of Tropical Meteorology, Pune, India during November 22-29, 2015. (iii) Delivered talk in "American Geophysical Union" held at San Francisco, USA during December 14-18, 2015.

Dr. Barun K. Chatterjee

Senior Professor

Scientific Reports

Study of liquid-vapor nucleation in superheated drop detectors

The change of amplitude of sound waves emitted during nucleation, due to increase in velocity of sound and increase in Gibbs barrier-height for liquid-vapor nucleation, causes the distribution of acoustic pulse-height to move towards lower values. The fraction of pulses with amplitude greater than a threshold value as observed to decrease exponentially with pressure.

A linear relationship of gamma-induced nucleation threshold temperature with the limit of superheat (the temperature at which the superheated liquid becomes unstable to liquid-vapor nucleation) was observed for R12, R114, R134a and R610-SDD.

It was observed that the steel-encased ^{241}Am gamma-source ($E_{\square}$ = 59.54 keV) also emitted neutrons as a contaminant (note that alpha from the ^{241}Am source cannot penetrate the steel casing). This was noted from the fact that it caused nucleation in R12-SDD at temperatures well below 38 °C which is the threshold for gamma induced nucleation. The nucleation rate was found to decrease with the insertion of paraffin blocks which attenuates the neutrons. It was checked using R114-SDD, which has a gamma-threshold at 66 °C but is sensitive to irradiation from ^{241}Am at about 30 °C, which can only be due to neutrons.

Publications

1. Chatterjee T, Mukherjee D, Banerjee M, Chatterjee B K and Chakrabarti P (2015) Crystal structure and activity of Protein L-isoaspartyl-O-methyltransferase from *Vibrio cholerae*, and the effect of AdoHcy binding; *Archives of Biochemistry and Biophysics;* 583, 140-149.
2. Sarkar R, Mondal P K and Chatterjee B K (2015) An alternative method for the measurement of neutron flux; *Pramana-J. Phys;* 85, 685-690.

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Delivered an invited lecture on "Amazing Liquids", at Sri Aurobindo Institute of Education, on 9th October 2015.

Dr. Pradip Das

Professor

Scientific Reports

Supramolecular Salts of Pheromones and Short-/Long-range Interactions in Liquid Crystals

The cholesteric phase thermal range is shown theoretically to be determined by molecular and dipolar structures, and resultant short-range interactions. Powder XRD results from cholesteryl oleate and

cholesteryl oleyl carbonate corroborate the theory. Also, theory of mesophase induction in binary mixtures of these materials is being studied theoretically. Supramolecular chemistry of some pheromone-generating esters is under NMR, single crystal XRD and computational studies.

Dr. Sanjay K. Ghosh

Senior Professor

Scientific Reports

Passive detector set up for Cosmic Ray: *with R. Bhattacharyyaa, Dr. S. Dey, A. Mauli, Dr. Sibaji Raha and Dr. D. Syam*

In this work we investigated the detection threshold of the polymer material Polyethylene Terephthalate (PET) intended to be used as Nuclear Track Detector (NTD) in the search for rare events (e.g. strangelets) in cosmic rays. 11 MeV ^{12}C and 2 MeV proton beams from the accelerator at the Institute of Physics (IOP), Bhubaneswar were utilized for this study. The results show that the PET detector has a much higher detection threshold ($Z/\beta \sim 140$) compared to many other commercially available and widely used detector materials like CR-39 ($Z/\beta \sim 6–20$) or Makrofol ($Z/\beta \sim 57$). This makes PET a particularly suitable detector material for testing certain phenomenological models which predict the presence of strangelets as low energy, heavily ionizing particles in cosmic radiation at high mountain altitudes.

Physics of strong interaction – Effective models: *with Dr. Rajarshi Ray, Kinkar Saha, and Sudipa Upadhaya, External Collaborator: Dr. Abhijit Bhattacharyya, Calcutta University*

We have studied the 2 + 1 flavor Polyakov loop enhanced Nambu–Jona- Lasinio model in a finite volume. The main objective is to check the volume scaling of thermodynamic observables for various temperatures and chemical potentials. We observe the possible violation of the scaling with system size in a considerable window along the whole transition region in the T – μ_q plane.

Atmospheric Science: *with Dr. Sanat Kumar Das, Dr. Abhijit Chatterjee and Dr. Sibaji Raha*

An outflow of continental haze occurs from Indo-Gangetic Basin (IGB) in the North to Bay of Bengal (BoB) in the South. An integrated campaign was organized to investigate this continental haze during December 2013–February 2014 at source and remote regions within IGB to quantify its radiative effects. Measurements were carried out at three locations in eastern India; 1) Kalas Island, Sundarban (21.68°N, 88.57°E) — an isolated island along the north-east coast of BoB, 2) Kolkata (22.57°N, 88.42°E) — an urban metropolis and 3) Siliguri (26.70°N, 88.35°E) — an urban region at the foothills of eastern Himalayas. Ground-based AOD (at 0.5 μm) is observed to be maximum (1.25 ± 0.18) over Kolkata followed by Siliguri (0.60 ± 0.17) and minimum over Sundarban (0.53 ± 0.18). Black carbon concentration is found to be maximum at Kolkata (21.6 ± 6.6 $\mu g \cdot m^{-3}$) with almost equal concentrations at Siliguri (12.6 ± 5.2 $\mu g \cdot m^{-3}$) and Sundarban (12.3 ± 3.0 $\mu g \cdot m^{-3}$). Combination of MODIS-AOD and back-trajectories analysis shows an outflow of winter-time continental haze

cholesteryl oleyl carbonate corroborate the theory. Also, theory of mesophase induction in binary mixtures of these materials is being studied theoretically. Supramolecular chemistry of some pheromone-generating esters is under NMR, single crystal XRD and computational studies.

Dr. Sanjay K. Ghosh

Senior Professor

Scientific Reports

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originating from central IGB and venting out through Sundarban towards BoB. This continental haze with high extinction coefficient is identified up to central BoB using CALIPSO observations and is found to contribute ~ 75% to marine AOD over central BoB. This haze produces significantly high aerosol radiative forcing within the atmosphere over Kolkata (75.4 Wm^{-2}) as well as over Siliguri and Sundarban (40 Wm^{-2}) indicating large forcing over entire IGB, from foothills of the Himalayas to coastal region. This winter-time continental haze also causes about similar radiative heating (1.5 $K{\cdot}day^{-1}$) from Siliguri to Sundarban which is enhanced over Kolkata (3 $K{\cdot}day^{-1}$) due to large emission of local urban aerosols. This high aerosol heating over entire IGB and coastal region of BoB can have considerable impact on the monsoonal circulation and more importantly, such haze transported over to BoB can significantly affect the marine hydrological cycle.

Publications

1. Bhattacharyya R, Dey S, Ghosh S K, Moulik A, Raha S and Syam D (2016) Determination of detection threshold of Polyethylene Teraphthalate (PET) Nuclear Track Detector (NTD), *BNucl. Instrum. Meth, B370, 63.*
2. Das S K, Chatterjee A, Ghosh S K and Raha S (2015) An integrated campaign for investigation of winter-time continental haze over Indo-Gangetic Basin and its radiative effects, *Science of the total environment 533, 370.*
3. Sharma S K, Mandal T K, Shenoy D M, Bardhan P, Srivastava M K, Chatterjee A, Saxena M, Saraswati, Singh B P, Ghosh S K (2015) Variation of Stable Carbon and Nitrogen Isotopic Composition of PM10 at Urban Sites of Indo Gangetic Plain (IGP) of India, *Bulletin of Environmental Contamination and Toxicology,* 95 661.
4. ALICE Collaboration (J. Adam et al.) (2016) Event shape engineering for inclusive spectra and elliptic flow in Pb-Pb collisions at √sNN = 2.76 TeV, *Phys. Rev.* C93 034916.
5. ALICE Collaboration (J. Adam et al.) (2016) Centrality dependence of the nuclear modification factor of charged pions, kaons and protons in Pb-Pb collision at $\sqrt{s_{NN}}$ = 2.76 TeV, Published in *Phys. Rev.* C93 034913.
6. ALICE Collaboration (Jaroslav Adam et al.) (2016) Transverse momentum dependence of D-meson production in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV, JHEP 03 081.
7. ALICE Collaboration (J. Adam et al.), (2015) Coherent ψ(2S) photo-production in ultra-peripheral Pb Pb collisions at √sNN = 2.76 TeV, 358, *Phys.Lett.* B751.
8. ALICE Collaboration (J. Adam et al.) (2016) Study of cosmic ray events with high muon multiplicity using the ALICE detector at the CERN Large Hadron Collider, *JCAP* 1601 032.
9. ALICE Collaboration (J. Adam et al.) (2016) Centrality dependence of pion freeze-out radii in Pb-Pb collisions at √sNN = 2.76 TeV, *Phys.Rev.* C93 024905.
10. ALICE Collaboration (J. Adam et al.) (2016) Elliptic flow of muons from heavy-flavour hadron decays at forward rapidity in Pb–Pb collisions at √sNN = 2.76 TeV, *Phys.Lett.* B753 41.

11. ALICE Collaboration (J. Adam et al.) (2016) Production of light nuclei and anti-nuclei in pp and Pb-Pb collisions at energies available at the CERN Large Hadron Collider, Phys.Rev. C93 024917.

Participation in Conferences / Symposia / Workshops&Invited Talks Delivered at Various Organizations

Participated in ALICE collaboration experimental activities at CERN, Geneva, Switzerland during August 17 – September 5, 2015.

Symposia and Seminar Organized

- Member, Organizing committee, Winter Workshop and School on Astroparticle Physics held at Bose Institutte, Darjeeling during December 27 – 29, 2015.
- Coordinator of NESST-BASE 2015, a summer training programme for North-East students in basic sciences held at Bose Institute, Darjeeling during May 18-30, 2015.

Dr. Supriya Das

Associate Professor

Scientific Reports

Design and development of Common Readout Unit (CRU) for the ALICE experiment: *with Sanjoy Mukherjee in collaboration with Tapan K. Nayak, Shuaib Ahamed and Zubin Mitra: VECC, Kolkata, Amlan Chakrabarti and Rourab Pal: University of Calcutta)*

The common read out unit (CRU) creates a bi-directional way for information exchange in between online offline system (O^2) and different sub-detector systems of ALICE. Inside CRU, there are some interfaces, which are common to all detector systems,and one detector specific module that is different for different detectors. The protocol used with respect to DAQ (alias O^2) side to send the control information and receive data from detector side is PCI Express on which we have been working.

At the beginning, the protocol used for CRU and DAQ was 10G Ethernet. We need twelve such 10G Ethernet ports to cover the input bandwidth. We moved to PCI Express protocol as 12x 10G will consume more than 50% of FPGA resource that is not good enough to make space for rest of the logic. PCI Express will not consume FPGA resource as it is built in block inside the FPGA we are using. In the following section, the work done on PCI Express is explained:

PCI Express offers large bandwidth. To utilize the bandwidth efficiently, we used Direct Memory Access (DMA) protocol to push data into PCI Express. There were few reference designs on PCIe based DMA from Altera. We started to evaluate those through simulation as we will have to know how DMA works and which design is more suitable for CRU. We selected one register based design as it is easy to interface user logic with it and got some initial idea about the DMA based data flow.

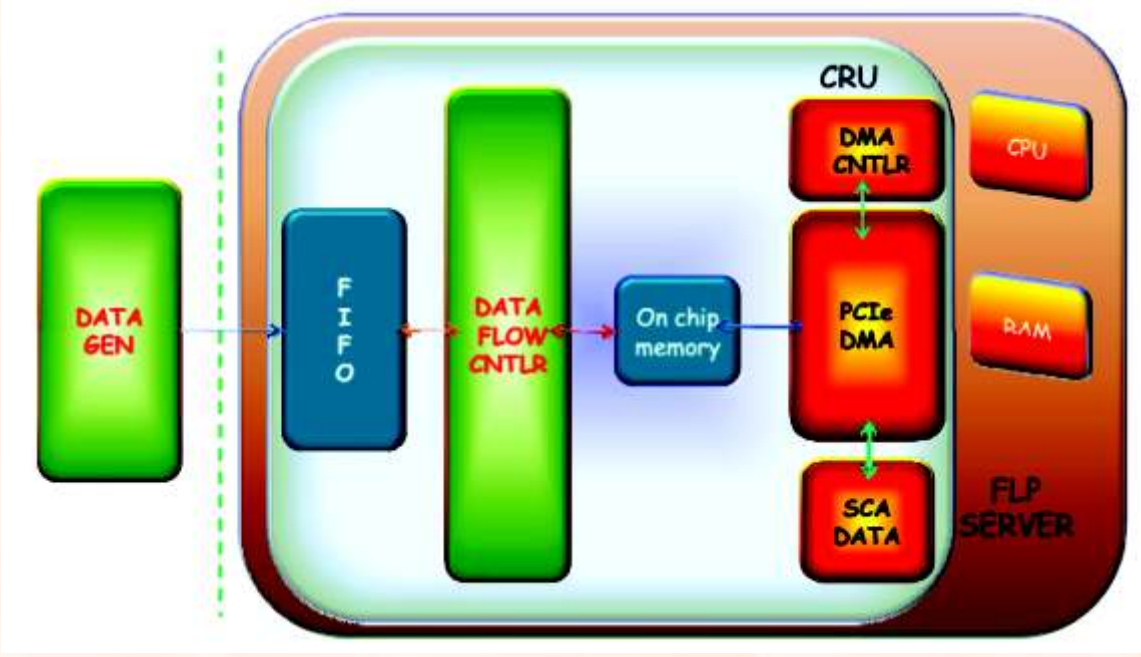
Next step was to carry out some basic tests related to DMA performance on hardware. We compiled the same design that we evaluated and used the software that came from Altera to measure the

performance. We got some numerical values regarding performance but we could not validate data as software does not have that feature.

Till now, we were using Altera Stratix V FPGA for evaluation but actual CRU will be based Arria 10 hardware which was not available at that time. After gaining some experience on Stratix V, we started to look into Arria 10 based PCIe DMA design. We found that the principle is almost same as Startix Vbut Arria 10 one has some new feature.

We evaluated the Arria 10 based design in two phases: simulation and real time. The main points of evaluation were to break the loopback model of design to insert custom data, control over the simulation model and develop logic to achievemax DMA performance. The evaluation result was quite good to meet our needs. We achieved around 6.7 GB/s data transfer rate after four stages of iteration. We used x8 lane card. The performance will be more or less double if we use x16 lane card like PCIe40 which is our target hardware for CRU.

Not only the firmware, we developed a part of DAQ software related with PCIe. We replaced PHYMEM driver with PDA-DMA that will be used in RUN3. We were able to access registers of firmware logic via PCI Express and measure DMA performance in software.



Till now, the firmware user logic was developed to check the performance only. It was decided to continue develop further user logic, add features as the performance was good enough. Next step was to add one FIFO having optimum size to manage the situation when the card side memory could not be over-written as data movement was in process. FIFO logic was developed but we could not test it as the hardware was not available at that moment.

The logic developed excluding FIFO was tested on the server close to FLP server. But there were some issues with that particular server, so we could not proceed much more with that server. However, we have tested entire logic (firmware + software) in CENT OS 7 environment, which is the target OS for RUN3.

Dr. Dhruba Gupta

Associate Professor

Scientific Reports

Search for higher excited states of ^{8}Be* to study the cosmological ^{7}Li problem: *with Dr. Swapan K Saha*

We have an upcoming experiment (IS 554) at HIE-ISOLDE at CERN, Geneva, Switzerland to study the ^{7}Li abundance anomaly. We carried out detailed Geant4 simulations for the experiment involving the T-REX charged particle detector array. Work is also in progress to incorporate the MINIBALL detector array to detect gamma rays in coincidence. Since there is existing contradiction between theory and observation of the destruction channel of ^{7}Be, we also carried out DWBA calculations for the reaction ^{7}Be(d,p)^{8}Be* using the code FRESCO. All these studies are extremely important before invoking physics beyond the standard Big Bang Nucleosynthesis.

Breakup of ^{7}Be in presence of heavy targets: *with Dr. Swapan K Saha*

Geant4 simulations of the breakup of ^{7}Be in the presence of heavy targets are being carried out. In essence we would be measuring the reverse reaction of Coulomb dissociation of ^{7}Be to derive information on the reaction 3He + 4He → 7Be + γ. This would help in the study of ^{7}Li abundance anomaly by considering also the production channel of ^{7}Li which is linked to the production of ^{7}Be. Theoretical calculations of the above breakup reaction in the framework of prior-form DWBA is in progress. We plan to submit a beam time proposal on this project soon.

Study of n-p pairing through two-nucleon transfer reactions: *with Dr. Swapan K Saha*

Analysis of the data for the n-p pairing experiment at the rare isotope facility GANIL, Caen, France was continued. The aim is to study two nucleon n-p transfer reactions on two nuclei, a mid-shell nucleus ^{48}Cr, a candidate for n-p pairing correlations, and the doubly magic nucleus ^{56}Ni which will not show any pairing effects. On both these nuclei we measured (p,^{3}He) and (d,α) reactions in order to investigate the competition between T = 1 and T = 0 pairing and probe n-p pairing. We are carrying out a part of the data analysis at Bose Institute in the NPTool framework in collaboration with IPN, Orsay, France. The preliminary analysis shows that n-p pairing in ^{56}Ni is mainly of isovector type.

Study of resonance states of ^{15}Be with isospectral bound state microscopic potential: *with Dr. Swapan K Saha in collaboration with: Dr. S. K. Dutta (B. G. College, Berhampore, Murshidabad).*

Recently there has been a surge in interest in the neutron-unbound nucleus ^{15}Be. It is very difficult to tackle theoretically the unbound states by conventional methods. We have resorted to a very effective technique used earlier by us to detect low-lying broad resonances of weakly bound nuclei. Its success has prompted us to apply it effectively for unbound nuclei like ^{15}Be. The theoretical procedure of supersymmetric quantum mechanics (SQM) is adopted to tackle the resonance states of unbound nuclei. We have been able to reproduce the unbound state energies without any modification of our constructed density dependent M3Y (DDM3Y) microscopic potential. Our

procedure confirmed the existence of $5/2^+$ state and also reproduced the experimentally predicted unbound resonance energy of 1.8 MeV.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
With Dr. Swapan K Saha	
Astrophysical S-factor from nuclear reactions with a rare isotope beam of ^{7}Be	ISRO

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(I) Participated and presented a poster titled "The cosmological lithium problem in the context of resonant enhancement" at the ISOLDE Workshop and Users Meeting 2015, CERN, Geneva, Switzerland, December 2-4, 2015; (ii) carried out collaborative research for upcoming experiment IS554 at CERN, December 5-9, 2015; (iii) visited the Institut de Physique Nucleaire, Orsay, France, December 9-17, 2015 for collaborative research; (iv) served as a member of the organizing committee of the Workshop and Winter School on Astroparticle Physics (WAPP 2015) held at Bose Institute, Darjeeling, December 18-29, 2015 (v) delivered an invited talk on "Interaction of Radiation with Matter" at WAPP 2015.

Dr. Dipankar Home

Senior Professor and Coordinator

Scientific Reports

a) Effect of quantum statistics on the gravitational weak equivalence principle

The effect of quantum statistics on the arrival time distribution of quantum particles computed through the probability current density has been studied. In particular, the effect of quantum statistics on the weak equivalence principle in quantum mechanics (WEQ) has been demonstrated through the violation of WEQ evidenced by the mass dependence of the mean arrival time.

b) Bell measurements as a witness of a dualism in entanglement

This work demonstrates how the newly discovered property of dualism of the entanglement of identical particles can be tested in the usual photonic Bell measurement apparatus with minor modifications. Two different sets of coincidence measurements on the same experimental setup consisting of a Hong-Ou-Mandel interferometer demonstrate how the same two-photon state can emerge entangled in the polarization or the momentum degree of freedom depending on the dynamical variables used for labeling the particles.

Publications

1. Home D (2015) Facets of the Leggett-Garg inequality: some recent studies; *Current Science 109, 1980.*
2. Moreva E, Brida G, Gramegna M, Bose S, Home D and Genovese M (2015) Bell measurements as a witness of a dualism in entanglement; *Physical Review* A 91, 062117**.**
3. Mousavi S V, Majumdar A S and Home D (2015) Effect of quantum statistics on the gravitational weak equivalence principle; *Classical and Quantum Gravity* 32, 215014**.**

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
Jointly with Prof. Archan S. Majumdar of SNBNCBS (PI)	
Fundamental aspects of quantum theory and quantum information: a multidisciplinary approach	DST
Jointly with Prof. Alexandre Matzkin, Université de Cergy-Pontoise, France (PI) and Prof. Urbasi Sinha of Raman Research Institute, Bangalore (Co-PI)	
Unveiling the nature of quantum reality: a theoretical and experimental approach employing non-destructive weak measurements	John Templeton Foundation

Dr. Parthasarathi Joardar

Associate Professor

Scientific Reports

High Energy Astrophysics and Computational Astrophysics

Group Members: **Dr. Parthasarathi Joarder**, **Dr. Shubhrangshu Ghosh** (Post-Doctoral Research Associate, Institute), **Mr. Sayan Biswas** (Senior Research Fellow, Institute; Principal Supervisor: Professor Sibaji Raha), **Ms. Sananda Raychaudhury** (Junior Research Fellow, Institute), **Ms. Pooja Bhattacharjee** (Junior Research Fellow, DST Inspire Scheme).

Exact relativistic Newtonian-like representation of gravitational static space-time geometry:

We construct a self-consistent and an exact relativistic Newtonian analogue corresponding to gravitational static spherical symmetric space time geometries, staring directly from a generalized scalar relativistic gravitational action in Newtonian framework that gives geodesic equations of motion identical to those of the parent metric. Consequently, the derived velocity dependent relativistic scalar potential, which is a relativistic generalization of Newtonian gravitational potential, exactly reproduces the relativistic gravitational features corresponding to any static

spherical symmetric space time geometry in its entirety, including all the experimentally tested gravitational effects **in the weak field** till date. This relativistic analogous potential is expected to be quite useful in studying wide range of astrophysical phenomena, especially in strong field gravity.

Effects of dark energy and flat rotational curve on the gravitational time-delay of particle with non-zero mass

The effects of several dark energy models on gravitational time delay of particles with non-zero mass are investigated and analytical expressions for the same are obtained at the first order accuracy. Also the expression for gravitational time delay under the influence of conformal gravity potential that well describes the flat rotation curve of spiral galaxies is derived. The findings suggest that i) the conformal gravity description of dark matter reduces the net time delay in contrast to the effect of normal dark matter and therefore in principle the models can be discriminated using gravitational time delay observations and ii) the effect of dark energy/flat rotation curve may be revealed from high precision measurements of gravitational time delay of particles involving megaparsec and beyond distancescale.

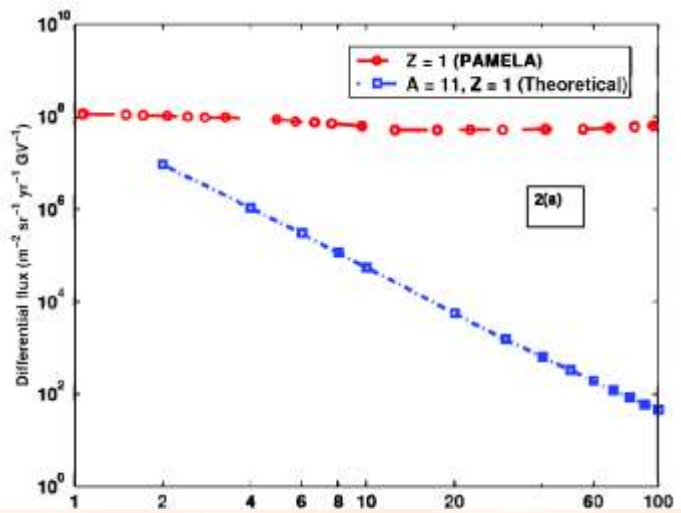
2.5 Dimensional, viscous, resistive, advective, magnetized accretion outflow coupling in black hole systems

The correlated and coupled dynamics of accretion and outflow around black holes (BHs) are essentially governed by the fundamental laws of conservation as outflow extracts matter, momentum and energy from the accretion region. Here we analyzed 2.5-dimensional viscous, resistive, advective magnetized accretion-outflow coupling in BH systems, in the mean field magnetohydrodynamical (MHD) regime, in the context to accretion powered hydromagnetic outflows. We solve the complete set of coupled MHD conservation equations self-consistently, through invoking a generalized polynomial expansion in two dimensions. We perform a critical analysis of accretion-outflow region and provide a complete quasi-analytical family of solutions for advective flows (with $\dot{M} \lesssim 10^{-2}\, \dot{M}_{Edd}$). We obtain the physical plausible outflow solutions at high turbulent viscosity parameter $\alpha(\gtrsim 0.3)$, and at a reduced scale-height, as magnetic stresses compress or squeeze the flow region. We found that the value of the large scale poloidal magnetic field is enhanced with increasing geometrical thickness of the accretion flow as well as with the increase in the value of α. The differential magnetic torque increases with the increase in $\dot{M}$as well as with the increase in α. Our solutions indicate that magnetocentrifugal acceleration plausibly plays a dominant role in effusing out plasma from the radial accretion flow in moderately advective paradigm which are more centrifugally dominated, however in strongly advective paradigm it is likely that the thermal pressure gradient would play a more contributory role in the vertical transport of the plasma.

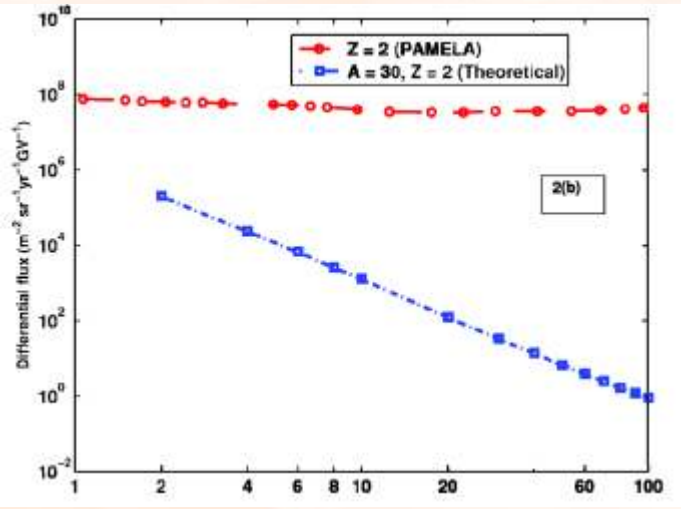
Multifragmentation model for the production of astrophysical strangelets:

Sayan Biswas, Parthasarathi Joarder and Sibaji Raha with external collaborators, Under revision in Phys. Rev. C, 2016;

A production scenario of the galactic strangelets and an estimation of their possible flux in the solar neighborhood, Sayan Biswas, Parthasarathi Joarder and Sibaji Raha with external collaborators, **POS**, *ICRC-2015*, p. 504, 2015.



(a)



(b)

Figure 1: Differential flux vs. rigidity for the strangelet fragments with $B^{1/4}$ = 145 MeV and m_s = 95 MeV at T = 10 keV at freeze-out. Comparisons with PAMELA results are displayed for (a) A = 11, Z = 1 and for (b) A = 30, Z = 2. Available volume is determined to be $\gamma \approx 4 \times 10^{50}$ MeV^{-3}, $A_b = 1 \times 10^{53}$ and $\beta^i = v^i / c$, v^i is the velocity of ith species(Reproduced from: Biswas *et al.*, **POS**, ICRC-2015, p. 504, 2015.

Finite lumps of strange quark matter in the form of strangelets, the theorized absolute ground state of QCD, are supposed to be more stable than ^{56}Fe nuclei. Recent simulation studies suggest that a major source of strangelets in the Galaxy may be the fragmentation of the bulk strange matter which is tidally released in the merger of strange stars in compact binary stellar systems. Here, we determine a plausible baryon number (or mass) distribution of such strangelets by invoking a statistical disassembly model often used in nuclear systems. The produced strangelets are likely to be accelerated by the shock front generated in the stellar merger itself thereby gaining a power law energy spectrum with spectral index close to -2. We estimate the fluxes of such accelerated strangelets of different masses in the neighborhood of the Sun considering diffusive propagation of strangelets from the sources in the stochastic magnetic field of the interstellar medium. The determined fluxes are found to be consistent with the null results of the PAMELA experiment. The reported limit of sensitivity of the AMS-02 experiment suggests that the experiment should be able to detect strangeletevents, as per the prediction of the proposed model, thereby (possibly) vindicating the strange matter hypothesis.

Indirect dark matter search using FERMI gamma ray data from lowsurface brightness galaxies: with Sayan Biswas, Pooja Bhattacharjee as external collaborators, **Poster No. EA 13**, *XXXIV Meeting of Astronomical Society of India*, Srinagar, J&K, India, May 10-13, 2016; Work in Progress.

The physical nature of dark matter remains enigmatic even in these days of the advent of modern physics and astrophysics. Recent experimental evidences as well as theoretical arguments favor the existence of some form of non-baryonic cold dark matter (CDM) for explaining large scale structure

of the Universe. Although such dark matter is supposed to constitute about one fourth of the total energy density of the Universe, its exact nature is not yet understood. Weakly interacting massive particles (WIMPs), predicted in several theories beyond the Standard Model (of particle physics), are the most probable candidates for CDM. Pair annihilation (or decay) of WIMPs would yield particles such as neutrinos, (anti-) protons and electron-positron pairs simultaneously producing a significant flux of high energy gamma rays. Low surface brightness (LSB) galaxies are one of the most dark matter dominated galaxies that we know of. Hence these galaxies are ideal laboratories for indirect dark matter search through the observations of dark matter (or decay) products. In this work, we have chosen a LSB galaxy, UGC 12632 and analyzed the FERMI data, obtained from these galaxies over approximately seven years, in the energy range 100 MeV to 50 GeV. The theoretically possible gamma ray fluxes originating from WIMP annihilation in this source can be divided into two factors, namely, the "astrophysical factor" and the "particle physics factor". Here, the astrophysical factors pertaining to our concerned LSB galaxy are calculated by taking a standard dark matter density profile and the corresponding halo properties into account. These astrophysical factors are further used to calculate the particle physics factors so that a plausible (theoretical) upper limit of gamma ray flux due to the annihilation of WIMPs in the particular LSB galaxy, examined in this work, is finally obtained. Such comparisons between theoretical and observational upper limits of gamma ray fluxes from this galaxy would hopefully be useful to put constraints on the pair-annihilation cross section of WIMPs in various widely studied extensions of the standard model including its supersymmetric extensions.

Modelling of quasiperiodic oscillations (QPOs) in stellar-mass black hole systems (with Shubhrangshu Ghosh, Sayan Biswas work in progress).

Computational Fluid Dynamics (CFD) with possible astrophysical applications (with Sananda Raychaudhury as external collaborator, work in progress).

New future direction of research planned by Dr. Parthasarathi Joarder Solar Physics, Solar-Terrestrial (ST) Physics and Space weather prediction.

Publications

1. Ghosh S (2016) Exact relativistic Newtonian-like representation of gravitational static space-time geometry, *Astrophys. J.*,828, 6.
2. Ghosh S (2016) Effects of dark energy and at rotational curve on the gravitational time-delay of particle with non-zero mass, *Euro. Phys. J. C*, 76, 405.
3. Ghosh S (2016) 2.5 Dimensional, viscous, resistive, advective, magnetized accretion outow coupling in black hole systems, submitted to MNRAS.

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(I) Attended "Current issues in Cosmology, Astrophysics and High Energy Physics (CICAHEP)" national conference at the Department of Physics, Dibrugarh University, Assam during June 14-16, 2015 and chaired two sessions. (ii) Attended "Exploring the relativistic universe: an UGC and NBU

sponsored conference on Astrophysics, Astroparticle Physics and High Energy Physics" at the High Energy and Cosmic Ray Research Centre (HECRRC), North Bengal University, Siliguri on 15th and 16th December, 2015.

Dr. Sidharth Kumar Prasad

Assistant Professor

Scientific Reports

Charged jet production cross sections and its properties in proton-proton collisions at 7 and 2.76 TeV with ALICE at LHC: *with Rathijit Biswas, Dr. Supriya Das, Prof. Sanjay K. Ghosh, Prof. S. Raha (ALICE Collaboration)*

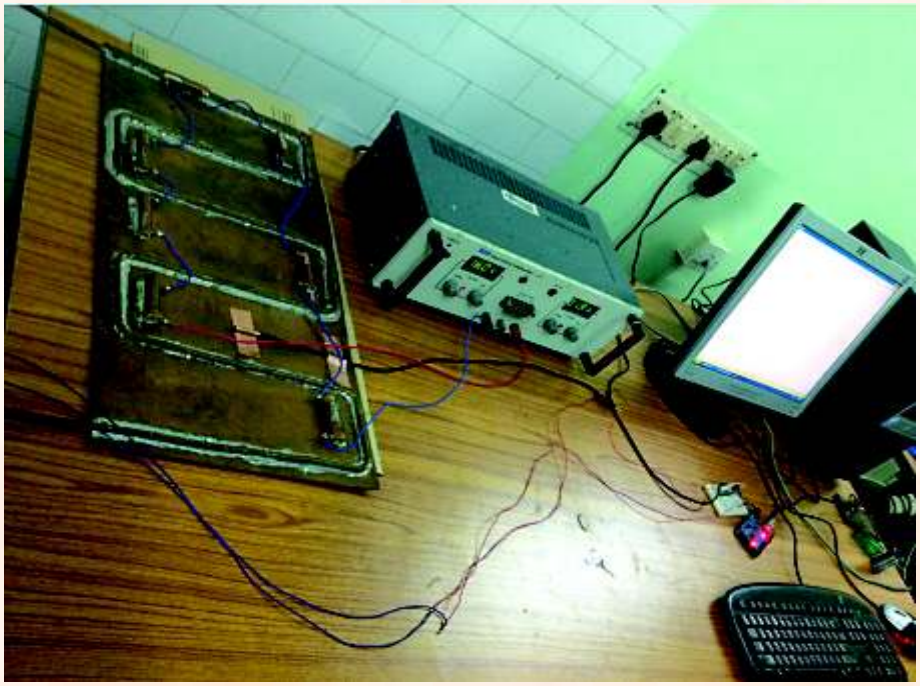
Jets are produced in interactions with large momentum transfer in hadronic and nucleon-nucleon collisions. The production cross-section of jets and its associated properties can be calculated using the framework of perturbative quantum chromodynamics (pQCD). The jet measurements in hadronic collisions therefore, provide a solid testing ground for the pQCD. Jets are important probes to understand the medium properties in high-energy nucleus-nucleus collisions where a thermalized system of quarks and gluons (QGP) is expected to be formed. Measurements in hadronic collisions are used as a baseline for similar measurements in nucleus-nucleus collisions to make final conclusions. We have recently publised the results from the study of charged jet measurements in proton-proton collisions at 7 TeV. Presently we are working on measurements of charged jet cross-sections and properties in pp collisions at 2.76 TeV. Jets are reconstructed using the charged tracks obtained from TPC and ITS detector systems of the ALICE. Jet reconstruction is performed using anti-kT algorithm from FastJet at mid-rapidity in the pT range from 10 GeV/C to 70 GeV/c. The correction for the instrumental effects is achieved by performing Monte Carlo simulations with full instrumental effects implemented by GEANT3. The estimation of systematic uncertainties from various sources is under study.

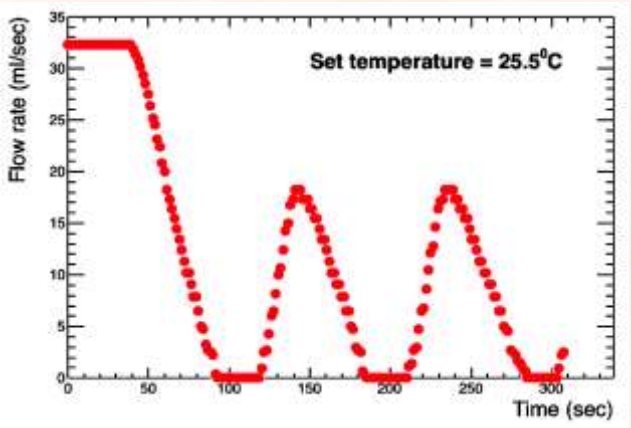
Probing high multiplicity proton-proton collisions at LHC using charged jets: *with Dr. Supriya Das (ALICE Collaboration)*

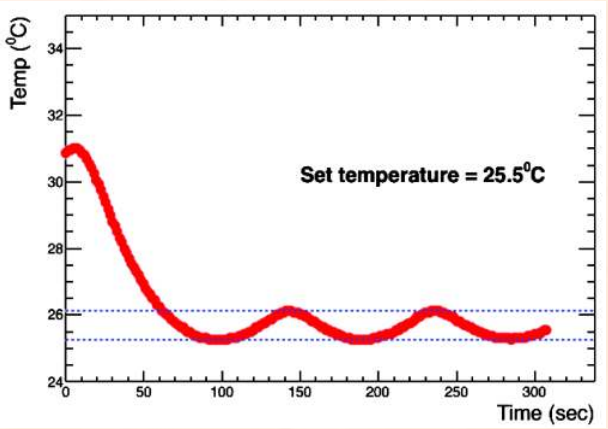
Recently several surprising results both from experimental and theoretical fronts are being discussed indicated the possible medium formation in proton proton collisions at LHC energies, especially in high multiplicity proton-proton interactions. The multiplicities and thereby the energy densities achieved in these collisions are comparable to that obtained in peripheral heavy ion collisions. Study of such interactions is of great interest and will help understanding the underlying physics. Jets are among the best probes to understand the medium in heavy-ion collisions. Our aim therefore is to study jet properties in high multiplicity pp interactions compared to minimum bias interactions, which will eventually help us understand such pp interactions.

Design and development of a water based cooling system for the CBM Muon Chamber: *with Dipanjan Nag, Dr. Supriya Das, Dr. Saikat Biswas (External Collaborators from VECC Kolkata: Dr. Subhasis Chattopadhyay, Dr. Anand K. Dubey, J. Saini)*

In the Compressed Baryonic Matter (CBM) experiment at the upcoming Facility for Antiproton and Ion Research (FAIR) facility in Darmstadt, India (Variable Energy Cyclotron Centre, Bose Institute and other collaborating institutes) is building a GEM based muon detector (muon chamber (MUCH)) and its associated readout. MUCH consists of alternating layers of six absorbers and detector stations. India is responsible for building of three stations of MUCH. Each full size GEM module uses 32 front end electronic (FEE) boards to collect the signals from the detector. These boards are sensitive to temperature, the operating range being 25-30 0C. The heat dissipated by FEE boards is estimated to be ~90 W per GEM module. This heat is to be continuously dissipated out to keep the ambient temperature within the desirable range. We are designing water based cooling system to achieve this. Using a small prototype as shown in Fig.1 we already tested and verified the proof-of-concept. Figure.1 (top panel) shows the experimental setup while the bottom panels show the performance. We are now designing a real size prototype, which will be tested soon.







Publications

Conference Proceeding:

1. Prasad SK, Jet measurements in pp, p-Pb and Pb—Pb collisions with ALICE at the LHC. *Proceedings of the 7th International Conference on Physics and Astrophysics of Quark Gluon Plasma* (arXiv: 1601:04462)

Referred Journals:

(with Prof. S. Raha, Prof. Sanjay K. Ghosh, Dr. Supriya Das, Dr. Saikat Biswas, Rathijit Biswas as a part of the ALICE Collaboration)

1. J. Adam et al. (ALICE Collaboration) (2016) Search for weakly decaying Λn and ΛΛ exotic bound states in central Pb-Pb collisions at sqrt(sNN) = 2.76 TeV. *Phys. Lett. B*: 752: 267-277.
2. J. Adam et al. (ALICE Collaboration) (2016) Pseudorapidity and transverse-momentum distributions of charged particles in proton-proton collisions at sqrt(s) = 13 TeV. *Phys. Lett. B*: 753: 319-329.
3. J. Adam et al. (ALICE Collaboration) (2016) Multiplicity and transverse momentum evolution of charge-dependent correlations in pp, p-Pb and Pb-Pb collisions at the LHC. *Eur. Phys. J. C*: 76: 86.
4. J. Adam et al. (ALICE Collaboration) (2016) Direct Photon Production in Pb-Pb Collisions at sqrt(s_NN) = 2.76 TeV. *Phys. Lett. B*: 754: 235-248.
5. J. Adam et al. (ALICE Collaboration) (2016) Measurement of electrons from heavy-flavour hadron decays in p-Pb collisions at $\sqrt{s_{{\rm NN}}}$ = 5.02 TeV. *Phys. Lett. B*: 754: 81-93.
6. J. Adam et al. (ALICE Collaboration) (2016) D_s production and nuclear modification factor in Pb-Pb collisions at sqrt{s_NN} = 2.76 TeV. *Journal of High Energy Physics*: 03: 082.
7. J. Adam et al. (ALICE Collaboration) (2016) Centrality evolution of the charged-particle pseudorapidity density over a broad pseudorapidity range in Pb-Pb at sqrt(sNN) = 2.76TeV. *Phys. Lett. B*: 754: 373-385.
8. J. Adam et al. (ALICE Collaboration) (2016) Azimuthal anisotropy of charged jet production in $\sqrt{s_{\mathrm{NN}}}$ = 2.76 TeV Pb–Pb collisions with ALICE. *Phys.Lett. B*: 753: 511-525.
9. J. Adam et al. (ALICE Collaboration) (2016) Transverse momentum dependence of D-meson production in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. *Journal of High Energy Physics*: 03: 081.
10. J. Adam et al. (ALICE Collaboration) (2016) Study of cosmic ray events with high muon multiplicity using the ALICE detector at the CERN Large Hadron Collider. *Journal of Cosmology and Astroparticle Physics:* 01: 032.
11. J. Adam et al. (ALICE Collaboration) (2016) Centrality dependence of pion freeze-out radii in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. *Phys. Rev. C*: 93: 024905.

12. J. Adam et al. (ALICE Collaboration) (2016) Event shape engineering for inclusive spectra and elliptic flow in Pb--Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. *Phys. Rev. C*: 93: 034916.

13. J. Adam et al. (ALICE Collaboration) (2016) Elliptic Flow of Muons from heavy-flavour hadron decays at forward rapidity in Pb--Pb collisions at $\sqrt {s_{\rm NN}} = 2.76$ TeV. *Phys. Lett. B*: 753: 41-56.

14. J. Adam et al. (ALICE Collaboration) (2016) Hypertriton and anti-hypertriton production in Pb–Pb collision at sqrt(sNN) = 2.76 TeV. *Phys. Lett. B*: 754: 360-372.

15. J. Adam et al. (ALICE Collaboration) (2016) Forward-central two-particle correlations in p-Pb collisions at sqrt(s_NN) = 5.02 TeV. *Phys. Lett. B*: 753:126-139.

16. J. Adam et al. (ALICE Collaboration) (2016) Centrality dependence of nuclear mdification factor of charged pions, kaons, and protons in Pb-Pb collisions at sqrt(sNN) = 2.76 TeV. *Phys. Rev. C*: 93: 034913.

17. J. Adam et al. (ALICE Collaboration) (2015) Coherent Psi(2s) photo-production in Ultra Peripheral Pb-Pb Collisions at sqrt(sNN) = 2.76 TeV. *Phys. Lett. B:* 751: 358-370,

18. J. Adam et al. (ALICE Collaboration) (2015) Production of light nuclei and anti-nuclei in pp and Pb--Pb collisions at energies available at the Large Hadron Collider. *Phys. Rev. C*: 93: 024917.

19. J. Adam et al. (ALICE Collaboration) (2015) Centrality dependence of inclusive J/psi production in p-Pb collisions at sqrt(s_NN) = 5.02 TeV. *Journal of High Energy Physics*: 11: 127.

20. J. Adam et al. (ALICE Collaboration) (2015) One dimensional pion, kaon, and proton femtoscopy in Pb-Pb collisions at sqrt(sNN) = 2.76 TeV. *Phys. Rev. C*: 92: 054908.

21. J. Adam et al. (ALICE Collaboration) (2015) Centrality dependence of high-pT D-meson suppression in Pb–Pb collisions at sqrt(sNN) = 2.76 TeV. *Journal of High Energy Physics*: 11: 205.

22. J. Adam et al. (ALICE Collaboration) (2015) Measurement of jet quenching with semi-inclusive hadron-jet distributions in central Pb-Pb collisios at sqrt(NN) = 2.76 TeV. *Journal of High Energy Physics:* 09: 170.

23. J. Adam et al. (ALICE Collaboration) (2015) Measurement of charm and beauty production at central rapidity verses charged-particle multiplicity in proton–proton collisions at sqrt(s) = 7 TeV. *Journal of High Energy Physics*: 09: 148.

24. J. Adam et al. (ALICE Collaboration) (2015) Inclusive, prompt and non-prompt J/psi production at mid-rapidity in Pb-Pb collisions at sqrt(sNN) = 2.76 TeV. *Journal of High Energy Physics:* 07: 051.

25. J. Adam et al. (ALICE Collaboration) (2015) Production of pions, kaons and proton production in proton-proton collisions at sqrt(s) = 7 TeV. *European Physical Journal C:* 75: 226.

26. J. Adam et al. (ALICE Collaboration) (2015) Coherent rho0 production in ultra-peripheral Pb-Pb collisions at sqrt{s_NN} = 2.76 TeV. *Journal of High Energy Physics*: 09: 095.

27. J. Adam et al. (ALICE Collaboration) (2015) Rapidity and transverse-momentum dependence of the inclusive J/psi nuclear modification factor in p-Pb collisions at sqrt(sNN) = 5.02 TeV. *Journal of High Energy Physics*: 06: 55.

28. J. Adam et al. (ALICE Collaboration) (2015) Measurement of dijet kT in p-Pb collisions at sqrt(sNN) = 5.02 TeV. *Phys. Lett. B*: 746: 385-395.

29. J. Adam et al. (ALICE Collaboration) (2015) Measurement of charged jet production cross sections and nuclear modification in p-Pb collisions at sqrt(sNN) = 5.02 TeV. *Phys. Lett. B:* 749: 68-81.

30. J. Adam et al. (ALICE Collaboration) (2015) Precision measurement of the mass difference between light nuclei and anti-nuclei. *Nature Physics*: 11: 811-814.

31. J. Adam et al. (ALICE Collaboration) (2015) Measurement of jet suppression in central Pb-Pb collisions at sqrt{s_NN} = 2.76 TeV. *Phys. Lett. B*: 746: 1-14.

32. J. Adam et al. (ALICE Collaboration) (2015) Forward-backward multiplicity correlations in pp collisions at sqrt(s) = 0.9, 2.76 and 7 TeV. *Journal of High Energy Physics*: 05: 097.

33. J. Adam et al. (ALICE Collaboration) (2015) Centrality dependence of particle production in pPb collisions at sqrt(sNN) = 5.02 TeV. *Phys. Rev. C*: 91: 064905.

34. B. Abelev et al. (ALICE Collaboration) (2015) Charged jet cross sections and properties in proton-proton collisions at sqrt{s} = 7 TeV. *Phys. Rev.* D: 91: 112012.

35. B. Abelev et al. (ALICE Collaboration) (2015) Inclusive photon production at forward rapidities in proton-proton collisions at sqrt(s) = 0.9, 2.76 and 7 TeV. *European Physical Journal C*: 75: 146.

36. B. Abelev et al. (ALICE Collaboration) (2015) Elliptic flow of identified hadrons in Pb-Pb collisions at sqrt(sNN) = 2.76 TeV. *Journal of High Energy Physics*: 06:190.

Dr. Probir Roy

INSA Senior Scientist

Scientific Reports

Complex scaling in the neutrino mass matrix : *in collaboration with Rome Samanta and Ambar Ghosal of Saha Institute of Nuclear Physics*

The residual symmetry approach, along with a complex extension for some flavor invariance, is a powerful tool to uncover the flavor structure of the 3x3 neutrino Majorana mass matrix. We utilize this to propose a complex extension of the real scaling ansatz which was introduced some years ago. Unlike the latter, our proposal allows a nonzero mass for each of the three light neutrinos as well as a nonvanishing reactor mixing angle. The light neutrino masses are generated by a type-1 seesaw mechanism, incorporated within this scheme. A major result of this scheme is that leptonic Dirac CP-violation must be maximal while atmospheric neutrino mixing need not be

exactly maximal. Moreover, each of the two allowed Majorana phases, to be probed by the search for neutrinoless nuclear double beta decay, has to be at one of its two CP-conserving values.There are other interesting consequences such as the allowed occurrence of a normal mass ordering which is not favored by the real scaling ansatz. Our predictions will be tested in ongoing and future experiments at T2K, NOvA and DUNE.

Publication

arXiv : 1604.06731 [hep-ph]

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(i) Delivered a course of ten lectures on "Neutrino Physics" at IISER, Pune during January 20, 2015 – March 06, 2015. (ii) Attended colloquium on "Dark Energy of the Universe", at Science Club, IISER, Pune on February 18, 2015. (iii) Delivered lecture on "Dark Energy of the Universe", at CAPSS, Bose Institute on August 12, 2015. (iv) Delivered lecture on "Dark Energy of the Universe" at APCOS International Conference, Saha Institute of Nuclear Physics on October 13, 2015.(v) Attended seminar on "Complex Extension of Mu-Tau Exchange Symmetry" at WHEPP XIV Workshop, IIT, Kanpur on December 13, 2015. (vi) Delivered invited talk on "Complex Scaling in the Neutrino Mass Matrix" at NuHoRIzon Conference, Harish Chandra Research Institute, Allahabad on March 18, 2016.

Dr. S.K.Saha

Senior Professor

Scientific Reports

Search for higher excited states of ^{8}Be* to study the cosmological ^{7}Li problem: *with Dr. D. Gupta*

We have an upcoming experiment (IS 554) at HIE-ISOLDE at CERN, Geneva, Switzerland to study the ^{7}Li abundance anomaly. We carried out detailed Geant4 simulations for the experiment involving the T-REX charged particle detector array. Work is also in progress to incorporate the MINIBALL detector array to detect gamma rays in coincidence. Since there is existing contradiction between theory and observation of the destruction channel of ^{7}Be, we also carried out DWBA calculations for the reaction ^{7}Be(d,p)^{8}Be* using the code FRESCO. All these studies are extremely important before invoking physics beyond the standard Big Bang Nucleosynthesis.

Breakup of ^{7}Be in presence of heavy targets: *with Dr. D. Gupta*

Geant4 simulations of the breakup of ^{7}Be in the presence of heavy targets are being carried out. In essence we would be measuring the reverse reaction of Coulomb dissociation of ^{7}Be to derive information on the reaction $3He + 4He \rightarrow 7Be + \gamma$. This would help in the study of ^{7}Li abundance anomaly by considering also the production channel of ^{7}Li which is linked to the production of ^{7}Be. Theoretical calculations of the above breakup reaction in the framework of prior-form DWBA is in progress. We plan to submit a beam time proposal on this project soon.

Study of n-p pairing through two-nucleon transfer reactions: *with Dr. D. Gupta*

Analysis of the data for the n-p pairing experiment at the rare isotope facility GANIL, Caen, France was continued. The aim is to study two nucleon n-p transfer reactions on two nuclei, a mid-shell nucleus ^{48}Cr, a candidate for n-p pairing correlations, and the doubly magic nucleus ^{56}Ni which will not show any pairing effects. On both these nuclei we measured (p,^{3}He) and (d,α) reactions in order to investigate the competition between T = 1 and T = 0 pairing and probe n-p pairing. We are carrying out a part of the data analysis at Bose Institute in the NPTool framework in collaboration with IPN, Orsay, France. The preliminary analysis shows that n-p pairing in ^{56}Ni is mainly of isovector type.

Study of resonance states of ^{15}Be with isospectral bound state microscopic potential: *with Dr. D. Gupta in collaboration with Dr. S. K. Dutta (B. G. College, Berhampore, Murshidabad.)*

Recently there has been a surge in interest in the neutron-unbound nucleus ^{15}Be. It is very difficult to tackle theoretically the unbound states by conventional methods. We have resorted to a very effective technique used earlier by us to detect low-lying broad resonances of weakly bound nuclei. Its success has prompted us to apply it effectively for unbound nuclei like ^{15}Be. The theoretical procedure of supersymmetric quantum mechanics (SQM) is adopted to tackle the resonance states of unbound nuclei. We have been able to reproduce the unbound state energies without any modification of our constructed density dependent M3Y (DDM3Y) microscopic potential. Our procedure confirmed the existence of $5/2^{+}$ state and also reproduced the experimentally predicted unbound resonance energy of 1.8 MeV.

Publications

1. Basu B, Raha S, Saha S K, Biswas S, Dey S, Maulik A, Mazumdar A, Saha S and Syam D (2015) Observation of a rare cosmic ray event at mountain altitude; *Astroparticle Physics 61, 88.*

2. Dey S, Maulik A, Raha S, Saha S K and Syam D (2014) Particle identification with Polyethylene Terephthalate (PET) detector with high detection threshold *Nucl. Instr. and Meth. in Phys. Res. B* 336, 163.

Grants-In-Aid Schemes

Title of the Scheme	Schemes funded by
With Dr. D. Gupta	
Astrophysical S-factor from nuclear reactions with a rare isotope beam of ^{7}Be	ISRO

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(I) Presented a talk on Resonance excitation in 7Be + d reaction to study 7Li abundance anomaly at the HIE-ISOLDE Experiments Workshop at European Organization for Nuclear Research (CERN), Geneva, Switzerland, February 1, 2016; (ii) Presented a talk on Astrophysical S-factor from nuclear reactions with a rare isotope beam of 7Be at the ISRO-RESPOND Review Meeting at Physical Research Laboratory (PRL), Ahmedabad, March 3-4, 2016.

Dr. Rajarshi Ray

Associate Professor

Scientific Reports

Physics of strongly interacting matter: *with Abhijit Bhattacharyya (CU), Subhasis Samanta and Subrata Sur (PC)*

The thermodynamics of hot and dense matter created in heavy-ion collision experiments are usually studied as a system of infinite volume. Here we report on possible effects for considering a finite system size for such matter in the framework of the Hadron Resonance Gas model. The bulk thermodynamic variables as well as the fluctuations of conserved charges are considered. We find that the finite size effects are insignificant once the observables are scaled with the respective volumes. The only substantial effect is found in the fluctuations of electric charge which may therefore be used to extract information about the volume of fireball created in heavy-ion collision experiments.

With Abhijit Bhattacharyya (CU) and Subrata Sur (PC)

We estimate the susceptibilities of conserved charges for two-flavor strongly interacting matter with varying system sizes, using the Polyakov loop enhanced Nambu–Jona-Lasinio model. The susceptibilities for vanishing baryon densities are found to show a scaling with the system volume in the hadronic as well as partonic phase. This scaling breaks down for a temperature range of about 30–50 MeV around the crossover region. Simultaneous measurements of the various susceptibilities may, thus, indicate how close to the crossover region the freeze-out occurs for the fireball created in heavy-ion collision experiments.

Publications

1. Bhattacharyya A, Ray R, Samanta S, Sur S (2015) Thermodynamics and fluctuations of conserved charges in a hadron resonance gas model in a finite volume. *Physical Review C* 91:041901.
2. Bhattacharyya A, Ray R, Sur S (2015) Fluctuation of strongly interacting matter in the Polyakov–Nambu–Jona-Lasinio model in a finite volume. *Physical Review D* 91:051501.

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

(i) Served as resource person in the **NESST-BASE 2015** program held at Mayapuri Campus, Bose Institute, Darjeeling, India, in May 2015. (ii) Served as resource person in the two week course on Finite Temperature Field Theory, in the **SERC (Main) THEP School**, sponsored by Science and Engineering Research Board, GOI, at the Birla Institute of Technology and Science, Pilani, in November 2015. (iii) Served as resource person in the **WAPP 2015** program held at Mayapuri Campus, Bose Institute, Darjeeling, India, in December 2015.

Dr. Soumen Roy

Associate Professor

Scientific Reports

Using network theory towards image processing and diagnostics

Unsupervised machine learning methods have been applied with good success in image processing. However, they are also computationally costly. Building up on our earlier work, we propose a new method of applying networks to the classic problem of information retrieval from multidimensional, dynamic images. We show that our method works as good as the aforementioned computationally expensive methods like principal component analysis. In collaboration with clinicians at the Calcutta Medical College and Hospital, we also show that our method can be successfully applied towards non-invasive diagnosis in dry eye disease. This work is now published in Scientific Reports (Nature).

Networks in synthetic biology inspired optogenetics

The prime aim of optogenetics is to confer light sensitivity to genetically encoded molecules, with a view to controlling multifarious organismal functionalities with great spatiotemporal precision. Smart design of biologically inspired artificial photosensors may lead to targeting of many significant cellular events through optogenetics. An important aspect in this field is the light-dark transition observed in photoreceptors. We propose the method of differential networks towards building a theoretical framework to study this transition. These networks uncover and important interactions and prime residues dictating the light-dark transition. Our findings are in total agreement with previous experimental findings and provide first-hand information on fundamentals of photo-adaptation and rational design of synthetic photoreceptors in optogenetics. This work was done in collaboration with Dr. Devrani Mitra of Presidency University and is now published in the journal Bioinformatics (Oxford).

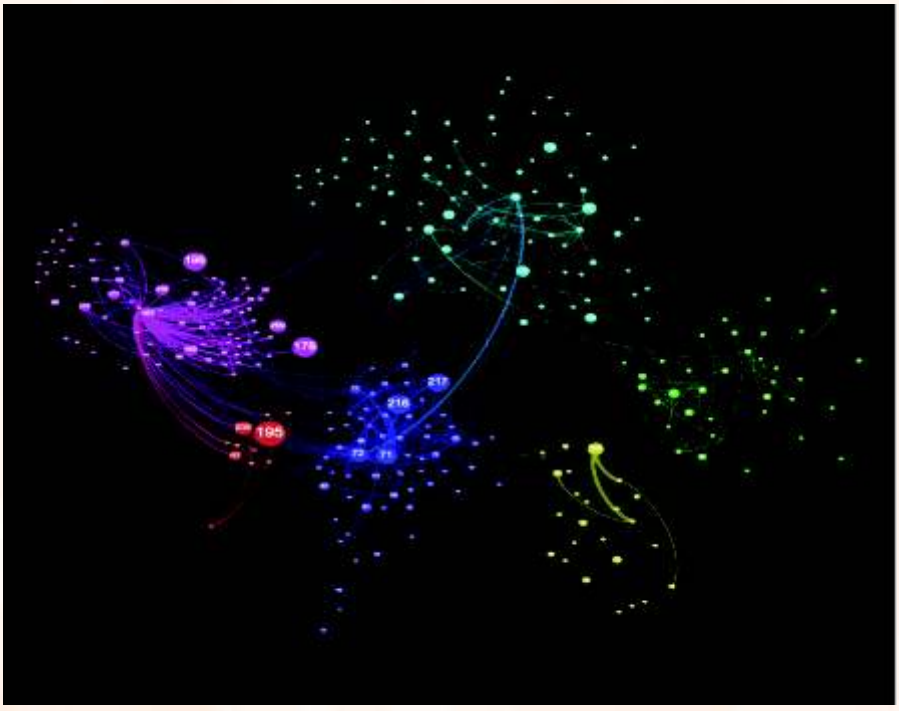
Dynamics of phage bacteria host interaction: evidence for secondary mechanisms of host lethality

Mycobacteria are infected by mycobacteriophages, which eventually lead to their death. The possibility of using mycobacteriophages as therapeutic agents is therefore of great value in the battle against tuberculosis (TB). We implement a goal-oriented iterative cycle of experiments (conducted by Prof. Sujoy Dasgupta's group) on one hand and mathematical modeling combined with Monte Carlo simulations on the other. This study was conducted using mycobacteriophage D29 and Mycobacterium smegmatis as the phage-host system. Valuable insight was obtained from this integrative approach.

Time-dependent changes in host viability during the growth of phage D29 in M. smegmatis were measured at different multiplicities of infection (MOI) which were modeled theoretically. Our predictions were further examined by Prof. Dasgupta's group using biochemical and cell biological assays. With multiple rounds of infection, cell counts drop more rapidly than expected if cell lysis is considered as the *only* mechanism for cell death. Therefore, we consider a secondary factor for

cell death in addition to the well-known primary mechanism of lysis. Further experiments reveal the association of increased production of superoxide radicals with phage infection. ROS appears to be the secondary factor. Thus, the killing potential of D29 may be amplified through secondary mechanisms and it can function as an effective antimycobacterial agent.

This work has been published in Applied and Environmental Microbiology (ASM) and has also been highlighted in the 'spotlight' section of the journal, by AEM editors.



Publications

1. Banerjee SJ, Azharuddin Md, Sen D, Savale S, Datta H, Dasgupta AK and Roy S (2015) Using complex networks towards information retrieval and diagnostics in multidimensional imaging; *Scientific Reports [Nature]* 5 17271.
2. Banerjee SJ, Sinha S and Roy S (2015) Slow poisoning and destruction of networks: Edge proximity and its implications for biological and infrastructure networks; *Physical Review E [APS]* 91 022807.
3. Grewal RK, Mitra D and Roy S (2015) Mapping networks of light-dark transition in LOV photoreceptors; *Bioinformatics [Oxford]* 31 3608-3616.
4. Grewal RK and Roy S (2015) Modeling proteins as residue interaction networks Protein & peptide letters [Bentham] 22 923-933.
5. Samaddar S, Grewal RK, Sinha S, Ghosh S, Roy S and Das Gupta S (2016) Dynamics of Mycobacteriophage-Mycobacterial host interaction - evidence for secondary mechanisms for host lethality; *Applied and Environmental Microbiology [ASM]* 82 124-133.

   [Also selected as article of significant interest by Editors for AEM Spotlight]

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Delivered talks at: (i) Department of Biological Sciences Colloquium at Presidency University, Kolkata on March 9, 2016; (ii) Indian Statistical Physics Discussion Meeting held at International Center for Theoretical Sciences, ICTS - TIFR, Bengaluru during February 12-14, 2016; (iii) School on population genetics and evolution held at International Center for Theoretical Sciences, ICTS-TIFR, Bengaluru during January 25 - February 6, 2016; (vi) National meeting of the National Network for Mathematical and Computational Biology (NNMCB) organised jointly by IISER-Pune and National Chemical Laboratory (NCL), Pune during December 27-30, 2015; (v) 15'th International Symposium on Mathematical and Computational Biology - IIT Roorkee BIOMAT 2015 (BIOMAT consortium), IIT-Roorkee Nov 1-7, 2015.

Patents

A system and method for analyzing videos of application or function for feature identification of the videos and related application or function; Soumen Roy *et al*. IPO 628/KOL/2015

Copyright

Software for analyzing videos of application or function for feature identification of the videos and related application or function; Soumen Roy *et al*. 9406/2015-CO/SW

Dr. Achintya Singha

Associate Professor

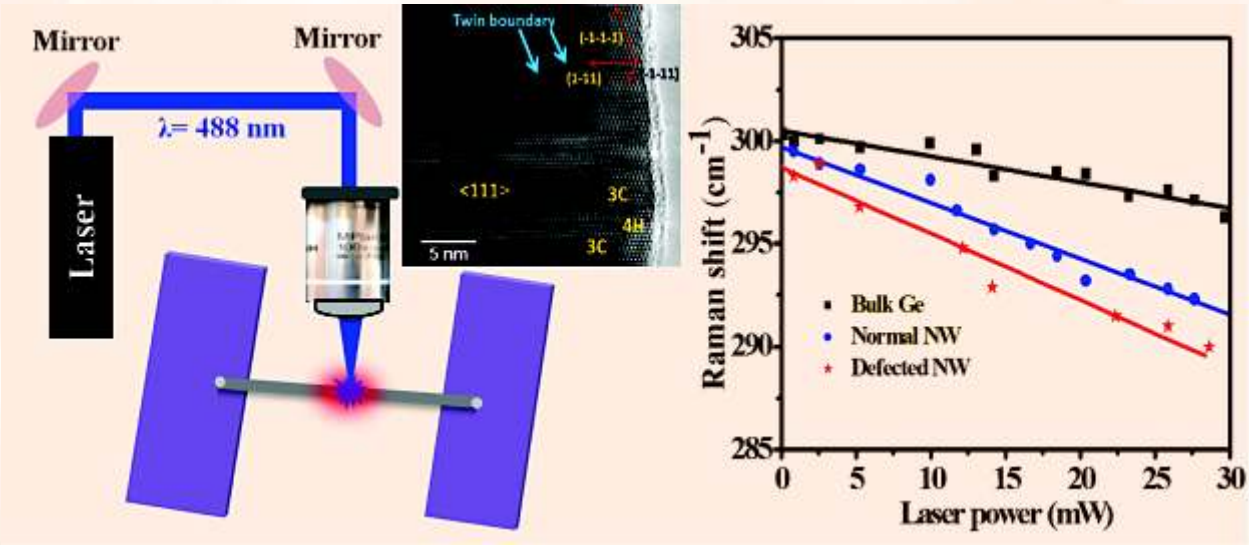
Scientific Reports

Probing thermal flux in twinned Ge nanowires through Raman spectroscopy: *alongwith Ms. Dipanwita Majumdar*

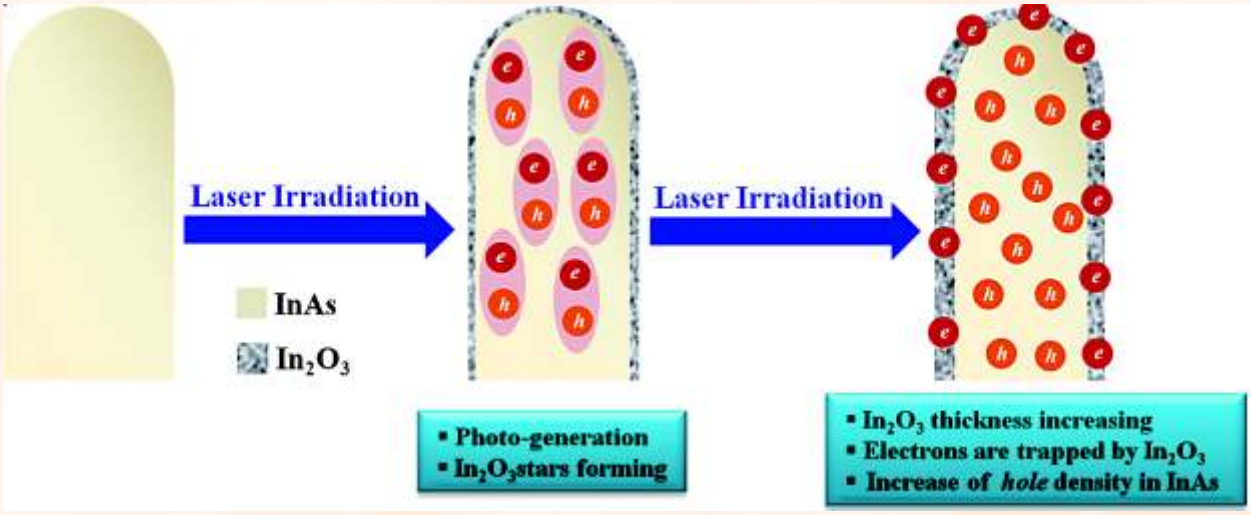
Defect-engineered nanostructures are gaining interest in the past few years due to their interesting mechanical, thermo-electrical and electronic properties. We report a noninvasive optical technique based on micro-Raman spectroscopy to study the thermo-physical properties of normal (non-defective) and twinned (defective) Ge NWs based on Raman spectroscopy. The role of lamellar twinning and polytype phase on the heat transport properties of NWs has been demonstrated.

Study of laser-induced photothermal effect in InAs nanowire: *alongwith Ms. Dipanwita Majumdar*

We have investigated the feasibility of using Raman spectroscopy as a non-contact tool to study the photothermal effects in nanoscale materials and shows how optical control over hole density can be achieved in InAs NWs. Typically, the laser irradiation during Raman measurement can cause local sample heating and can create electron-hole pairs. The oxide layer formed on the surface of InAs NWs, due to laser-induced heating; decouples electron-hole pairs by trapping electrons. The interplay between optical phonons and the photogenerated charge carriers is realized by



monitoring coupled plasmon-LO phonon (CPLP) modes at different laser powers. The study shows a significant correlation between the oxide layer thickness and hole density.



Publications

1. Biswas S, Doherty J, Majumdar D, Ghoshal T, Rahme K, Conroy M, Singha A, Morris M A and Holmes J D (2015) Diameter-controlled germanium nanowires withlLamellar twinning and polytypes. *Chem. Mater.*, 27: 3408-3416. Impact Factor: 9.407.

2. Ghatak S K, Sen S, Majumdar D, Singha A and Sen K (2016) Peanut proteins in periodate specific anion sensing: an ensuing reduction in allergic response. *Food Chemistry*, 197: 1286-1291. Impact Factor: 3.391.

3. Majumdar D, Biswas S, Ghoshal T, Holmes J D and Singha A (2015) Probing thermal flux in twinned Ge nanowires through Raman spectroscopy. *ACS Appl. Mater. Interfaces*, 7: 24679-24685. Impact Factor: 7.145.

4. Majumdar D, Ercolani D, Sorba L and Singha A (2016) Laser induced photothermal effect in InAs nanowire: tuning hole density. *J. Mater. Chem. C*, 4: 2339-2344. Impact Factor: 5.066.

5. Sarkar T, Konar A, Sukul N C, Majumdar D, Singha A, Sukul A (2016) Raman spectroscopy shows difference in drugs at ultra-high dilution prepared with stepwise mechanical agitation. *Int J High Dilution Res.* 15(1): 2-9.

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

Delivered invited talk at (i) C. K. Majumdar Memorial Summer Workshop in Physics (CKMMSWP) organized by IAPT and S N Bose National Centre for Basic Sciences (SNBNCBS), Salt Lake, Kolkata during May 26 to June 05, 2015 (ii) 4th Science Workshop for School Students held at Vidyasagar Metropolitan College, Kolkata organized by CIRE Kolkata on February 03, 2016.

Group Members

Mr. Shib Shankar Singha (i) Attended and presented a poster at International Conference on Frontiers in Materials Science & Technology (ICFMST-2015) held during 10–12 December, 2015 in National Institute of Science & Technology (NIST), Palur Hills, Berhampur, Odisha -761008, India (ii) Attended and presented a poster at National Conference on Advancement in Frontier Physics: from 20th Century to the Present held during 26-27 February, 2016 in the Department of Physics, Bhairab Ganguly College, Belghoria, Kolkata- 700056, India

Mr. Tara Shankar Bhattacharya (i) Attended and presented a poster at International Conference on Frontiers in Materials Science & Technology (ICFMST-2015) held during 10–12 December, 2015 in National Institute of Science & Technology (NIST), Palur Hills, Berhampur, Odisha-761008, India (ii) Attended and presented a poster at National Conference on Advancement in Frontier Physics: from 20th Century to the Present held during 26-27 February, 2016 in the Department of Physics, Bhairab Ganguly College, Belghoria, Kolkata- 700056, India

Awards / Honors received

Group Member:

Mr. Tara Shankar Bhattacharya received 2nd prize in poster presentation in International Conference on Frontiers in Materials Science & Technology (ICFMST-2015) held during 10– 12 December, 2015 in National Institute of Science & Technology (NIST), Palur Hills, Berhampur, Odisha

Dr. T. P. Sinha

Senior Professor

Scientific Reports

Multiferroicity in perovskite oxides

The magnetic and dielectric properties of rare earth based $LaFeO_3$ have been investigated at various temperatures. The antiferromagnetic nature of the samples is explained using zero field cooled and

field cooled magnetization and the corresponding hysteresis loop. A signature of weak ferromagnetic phase is observed in the samples at low temperature due to the canting of the iron sublattices.

Electronic structure and Optical properties of perovskite oxides

The interband contribution to the optical properties of various perovskite oxides has been investigated using first-principles calculations. The valence-band density-of-states spectra are generated to analyze the experimental X-ray photoemission spectra. The Born effective charges of the materials have been calculated to elucidate the nature of cation-oxygen bonds in the material.

Dielectric relaxation of perovskite

The frequency dependent dielectric relaxation (a conduction process) of various *synthesized* perovskite oxides *has been investigated by impedance spectroscopy at different temperatures*. The activation energy of the system is obtained and the transport mechanism for the conduction process has been proposed.

Publications

1. Chanda S, Saha S, Dutta A, Irfan B, Chatterjee R, and Sinha T P (2015) Magnetic and dielectric properties of orthoferrites $La_{1-x}Pr_xFeO_3$ (x = 0, 0.1, 0.2, 0.3, 0.4 and 0.5), *Journal of Alloys and Compounds*, 649, 1260-1266.
2. Das S, Banerjee S., Dutta A and Sinha T P (2015) Vibrational and thermal studies of CdSe nanorods, *Materials Science in Semiconductor Processing*, 40,412–417.
3. Dutta A, Saha S., Kumari P, Sinha T P and Shannigrahi S (2015) Crystal structure and X-ray photoemission spectroscopic study of $A_2La\,MO_6$ [A = Ba, Ca; M = Nb, Ta], *Journal of Solid State Chemistry*, 229, 296-302.
4. Dutta A, Kumari P. and Sinha T P (2015) Electrical properties of double perovskite oxides Sr_2LaSbO_6: an impedance spectroscopic study, *Electronic Materials Letters*,11, 775-781.
5. Ghosh S K, Ganguly M, Rout S. K and Sinha T P (2015) Order-disorder correlation on local structure and photo-electrical properties of La^{3+} ion modified BZT ceramics, *The European Physical Journal Plus*, 130, 68-1-18.
6. Ghosh B, Dutta A, Shannigrahi S. and Sinha T P (2015) Photophysical electronic structure of double-perovskites A_2GdTaO_6 (a = Ba and Sr), *Journal of Alloys and Compounds*, 648, 111-115.
7. Gupta R, Das S, Sinha T P and Bamzai K. K. (2015) Effect of cadmium doping on electrical properties of lead nickel niobate-lead zirconate titanate $[Pb_{1.0}(Ni_{0.167}Nb_{0.333}Zr_{0.155}Ti_{0.345})O_3]$ ceramics, *Ceramics International*, 41, 13241-13249.
8. Halder S, Agrawal L, Dutta A, Sheikh M S and Sinha T P (2015) Structural and Dielectric relaxation of $A(In_{1/4}Fe_{1/4})Nb_{1/2}O_3$ (A = Ba, Sr, Ca), *IISER- International Journal of Research*, 1, 55-58.

9. Mahato D K and Sinha T P (2015) Electrical conductivity and dielectric relaxation in Pr_2CoZrO_6 double perovskite, *Journal of Alloys and Compounds,* 634, 246-252.

10. Mahato D K, Saha S and Sinha T P (2016) Structural studies and impedance spectroscopy of sol-gel derived $Bi_{0.9}Pr_{0.1}FeO_3$ nanoceramics, *Journal of Physics and Chemistry of Solids*, 92, 45-52.

11. Mukherjee R, Dutta A and Sinha T P (2015) Collective vibrational modes and dielectric relaxation of Ca_2ErNbO_6, *Materials Science in Semiconductor Processing*, 39, 67-73.

12. Mukherjee R, Saha S, Dutta A, and Sinha T P (2015) Dielectric and Raman spectroscopic studies of A_2ErSbO_6 (A = Ba, Sr and Ca), *Journal of Alloys and Compounds*, 651, 222-229.

13. Mukherjee R, Dutta A and Sinha T P (2016) Dielectric relaxation of rare earth ordered double perovskite oxide Ba_2ErTaO_6, *Journal of Electronic Materials*, 45, 846-852.

14. Saha S, Chanda S, Dutta A, Das D and Sinha T P (2015) Dielectric dispersion and antiferromagnetism in $BiTb_xFe_{1-x}O_3$ (x = 1.0, 0.75), *Journal of Magnetism and Magnetic Materials*, 398, 289-297.

15. Sakhya A P, Dutta A and Sinha T P (2015) Dielectric relaxation, modulus behaviour and conduction mechanism in $NdAlO_3$ ceramics, *Journal of Electronic Materials*, 44, 3801-3810.

16. Sakhya A P, Dutta A and Sinha T P (2016) Dielectric and impedance spectroscopic studies of neodymium gallate, *Physica B*, 488, 1-7.

17. Sakhya A P, Dutta A, Shannigrahi S and Sinha T P (2016) Electronic structure, optical dielectric constant and born effective charge of $EuAlO_3$, *Journal of Physics and Chemistry of Solids*, 88, 1-7.

18. Tripathi R, Dutta A, Das S, Kumar A and Sinha T P (2016) Dielectric relaxation of CdO nanoparticles, *Applied Nanoscience*, 6, 175-181.

Conference/Symposia publications

1. Badapanda T, Sarangi S, Behera B, Saha S and Sinha T P (2015) Structure and phase transition behavior of strontium modified barium zirconium titanate, *AIP Conf. Proc.,* 1665, 030037; http://dx.doi.org/10.1063/1.4917612.

2. Das S, Dutta A, Ghosh B, Banerjee S and Sinha T P (2015) Structural and transport properties of CdSe nanorod, *AIP Conf. Proc.,*1665, 050056 ; http://dx.doi.org/10.1063/1.4917697.

3. Das S, Banerjee S and Sinha T P (2016) Magnetic study of Fe-doped CdSe nanomaterials, *AIP Conf. Proc.*, 1728, 020105; http://dx.doi.org/10.1063/1.4946156.

4. Ghosh B, Halder S, Das S and Sinha T P (2016) Understanding the photoluminescence characteristics of Eu3 + -doped double-perovskite by electronic structure calculation, *AIP Conf. Proc. 1731*, 090018; http://dx.doi.org/10.1063/1.4947982.

5. Maity S K, Dutta A, Sinha T P and Kumar S (2015) Impedance spectroscopy analysis of complex perovskite Sr2YbTaO6, *AIP Conf. Proc,*. 1665, 110044; http://dx.doi.org/10.1063/1.4918100.

6. Mondal T, Sarun P M, Das S and Sinha T P (2015) Investigation of dielectric properties of La0.33NbO3 ceramics, *AIP Conf. Proc.,* 1665, 110043; http://dx.doi.org/10.1063/1.4918099.

7. Pandey K K, Garg N, Mishra K, Sinha T P and Sharma S M (2016) High pressure structural evolution of SrFe0.5Nb0.5O3, *AIP Conf. Proc.,* 1731, 030029 (; http://dx.doi.org/10.1063/1.4947634.

8. Ray R , Himanshu AK, Lahiri J, Kumar U , Sen P, Bandyopadhyay S K and Sinha T P (2016) Optical and electronic properties of double perovskite Ba2ScSbO6, *AIP Conf. Proc.,* 1731, 140041; http://dx.doi.org/10.1063/1.4948207.

Participation in Conferences / Symposia / Workshops & Invited Talks Delivered at Various Organizations

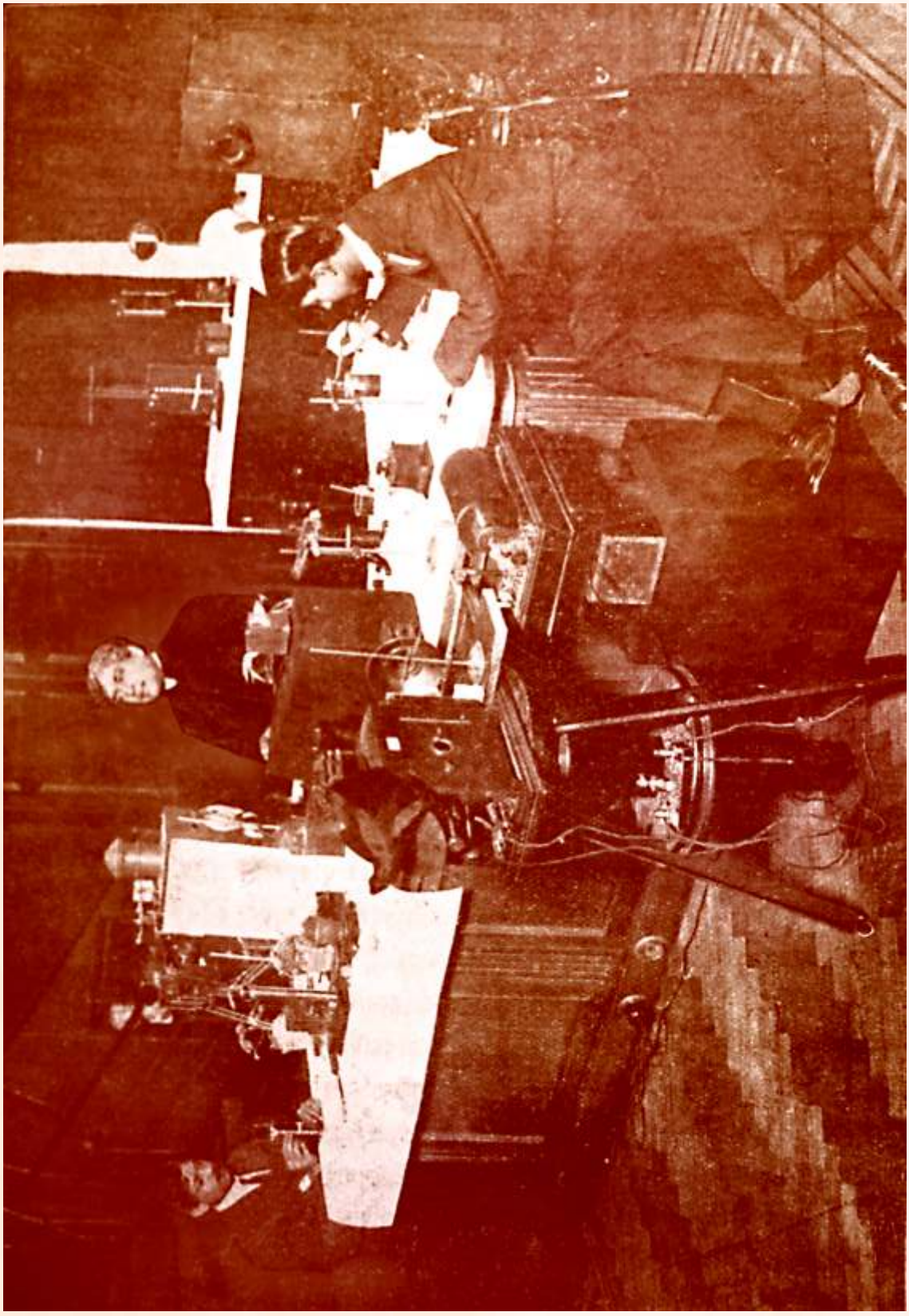
(i) Delivered an invited talk on "Quasiparticle band structure and optical dielectric function of perovskite oxides" in the International Conference on Advances in Functional Materials (AFM-2015) at Stony Brook University, New York, USA during 29 June to 03 July 2015 (ii) presented a paper on "Impedance spectroscopy study of CdTe nanoparticles" and chaired a session in the International Conference on Nanomaterials and Nanotechnology (NANO-15) at K. S. Rangasamy College of Technology, Tiruchengode, Salem during during 7-10 December 2015.

Participation of Group Members:

Mr.Sujoy Saha presented a paper on 'Dielectric Relaxation of PrFeO3 nanostructures' in UGC Sponsored National Workshop on Material Science and Technology at Maulana Azad College (Kolkata, West Bengal) during 10-12 December 2015.

Mr.Saswata Halder presented a paper on (i) 'Electronic Structure and X-ray photoelectron spectroscopic characterization of double-perovskites A_2SmTaO_6 (A = Ba, Sr, Ca)' at Condensed Matter Days 2015 (CMDAYS) held in Vishwabharati University, Shantiniketan, West Bengal during 27-29 August 2015 (ii) 'Understanding The Photoluminescence Characteristics Of Eu^{3+}-Doped Double-Perovskite by Electronic Structure Calculation' at DAE Solid State Physics Symposium 2015 (DAESSPS 2015) held in Amity University, Noida, Uttar Pradesh during 21-25 December 2015.

Mr. Rajesh Mukherjee presented a paper on 'Raman spectroscopy and Dielectric Relaxation of A_2ErSbO_6 (A = Ba, Sr, Ca)' at Condensed Matter Days 2015 (CMDAYS) held in Vishwabharati University, Shantiniketan, West Bengal during 27-29 August 2015.



J.C. Bose demonstrating his experimental work at Davy-Faraday Laboratory,
Royal Institute of Great Britain

OUTREACH AND MAN POWER DEVELOPMENT

Dissemination of knowledge has been an integral part of the charter of Bose Institute as proclaimed by J. C. Bose in his foundation speech in 1917. In recent years many outreach programmes has been undertaken to acquaint the school children's with the wonders of science and encourage them to pursue a career in science. Hands-on training of students from North-East states has become an annual event of Bose Institute for last nine years. Training programmes for the students of school students of Darjeeling is held regularly at the Darjeeling campus of Bose Institute. The faculties working at Darjeeling campus interact with the school students in regular intervals. Moreover, school students participating in the children's science congress interact with our faculties for their project work. Bose Institute also collaborates with other organizations for organizing science camps for school students in and around Kolkata. Hands-on training camps has also been organized for the school teachers of North-Eastern states as well as Darjeeling to help them in integrating the experiment based teaching with their regular class room teaching.

In order to extend the benefit of the advancement of our knowledge to rural sector Bose Institute is running a rural biotechnology programme at Falta Experimental Farm. Under this programme the people from rural sectors/scheduled castes/scheduled tribes are given training on various income generation schemes. Moreover, schedule caste and schedule tribe people are also being helped by Bose Institute to implement these schemes in their own land. In the current year under the DST-SEED project 80 scheduled caste people were given training through 4 training schedule on mushroom cultivation, vermicompost production, apiculture and sericulture and out of the 80 trainees 40 were provided with facilities for mushroom cultivation, vermicompost production and apiculture. Under "Scheduled Tribe-Specific Rural Biotechnology Programme" Bose Institute has started implementing various income generation schemes directly through departmental machinery and through some NGOs in five districts of West Bengal.

Bose Institute also organizes a Winter School in Astroparticle Physics (WAPP) every year in collaboration with Cosmic Ray Laboratory (CRL), TIFR as a part of man power development programme at Ooty and Darjeeling in alternate years. Under this programme M.Sc students as well fresh research scholar students are give hand-on training on the different aspects of Astroparticle Physics. Bose Institute organized the WAPP 2015 during December 17-29, 2015 in Darjeeling.

A major step for the development of trained man power was taken in 2006 when Bose Institute started M.Sc courses in Physical and biological sciences. Physical Science course was initiated in collaboration with St. Xaviers College, Kolkata, Calcutta University being the degree granting Institute. Biological Science course was started in collaboration with Calcutta University. The success of both of these courses was encouraging. So keeping in view the Institute's objective of creating man power for research, new plans were formulated to initiate M.Sc-Ph.D integrated course and subsequently M.Sc-Ph.D integrated course in life sciences was started in 2011 and Physical Science course was initiated in 2012.

Hand-on training programmes

(a) NESST-BASE 2015: May 18 – 30, 2015

The ninth North-East Students' Summer Training programme on Basic Sciences (NESST-BASE) was held at Darjeeling during May 18 – 30, 2015. This year, 24 students from north-east states as well as Sikkim and Darjeeling, along with one science teacher from each place, participated in this programme. The students were selected by the state authorities. These students were given hands-on training on physical, chemical and biological sciences. There were also sessions with the aim to introduce the students with the fun of mathematics. One day popular lecture was also arranged on May 22, 2015. The school children from Darjeeling were also invited on this occasion.

(b) Rural Biotechnology programmes:

Under the Scheduled Tribe-Specific Rural Biotechnology Programme hand-on training was imparted to the tribal beneficiaries in their own native place covering 80 villages in five districts of West Bengal. These trainings were mainly on 1) Concrete tank construction for rain water harvesting for drinking purpose, 2) Polypond construction for irrigation in orchard or for vegetable cultivation, 3) Vermicompost pit construction, vermicompost production and vermiculture, 4) How to develop fruit orchard, 5) Mushroom cultivation, 6) Fishery, 7) Bee-keeping, 8) Intercropping of vegetables and cultivation of crops with limited irrigation, 8) Croilar chicken rearing, 9) Animal health care and nutrition, 10) Food processing, 11) Preparation of some handicraft items, 12) Mulberry sericulture etc. Through these programmes more than 800 tribal beneficiaries were trained and benefitted. The key feature of all the above programmes was sustainability through year-round supervision.

Integrated M.Sc – Ph.D programme

The M.Sc. - Ph.D. course has been formulated as a combination of two year (four semester) Post-graduate M.Sc. Curriculum and a four year (approximately) Ph.d. programme with the objective to develop human resource with expertise in the broader areas of research interests and to motivate students to choose a career in basic and applied sciences.

The admission in the M.Sc course is based on written test followed by interview of the candidates short listed on the basis of their marks obtained in the secondary examination onwards. The intake of students, depending on the performance, varies between 6-10 in Physical Sciences and 14-20 in biological sciences.

(a) Physical Sciences

Course Coordinator: Dr. Rajarshi Ray

In 2015, around 200 students applied from all over India. 90 students were shortlisted for written test and then 40 students were called for interview based on their performance in the written test. Finally 6 students were selected and all of them joined the M.Sc course. The first semester classes for this batch commenced in the first week of August.

(b) Biological Sciences

A total of 305 valid applications were received from which 211 candidates were shortlisted for the Written Exam, based on the criteria that the average marks in Science subjects (in Class X and XII) be more than equal to 78.5%. Based on the written test, 42 candidates were interviewed of which 12 candidates were finally selected. Classes started from August 2015.

SERVICE DEPARTMENTS

Acharya J.C. Bose Biotechnology Innovation Centre
(Madhyamgram Experimental Farm)

Madhyamgram Experimental Farm (MEF) caters the needs of scientists of Bose Institute for successful implementation of their research into translational reality. It not only is an integral part of the research of the plant scientists but the recent addition of a state-of-art Central Animal Facility has provided a new feather to the crown of MEF. This unique facility of international standard has several openings in future.





Crop improvement is a continuous process. The plant scientists of Bose Institute work relentlessly for this direction. The demand of the time has converted the process of crop improvement to adopt several means, viz. biotechnology, transgenic technology and marker





assisted breeding. MEF fully supports this trio under one umbrella, which encompasses impeccably maintained agricultural field, advanced biotechnology laboratory and several greenhouses.

A number of scientists (Prof A N Lahiri Majumder, Prof Sampa Das, Prof D N Sengupta, and Dr S Chaudhuri) are using the laboratory/field and green house facilities for development of abiotic and biotic stress tolerant rice.













Two oilseed crops, one of kharif (Sesame) and the other of ravi season (mustard) have been grown in field in connection to different research programmes. Prof P K Saha and Prof S Sikder have studied diversity population while Dr Gaurab Gangopadhyay studied advanced recombinant population of sesame.





Prof Sampa Das, Prof D Basu and Prof S Sikder have availed both field and green house facilities for mustard improvement programmes targeted towards biotic stress tolerance. Prof Sampa Das has also availed the field facility for growing garlic, pigeon pea and chick pea (along with Prof D Basu) in ravi season in connection to different research progrmmes. Prof Amita Pal, Dr S Chaudhuri and Dr A Ghosh have used the field facility for the cultivation of *Vigna*, ground nut and maize respectively.

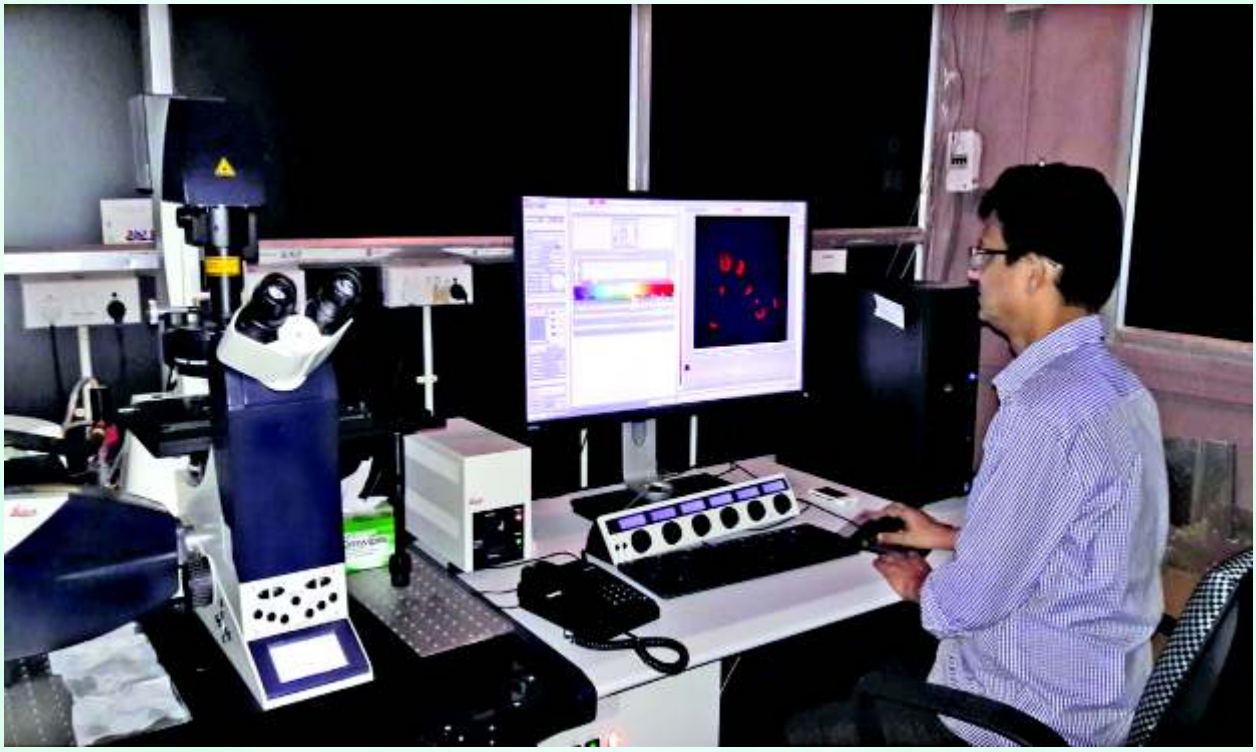
For successful implementation of different molecular biological experiments with tomato and tobacco Dr P Kundu, Dr S Chaudhuri and Dr A Bhuina have used both field and transgenic green house facilities. Prof Sampa Das also availed green house facility for research on pigeon pea.





Central Instruments Facility

The Central Instruments facility (which includes the DST/ IRHPA sponsored National center for proteomics and genomics) is an independent unit within the institute which houses a large number of sophisticated instruments required for advanced research in biological and chemical sciences. The facility is run by a group of highly trained technicians who not only look after the instrument but also advise research students about how to use them effectively.



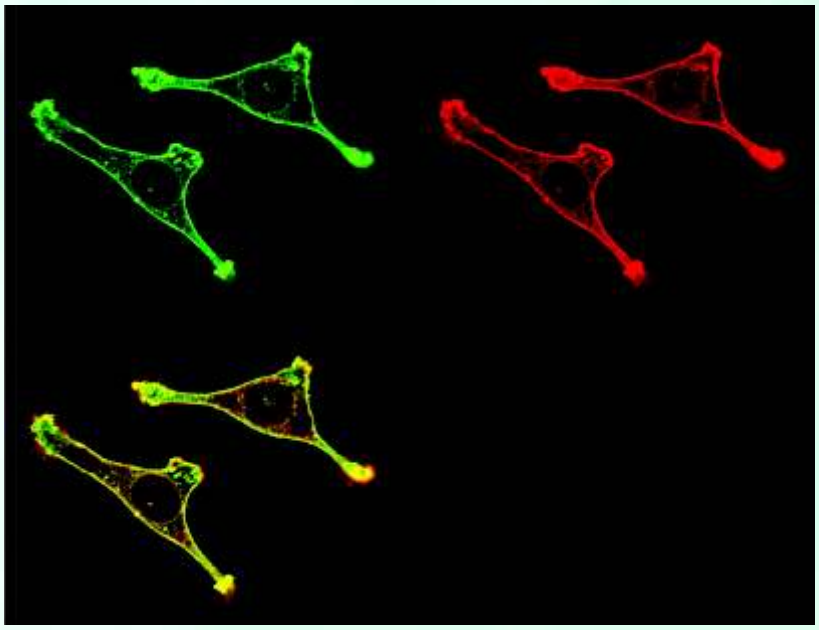
The equipments that are currently available are as follows:

A) DNA sequencer
B) Confocal Microscope
C) HPLC
D) CD Spectrometer
E) Cell sorters
F) Documentation systems
G) NMR (700 MHz)
H) GC MS
I) Fluorescence spectrophotometer
J) RT PCR.
K) Atomic Absorption Spectrophotometer

The CIF is frequently visited by student groups from colleges and universities from various parts of the country particularly the North East. The Msc-PhD students are given special training as a part of their curriculum so that they can use these instruments productively. Many of the equipments such as HPLC, Confocal microscope, FACS, GC-MS and NMR, are used extensively by both in-house and outside users.







Centre for Astroparticle Physics & Space Science

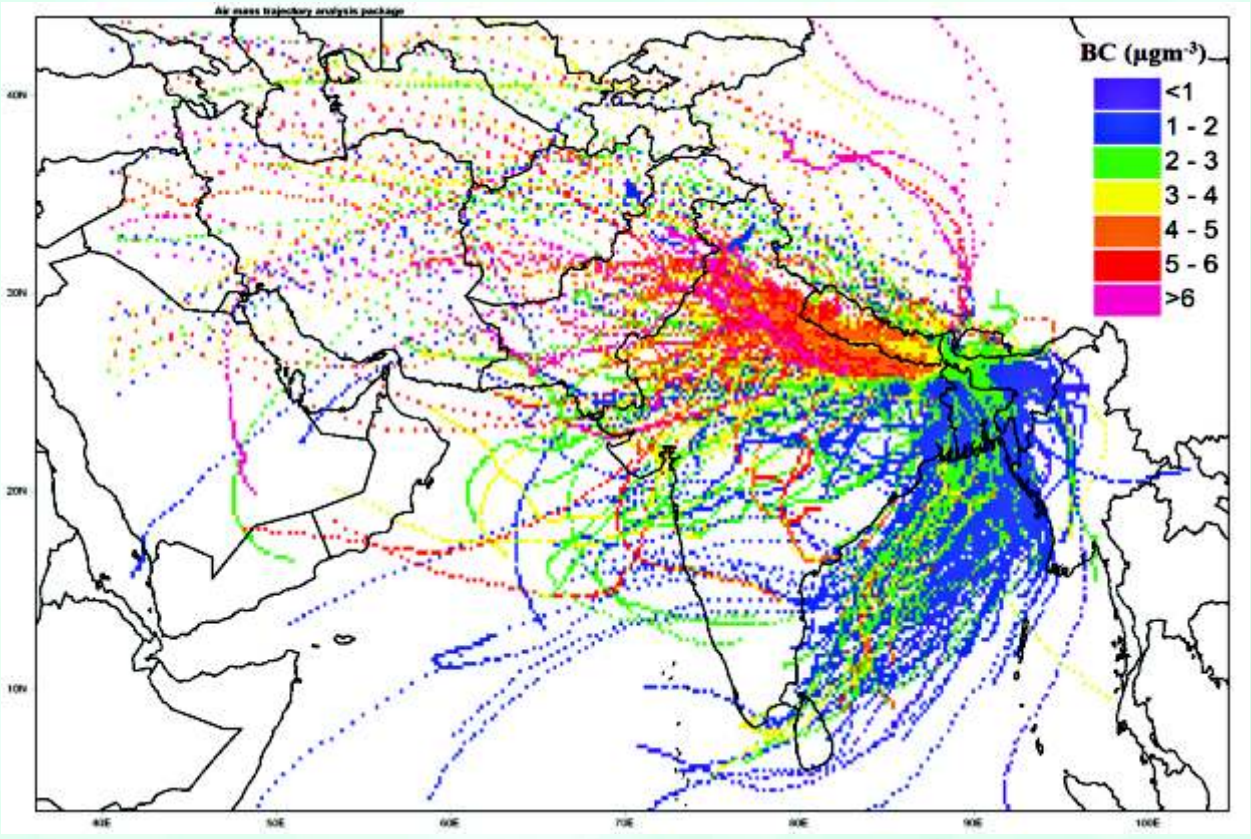
A national facility for the observational studies on Cosmic Ray and atmospheric phenomena has been developed at Darjeeling campus of Bose Institute under the IRHPA scheme of Department of Science & Technology, Govt. of India.

The main objectives of this center are to understand the interaction characteristics of Cosmic Ray at low and high energy, search for exotic phenomena in Cosmic Rays, studies of the changing Airspace Environment in Eastern Himalayas in the context of regional climate change along with the studies to understand the connection between the cosmic Ray and Cloud. In order to fulfil these objectives observational facilities for monitoring the various aspects of Cosmic Ray and atmospheric phenomena have been created at Darjeeling.

- Commercially available polymer polyethylene terephthalate (PET) has been standardized and calibrated for use as Nuclear track detector. These have also been deployed at Darjeeling along with Ooty and Hanley for cosmic ray measurements.
- An Air Shower array using active detectors is being developed to study the energy spectrum and components of primary cosmic rays. Infra structural facilities like detector tanks and metal frames have been designed and fabricated in-house at the Bose Institute workshop.
- Dual frequency radiometer has been installed for the measurements of column-integrated amounts of water vapor and liquid water.
- Vertical profile of rain rates, drop size distributions, radar reflectivity, fall velocity of hydro meteors and other rain parameters are being measured using Micro Rain radar (MRR).
- Vertical profile of water vapour mixing ratio and many other aerosol and cloud related quantities are being measured using Rama Lidar.
- Several automated online atmospheric trace gas analyzers e.g. SO_2, NO_x, CO, O_3 etc have been running to study the gaseous pollutants in the atmosphere.
- Particulate matter present in the atmosphere are being studied using high volume sampler, online particulate matter monitor for number and mass concentrations and condensation particle counter to study the ultrafine particulate matter.
- Black carbon or soot particle in the atmosphere over Darjeeling is being studied using Aethelometer.
- Cloud Condensation Nuclie counter is being run for the study of finer aerosol particles which forms cloud.
- Sunphotometer is being run for the study of Aerosol Optical Depth i.e. the attenuation of incoming solar radiation due to loading of aerosol particles in the atmosphere.

Major findings (2015-16)

- Detection threshold of the polymer material Polyethylene Terephthalate (PET) was studied using 11 MeV 12C and 2 MeV proton beams from the accelerator at the Institute of Physics (IOP), Bhubaneswar. PETs are intended to be used as Nuclear Track Detector (NTD) in the search for rare events (e.g. strangelets) in cosmic rays was studied. The results show that the PET detector has a much higher detection threshold (Z//β~ 140) compared to many other commercially available and widely used detector materials like CR-39 (Z/β~6–20) or Makrofol (Z//β~57). This makes PET a particularly suitable detector material for testing certain phenomenological models which predict the presence of strangelets as low energy, heavily ionizing particles in cosmic radiation at high mountain altitudes.
- It was observed in a Precipitation chemistry study during monsoon (June-September) over Darjeeling, that the total ionic composition in rainwater was maximum over Kolkata (391 μeq l-1) followed by Falta (204 μeq l-1) and Darjeeling (64 μeq l-1). Ca2 + was found to be the most potential species to completely neutralize the acidity over Kolkata whereas NH4 + was found to be the potential species to partially neutralize the acidity over Falta and Darjeeling.
- For the first time a study of 14 polycyclic aromatic hydrocarbons (PAHs or polyaromatic hydrocarbons) intrinsic to the inhalable fraction (10µm or less) of particulate matters in ambient air, simultaneously carried out at Kolkata and at Darjeeling. It was observed that more than half



Transport of Black Carbon (soot particles) aerosols over Darjeeling from several long-distant regions

of the quantified total-PAHs at both Kolkata and Darjeeling comprised of probable human carcinogens (40–60%).

- For the first time observations were carried out for Carbonyl compounds over Darjeeling. Principal component analysis was performed for the source apportionment of the observed carbonyl compounds for the entire study period and three factors were identified. Secondary photochemical production and vehicular emission were the major contributors and biomass/coal burning or biogenic emissions were the minor contributors of carbonyl compounds over the hill station.
- A study was conducted on understand the role of submicron aerosols transported from long-distant regions on the formation of CCN over eastern Himalaya in India. It was observed that during summer and winter, aerosols over Darjeeling were mostly contributed by local vehicular activities as well as transported from plain land cities at Indo-Gangetic Plain (IGP). Winter and summer-time aerosols over Darjeeling were also contributed by huge crop residue burning occurred at the IGP regions like Uttar Pradesh, Himachal Pradesh, Punjab and Haryana.

Environmental Sciences Section

The section was established in the year of 1992. Earlier, the section used to carry out several activities related to environmental impact assessment, preparation of environmental management plan, environmental audit, environmental budget, toxicological evaluations, and carcinogenicity assessment for several industries at the local and national level. From 2002, this section started



measurements of atmospheric pollutants and set up a wet laboratory for the *National Facility on Astroparticle Physics and Space Science*, Bose Institute campus in Darjeeling. Later on, this section has been equipped with several analytical instruments related to atmospheric monitoring studies. The major analytical instruments in this section are High Pressure Liquid Chromatography, Atomic Absorption Spectrophotometer, Ion Chromatograph etc.

Environmental Sciences Section is now fully engaged in chemical characterization of several particulate and gaseous pollutants collected from Darjeeling, Kolkata and Falta campuses on regular basis. The above mentioned instruments are fully used to characterize the chemical components of the atmospheric particulate pollutants. In addition to those instruments, several desiccators, pH and conductivity meter, temperature controlled digestion system, rotary evaporator are installed in this section. The sampling of atmospheric pollutants over Kolkata and Falta campuses are fully controlled by this section. This section is also carrying out chemical analysis of several samples from different academic institutes and universities.

Major Activities (2015-2016)

Studies on precipitation chemistry over urban, rural and high altitude Himalayan station in eastern India

A study was conducted on precipitation chemistry during monsoon (June-September) over Darjeeling, a high altitude station (2200 m asl) at eastern Himalaya; Kolkata, a typical metropolitan

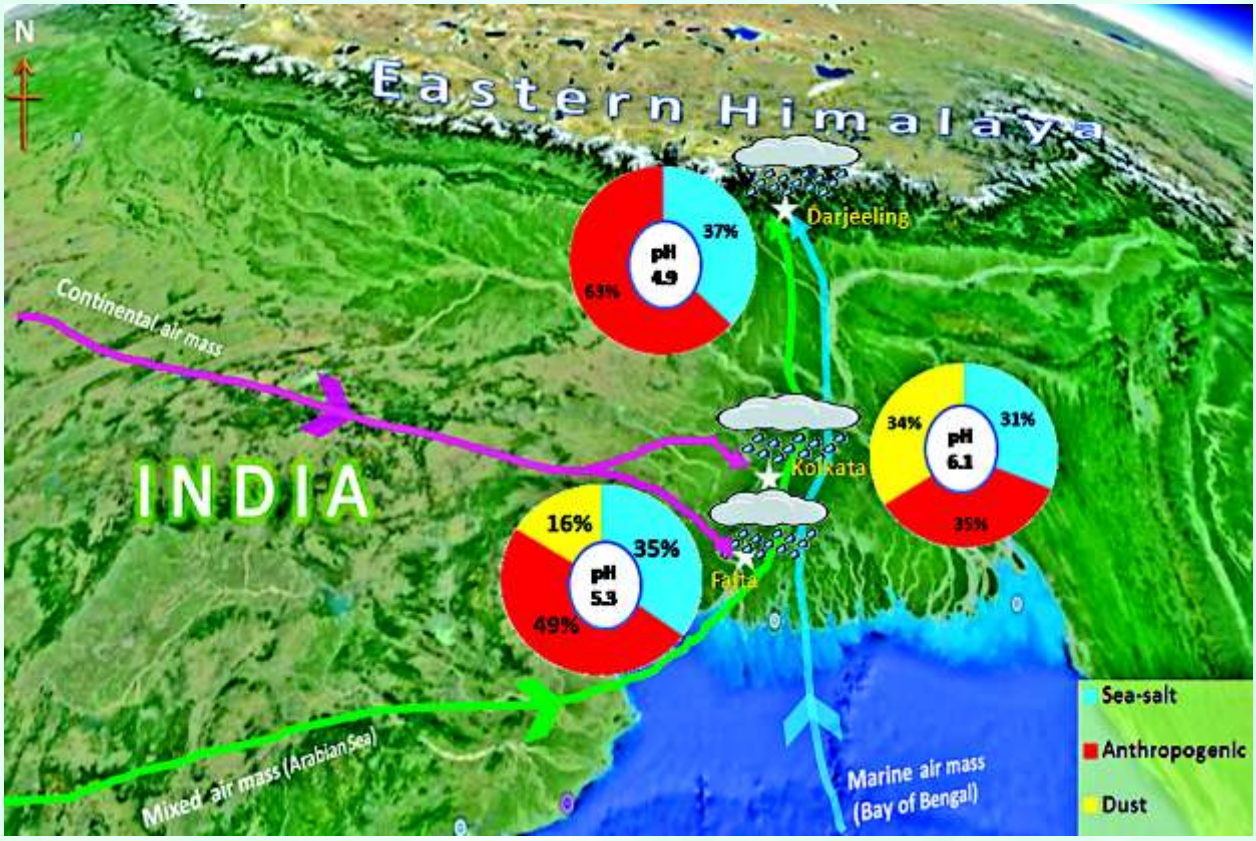


Fig 1: Schematic diagram of how transport of air masses affected rainwater over Kolkata, Falta and Darjeeling

urban station and Falta, a rural station near Bay of Bengal. It was observed that the total ionic composition in rainwater was maximum over Kolkata (391 μeq l^{-1}) followed by Falta (204 μeq l^{-1}) and Darjeeling (64 μeq l^{-1}). The concentration of sea-salt species was highest near Bay of Bengal which got diluted by ~15 % over the mega-city i.e. moving towards north and further diluted by ~65 % over eastern Himalaya i.e. moving far north. It was observed that 85 % rain events were alkaline over Kolkata whereas 55 and 65 % events were acidic over Falta and Darjeeling respectively. Ca^{2+} was found to be the most potential species to completely neutralize the acidity over Kolkata whereas NH_4^+ was found to be the potential species to partially neutralize the acidity over Falta and Darjeeling.

Positive matrix factorization model was used for the source apportionment of the ionic species scavenged by rain. High dust loading neutralized the rainwater acidity over Kolkata whereas very poor and negligible dust loading (compared to anthropogenic acidic species) increased the acidity over Falta and Darjeeling respectively. Anthropogenic and dust species increased by more than two times when air masses arrived from continental regions over Kolkata and Falta. It was observed that rainwater over Kolkata and Falta was alkaline under the influence of marine air masses. However under the influence of continental air masses, rainwater became acidic as transported anthropogenic ionic species had more acidic potentials than the neutralizing potentials of local and transported alkaline species whereas rainwater acidity did not vary with the air mass pathways over Darjeeling. Such high acidity of rainwater over Himalayan and coastal stations near Bay of Bengal is of paramount importance as acid rains could lead to deterioration of soil quality, agricultural growth, canopy cover, contamination of ground and surface water over these two ecologically important regions in India.

Characterization of winter-time aerosols over Sundarban mangrove forest and Arabian Sea

A field campaign was conducted over Chulkati, a remote and pristine island at Sundarban, north-east coast of Bay of Bengal for studying the effect of transport of anthropogenic polluted continental pollutants from Indo-Gangetic Plain regions to Bay of Bengal. It was observed that aerosols over Sundarban forest was mostly composed of locally generated sea-salt aerosols and carbonaceous and



Fig 2: Measurement site over Sundarban Mangrove Forest

other anthropogenic components. SO_4^{2-} was found to be the most abundant species amongst various water soluble ionic components. Chloride was found to be depleted by ~80 % from NaCl suggesting interactions between fresh marine sea-salt aerosols and other transported continental aerosol components. SO_4^{2-} and NO_3^- were the most efficient components depleting chloride ions from sea-salt particles. Strong westerly winds carried significant amount of carbonaceous aerosols like soot particles over Sundarban mangrove forest. These soot particles were found to be transported from the highly polluted Indo-Gangetic Plain regions. The huge transport of polluted aerosols could significantly affect the pristine marine environment at Sundarban.

An on-board ship cruise experiment was also conducted during 28 Feb-19 March, 2016 over Arabian Sea in order to characterize aerosols over open ocean. A significant impact of transported continental aerosols was also observed over the aerosols suspended over Arabian Sea. New particle formation was also observed because of phytoplankton blooming in Arabian Sea. Analysis is still under progress.



Fig 3: Ship-cruise campaign over Arabian Sea

Studies on Poly-nuclear Aromatic Hydrocarbon (PAH) over urban atmosphere of Kolkata and Himalayan high altitude station, Darjeeling

A first ever study of 14 polycyclic aromatic hydrocarbons (PAHs or polyaromatic hydrocarbons) intrinsic to the inhalable fraction (10 μm or less) of particulate matters in ambient air, simultaneously carried out at Kolkata, a megacity on the Indo-Gangetic plain and at Darjeeling, an Eastern-Himalayan high altitude station in India, during three seasons, viz., post-monsoon (October and November, 2015), winter (December 2015 to February 2016) and pre-monsoon (March to May, 2016). The concentrations of total-PAHs during post-monsoon, winter and pre-monsoon were in the ranges of (83.42—113.52 ngm^{-3}), (78.08—146.71 ngm^{-3}), (37.65—109.27 ngm^{-3}) respectively at Kolkata and (5.12—22.72 ngm^{-3}), (8.52—28.43 ngm^{-3}), (5.45—13.34 ngm^{-3}) respectively at Darjeeling. The present work elucidates the distributions, sources of PAHs, meteorological influences and possible health effect: 1) PAHs concentrations at the two sites differ by a factor of five to one order of magnitude but similarity between PAHs profiles of the two sites indicated they had common sources, which was attributed to the effect of local emission. 2) At both sites, the

profiles displayed obvious seasonal variations, as a result of the seasonality of sources and meteorological influences. The total-PAHs concentrations were in the order of winter > post-monsoon > pre-monsoon at Kolkata but post-monsoon > winter > pre-monsoon at Darjeeling. 3) Source apportionment by calculating diagnostic ratios and positive matrix factorization showed vehicle exhaust (~40%) was the greatest contributor in all seasons at Kolkata but coal and biomass combustion was the main contributor (~45%) at Darjeeling in all seasons. both sites. 4) Regarding meteorological parameters, a negative effect of temperature, wind speed, solar radiation and ozone concentration over PAHs was confirmed, with correlation coefficients of -0.84 ($p < 0.01$), -0.63 ($p < 0.01$), -0.81 ($p < 0.01$), -0.47 ($p < 0.05$) respectively for Kolkata and -0.61 ($p < 0.01$), -0.70 ($p < 0.01$), -0.78 ($p < 0.01$), -0.42 ($p < 0.05$) respectively for Darjeeling. 5) More than half of the quantified total-PAHs at both Kolkata and Darjeeling were comprising of probable human carcinogens (40–60%).

First ever study on major Aldehydes and Ketones over eastern Himalaya

A first ever study was made on atmospheric carbonyl compounds over a high altitude hill station, Darjeeling (27.01°N, 88.15°E, 2200 masl) at eastern Himalaya in India. Temporal variation, meteorological influence, source apportionment and ozone formation potential etc were studied for acetaldehyde, formaldehyde, acetone, butanaldehyde, propanaldehyde, benzaldehyde, crotonaldehyde, valeraldehyde, isovaleraldehyde, hexanaldehyde, p-tolualdehyde and o-tolualdehyde. Acetone was found to have high concentrations (81.6 ± 63.5 μgm^{-3}) which could be due to the higher photochemical production from its precursor volatile organic compounds emitted from tea plants and tea processing units. The concentration of acetaldehyde (20.7 ± 47.6 μgm^{-3}) and formaldehyde (11.6 ± 16.3 μgm^{-3}) were found to be comparable with metro cities of India and world. The average annual concentration of total carbonyl compounds was 174.2±184.6 μgm^{-3} with maximum during postmonsoon (456.9± 199.5 μgm^{-3}) and minimum during winter season (72.2 ± 42.9 μgm^{-3}). Meteorological parameters like surface reaching solar radiative flux and wind speed played the major roles for the seasonal variation of the carbonyl concentration over the hill station. The average ratio of formaldehyde to acetaldehyde over Darjeeling was found to be 1.64 ± 1.43 well representing a typical urban atmosphere at this part of Himalaya. Principal component analysis was performed for the source apportionment of the observed carbonyl compounds for the entire study period and three factors were identified. Secondary photochemical production and vehicular emission were the major contributors and biomass/coal burning or biogenic emissions were the minor contributors of carbonyl compounds over the hill station.

Role of local and transported submicron aerosols on the formation of Cloud Condensation Nuclie (CCN) over eastern Himalaya

A comprehensive study was conducted on how the submicron aerosols whether locally generated or transported from long-distant regions affect the formation of CCN over eastern Himalaya in India. Continuous monitoring was made for the measurement of aerosols and CCN during dry seasons in 2015-2016. It was observed that during summer and winter, aerosols over Darjeeling were mostly contributed by local vehicular activities as well as transported from plain land cities at Indo-Gangetic Plain (IGP). Winter and summer-time aerosols over Darjeeling were also contributed by huge crop

residue burning occurred at the IGP regions like Uttar Pradesh, Himachal Pradesh, Punjab and Haryana. These aerosols were very active and efficient to form cloud condensation nuclei and hence cloud droplets in the atmosphere of eastern part of Himalaya.

Publications

- Das SK, Chatterjee A**,** Ghosh S K, Raha S (2015). *An integrated campaign for investigation of winter-time continental haze over Indo-Gangetic Basin and its radiative effects; Science of The Total Environment*, 533, 370-382.
- Roy A, **Chatterjee A**, Tiwari S, Sarkar C, Kumar S Das , Ghosh S and Raha S (2016) Precipitation chemistry over urban, rural and high altitude Himalayan stations in eastern India;; *Atmospheric Research*, 181, 44-53.

Students Awarded Ph.d

Name of Student (University, Year)	Title of Thesis
Dr Chirantan Sarkar (C.U. 2016)	Studies on Gaseous and Particulate Carbonaceous Pollutants in the Atmosphere of a High Altitude Station Darjeeling over Eastern Himalaya, India



Falta Experimental Farm

Three training programmes were conducted under the Rural Biotechnology Programme. i) During November 3-7, 2015 a training programme was organized for supervisors and onsite trainers of "Scheduled Tribe-Specific Rural Biotechnology Programme". Seventeen trainees were trained on various aspects of Rural Biotechnology Programmes. ii) During November 18-22, 2015 a five-day training programme was organized at Amlasole Community Hall, Amlasole, Pashchim Medinipur on "Mushroom Cultivation, Vermicompost production, Bee-keeping, Food processing and Rain Water harvesting". Twenty-five local tribal beneficiaries were trained in that training programme. All the staffs and resource persons involved in the "Scheduled Tribe-Specific Rural Biotechnology Programme" attended the training programme. iii) During December 15-17, 2015 ten students and staffs of Chandraketugarh Sahidulla Smriti Mahavidyalaya, North 24 Parganas participated in a three-day training programme on Rain water harvesting for drinking purpose. This training programme was organized at Falta Experimental Farm on request from the college authority.

Nine Animal Health Camps were organized under the leadership of our Resource Persons Dr.Nihar Kanti Ghosh and Dr. Ashim Prasad Chattopadhyay. The BLDO of respective Block of the State Department helped us by providing necessary vaccines and some manpower. The details of the Animal Health Camp activity are depicted in the following Table.

Sl. No.	Date	Village	No. of people benefitted	No. of domestic animals treated			
				Cow/ buffalo	Goat/ sheep	Hen/ duck	Total
1	27.08.15	Puratan Gram, Md. Bazar, Birbhum	47	65	115	32	212
2	28.08.15	Basantapur, Manbazar-I, Purulia	113	267	509	50	826
3	29.08.15	Bhutadih, Manbazar-II, Purulia	161	259	264	726	1249
4	31.08.15	Amlasole, Binpur-II, Pashchim Medinipur	58	157	265	32	454
5.	18.11.15	Kankrajhor, Pashchim Medinipur	70	158	419	1042	1,619
6.	19.11.15	Amlasole, Binpur-II, Binpur-II, Pashchim Medinipur	38	121	344	635	1,100
7.	20.11.15	Amjharna, Binpur-II, Pashchim Medinipur	57	84	413	800	1,297
8.	11.12.15	Satyadaspur, Pathar Pratima, South 24 Parganas	78	306	260	550	1,116
9.	12.12.15	Sabuj Bazar, Pathar Pratima, South 24 Parganas	92	215	149	3333	3697
		TOTAL	714	1,632	2,738	7,200	11,570

Some programme-wise photographs and brief descriptions are given below:



Fig. 1: Glimpses of some training and awareness programmes. a) The BDO of Binpur 2, Pashchim Medinipur was addressing to the trainees during the training programme held during November 18-22, 2015 at Amlasole Community Hall; b) Mrs. Srabani Sikdar, one of our resource persons was addressing to the trainees on rain water harvesting at Falta experimental Farm; c) Mrs. Sikdar was discussing with the tribal women beneficiaries at Bhutadhi village, Purulia regarding preparation of different handicraft items; d) Officials from the Central Sericulture Training & Research Institute, Berhampore, Murshidabad was addressing to the mulberry sericulture farmers during an awareness programme held on 27.12.2015 at Bhutadhi, Purulia.

Animal Health Camp:



Fig. 2: Photographs of different activities of Animal Health Camp. a) Dr. Asim Prasad Chattopadhyay and other project personnel were distributing medicines to the beneficiaries for their domestic animals at Satyadaspur village, G-Plot, Patharpratima Block, Sunderban, South 24-Parganas; b) Some women beneficiaries with the help of project staff and LDA were carrying out vaccination to the goats in Amjharna village, Binpur 2 Block, Pashchim Medinipur; c) A tribal beneficiary was waiting with two cows for vaccination in the Animal Health Camp organized in the Bhutadhi village, Manbazar 2 Block, Purulia; d) In the same camp tribal beneficiaries were collecting medicines for their domestic animals from the camp office. Nine Animal Health Camps were organized in 2015-16 and 714 beneficiaries brought their domestic animals (11,570 Nos) in the camps and the animals were either vaccinated or provided with preventive medicines.

Rain water harvesting for drinking purpose:



Fig. 3: Photographs of concrete tanks constructed at different project sites for harvesting rain water for drinking purpose. a) School students were drinking harvested rain water from the tanks constructed at Rajarampur High School, Lavpur Block, Birbhum (this programme was operated by the NGO named Surulsuprity Society; b) Ms. Reba Murmu, the beneficiary of rain water harvesting tank was standing in front of her tank at Chhachanpur village in Bankura; c) One such tank atBhutadhi village of Purulia. The capacity of each tank is about 2,000 L. Total 27 Nos. of tanks had been constructed in 2015-16.

Rain water harvesting for irrigation purpose:



Fig. 4: Photographs of polyponds constructed at different sites for irrigation purpose. a) A polypond with full of harvested rain water. It was constructed near a developing orchard at Pashchim Medinipur; b) A demonstration polypond was prepared at Dalpur Ashram at Bankura; c) Leveling of pond walls was under progress for a polypond at Purulia; d) Polythene layering was under progress for a polypond at Pashchim Medinipur. Total 22 polyponds were constructed under the Scheduled Tribe-Specific Rural Biotechnology Programme in 2015-16.

Vermicompost Programme:



Fig. 5: a) A tribal woman beneficiary was standing in front of her vermicompost unit at Shihikapahari village in Bankura. b) Mr. Rupdas Murmu, a tribal beneficiary constructed two more pits and asbestos shed with profit from the vermicompost unit at Chhachanpur village in Bankura. c) The project staff and onsite trainer were standing near a vermicompost unit at Amlasole village of Pashchim Medinipur. d) A vermicompost unit at Chhachanpur village of Bankura showing the net covering and drainage system around the pits. e) Finished vermincompost ready to use at our Falta Experimental Farm. Total 54 vermicompost units (two pits in a unit) were constructed under the Scheduled Tribe-Specific Programme in 2015-16.

Kitchen Garden Programme:



Fig. 6. Photographs of Kitchen Garden Programme. a) The tribal beneficiary along with the village children were standing in front of the kitchen garden at Shihikapahari village, Bankura; b) Our project staff along with the NGO personnel of Surul Suprity Society was visiting a kitchen garden at a village near Ilambazar area of Birbhum. Seventy-seven tribal beneficiaries were engaged in kitchen gardening in 2015-16.

Orchard Programme:



Fig. 7: Different activities on orchard programme. Orchard development was given one of the priority areas in the Scheduled Tribe development programme. a) Tribal beneficiaries were distributing plant saplings for plantation in the field in Purulia; b) Pit preparation was under progress for plantation of orchard plants at Purulia; c) Plantation of orchard saplings were going on at Basantapur, Purulia; d) The tribal beneficiaries were placing pitchers at the vicinity of the planted sapling for watering purpose; e) One tribal beneficiary was standing in front of his two-years old mosambi orchard; f) One-year old karamcha orchard at basantapur village of Purulia. In the orchard programme 159 bigha land was used for orchard development in Purulia, Bankura, Pashchim Medinipur and Birbhum in 2015-16.

Agriculture Programme:



Fig. 8: Some photographs of Agriculture Programme. a) One beneficiary was harvesting bitter gourd at Krishnadaspur village, G-Plot, Patharpratima Block, Sunderban, south 24-Parganas; b) The beneficiaries were watering in the vegetable nursery bed at a village in Bankura; c) One beneficiary was showing his green chili production at Krishnadaspur village; d) One beneficiary was showing his tomato field at a village in Purulia.In the agriculture programme 136 beneficiaries were provided with financial support for purchasing vegetable seeds and manures.

Sericulture Programme:



Fig. 9: a) The tribal women beneficiaries were involved in rearing mutivoltine "Nistari" silkworm in Bhutadhi village of Purulia. b) In the same village the whole family members of the tribal beneficiaries were involved in shorting out "Nistari" cocoons in front of the rearing house. Community sericulture in two villages i.e., Bhutadhi of Purulia and Chhachanpur of Bankura are continuing for two years.

Goat/Sheep Rearing Programme:



Fig. 10: Different activities of goat rearing programme in different project sites. A) Distribution of goats to the tribal beneficiaries was going on at a village in Pashchim Medinipur; b) One beneficiary with her goats received from the project; c) Our project staff and resource person were talking with one beneficiary who received goats from the project at Puratangram village, Mahammad Bazar, Birbhum; d) Distribution of goat to the sabar beneficiary at Satyadaspur village, Sunderban. Total 243 and 5 tribal beneficiaries were given goats and sheep respectively from the Scheduled Tribe-Specific Rural Biotechnology Programme in 2015-16.

Pig Rearing Programme:



Fig. 11. Photographs of pig rearing programme at different project sites. A) The tribal beneficiary was feeding her pigs at Maniadih village, Pashchim Medinipur; b) The tribal beneficiary was taking care of her pigs at a village in Birbhum. Seventy-five tribal beneficiaries were given pigs from the project in 2015-16.

Croilar Chicken/Duck Rearing:



Fig. 12: Photographs of croilar chicken bird rearing programme at different project sites. a) Distribution of poultry birds, feed and other accessories to the beneficiaries at a village in G-plot, Pathar Pratima Block, Sunderban; b) One beneficiary was collecting eggs from his croilar chicken poultry; c) A woman beneficiary who was rearing her croilar birds in the makeshift poultry attached to her house; d) One beneficiary constructed his double deck poultry at Sunderban. In 2015-16 in the croilar chicken rearing programme 273 beneficiaries were provided with 12-24 chicken birds per beneficiary and in duck rearing programme 93 tribal beneficiaries were provided with 12-24 ducklings per beneficiary from the project.

Mushroom cultivation programme:

Total 61 tribal beneficiaries opted for mushroom cultivation in 2015-16. Funding was given to an NGO, Birbhum Makarampur Krishak Kalyan Sansthan near Santiniketan, Birbhumto set up a mushroomspawn production laboratory to meet the demand of spawn in that area. In this area nine beneficiaries could earn Rs. 80,433/- (net profit) from mushroom selling.



Fig. 13: Photographs of different activities of mushroom cultivation programme. a) Oyster mushroom grown by a tribal beneficiary at Ghosaldanga village, Sattor, Birbhum (operated by the NGO, Ghosaldanga Adibasi Seba Sangha; b) Milky mushroom grown at our Falta Experimental Farm; c) Sri Rabi Soren at Bharjuli village, Ahamadpur, Birbhum (operated by the NGO, Surul Suprity Society) showing his mushroom cultivation unit to Sri Sobhan Roy Chowdhury, Sr. Technical Assistant, Bose Institute; d) Paddy straw mushroom grown at Amlasole village, Pashchim Medinipur; e) Women beneficiary of a tribal Self Help Group at Maniadih village, Pashchim Medinipur were preparing oyster mushroom beds.

Fishery Programme:



Fig. 14: Photographs of different activities in Fishery Programme. a) Netting operation was going on in a pond at Satyadaspur village, G-Plot, Pathar Pratima Block, Sunderban, South 24-Parganas; b) The beneficiaries were releasing fish fingerlings in a pond at Bhutadhi village, Purulia. Total 15 ponds including a community pond operated by about 100 sabar beneficiaries were taken under the fishery programme in 2015-16.

Bee-keeping programme:



Fig. 15: Photographs of different activities of Bee-keeping programme. a) Two tribal beneficiaries at Amkhai village, Ilambazar, Birbhum (operated by the NGO, SurulSuprity Society) were involved in collecting honey from the beehives developed on the frame, b) Photograph of demonstration training on bee-keeping at Amlasole, Pashchim Medinipur, c) Photograph of demonstration training on bee-keeping at our Falta Experimental Farm, d) One beneficiary was handling bee-keeping box as a part of regular check-up schedule at Chhachanpur village, Bankura. Total 21 bee-keeping boxes were distributed to the tribal beneficiaries in 2015-16.

J C Bose Centre
(Publication and Museum)

J C Bose Centre comprises the Museum dedicated to J.C. Bose and the Publication unit. The museum is a special attraction in the Main Campus. It nestles a permanent exhibition on the life, research contributions and works Acharya Jagadis Chandra Bose. Presently the Museum is a repository of some significant scientific instruments designed by J.C. Bose, commemorative items, rare and significant archival documents. Guided tours are conducted on special occasions for group visits of school/college/university students. New acquisitions from various Libraries, Institues and other Museums are undertaken every year. The Museum takes part in different National-level Science Fairs and Exhibitions. Detailed information on J.C. Bose is available in the archives which are helpful for researchers/ professionals for any sort of academic work in this field. Further development of our museum is under progress.

Since its inception in 1980, the Publication Section has been entrusted with the responsibilty of bringing out publications of Bose Institute on a regular basis. The Annual Report (both English & Hindi Versions) and Bose Institute Newsletter (BI News) are published each year. The Orientation Booklet provides a detailed account of the Ph.D. Course Work mandatory for the scholars entering Bose Institute for their doctoral research work. Posters, pamphlets are regularly published as per the requisition during different Symposia, Seminars and Training Programmes. The following publications are presently available for sale : J. C. Bose and Microwaves – A Collection Rs.200.00; Science and Society – Reflections Rs.1050.00; Acharya J.C. Bose -A Scientist and A Dreamer – Vol. 1 Rs.1250.00; Vol. II Rs.1250.00; Vol. III Rs.600.00; Vol. IV 1500.00 ; Vol. V Rs.550.00; Patrabali (Bengali) Rs.150.00; Acharya Jagadis Chandra Bose (Bengali) Rs.12.00; Abyakta (Bengali book written by Sir J.C. Bose) Rs.50.00; Acharya Jagadis Chandra Bose (Bengali Combined) Rs.325.00; Bose Institute-Myself & Ribosome Rs. 200.00; In the Realm of Bose (the diary of a teenager's brief sojourn at Bose Institute) Rs. 180.00; An Appraisal of J. C. Bose – In the context of Sociology of Science Rs. 350.00.

Participation in Conferences/ Symposia/ Workshops & Invited Talks delivered at Various Organizations

Ishani Chattetjee (i) presented paper entitled "Cultural Heritage of Bishnupur: Conservation Approach of Archaeological Survey of India" at the 3-day All India Museums Conference held at Chennai during 30.01.16 to 1.02.16 ii) participated at the 19th National Science Exhibition at Netaji Maidan, Baranagar during 09.09.15 to 13.09.15.

T.K. Maji, I. Chatterjee (J.C. Bose Centre) participated at i) National Exhibition-cum- Fair 2015 at KMDA Mela Ground, Patuli held during 22.08.15 to 26.08.15. (ii) India International Science Festival (IISF-2015) at IIT, New Delhi held during 04.12.15 to 08.12.15.

Publications

Chatterjee, I. (2015) Museums for Regional Awareness on Indian Scientists, *J. of Indian Museums*, LXIX, 61-65.

Chatterjee, I. (2015) 'Oh!Touch Me Not!'- The Sensations of a Sensitive Plant, *Banobithi-Banmahatsav*-2015, 47-52.

Chatterjee, I. (2016). Biological Colonization of Terracotta Temples of Bishnupur, West Bengal,

Sanskriti Vichitra Essence of Art & Archaeology- Museums, Museology & Heritage Management,II, 173-178.

Library

The Institute Library system is one of the best 'Science Reference' Libraries in Eastern India, set-up in the main campus in 1917 by Acharya Jagadish Chandra Bose and a wing at the 'Centenary Building' was opened in 1983. In the year 2007 a small library was set-up in the Salt Lake Campus of the Institute. Library provides latest information to the BI faculty, researchers, staff members and students of Integrated M.Sc.-Ph.D. programme on Life Sciences and Physical Sciences. Library extends its physical Library facilities as well as online resources access to other Institutions /Universities /R&D organisations in and around Kolkata. Library also regularly provides document delivery services and other services to Faculty / researchers/students of the institute as well as faculty/scholars/researchers of DST and CSIR Institutes in India as a mandate of National Knowledge Resource Consortia (NKRC), Govt of India.

The library total collection of reading materials is 43,864 as on 31.03.2015 and subscribed to more than 5000+ online journals packages from more than 50 Publishers. Library also subscribed to online-only full–text journals / databases of different academic societies and national and international publishers. Library subscribed to e-books packages. All subscribed journals can be accessed from 1997 onwards. Library is also having very old & rich print collection of important science journals.

Bose Institute Library Activities:

Collection Development

Collection	Total as on 31 March 2015
Books	14719
Theses	560
Bound Volumes of Journals	28585

Other Collection

Sir J.C. Bose Collection

Reports, Newsletters, Annual Reports of other Institute(s), Publication of Bose Institute etc.

Online Journals subscribed

Online journals through National Knowledge Resource Consortia (NKRC)

Back Volume Journals (online)

Scientific Software(s)

Access Management of Resources

All Library resources can be accessed by Institute faculty / scholar from all campuses of Bose Institute. Library also provides off campus access to its resources to Institute faculty members through RemoteXS service. Library uses open sources software KOHA for OPAC and D-Space for IDR. For access management library maintains seven servers.

Resources of Bose Institute Library

Resources of BI Library can be accessed from Bose Institute Library Portals (www.boseinst.ernet.in/library , http://www.jcbose.ac.in/library & http://boseinst.remotexs.in/).

A. Journals Resources

Library subscribed to major publishers journals such as ASM, ACS, Life Sciences Reviews, Cell Press journals of Elsevier, Science Direct, Nature Journals, John Wiley & Sons, Inc, IOP, AIP, APS, Adenine Press , Cambridge Jorurals Online, The Company of Biologists. EDP Sciences, Emerald Publishing Group /MCB University Press, Genetics Society of America, IEEE, Indian Academy of Sciences, Informa Healthcare, Japan Institute of Heterocyclic Chemistry, Japan Publications Trading Co. Ltd., Japanese Society of Allergology, Kluwer Academic Publishers Group (KAPG))/Springerlink, Landes Bioscience, Microbiology Research Foundations, National Academy of Sciences, Physical Society of Japan, Polish Academy of Sciences, Portland Press, Reed Business, Rinton Press, Rockefeller University Press, Royal Society of Chemistry / Turpin Distribution UK, Thieme, Landes Bioscience, Karger. Current Protocols (Online) of John Wiley / Blackwell, Annual Reviews Online (Back volume), Methods in Enzymology (Online) etc.

B. Databases

Library also subscribed to different databases such as :

- **BIOBASE BIOLOGICAL Database-TRAN-AC/SE-O TRANSFAC®-Seat (Online);**
- **PROT-AC/SE-O PROTEOME™-Seat (Online);**
- **EXPL-AC/SE-O ExPlain™-Seat (Online);**
- **HGMD-AC/SE-O HGMD®-Seat (Online).**

- **Century of Science - Science Citation Index Expanded and ENDNOTE Web of ISI Web of Science, Thompson, USA.**
- **SCOPUS the largest abstract and citation database of research literature and quality web sources of Elsevier.**
- **SCIFINDER of ACS.**

Science of Synthesis—The Electronic Version

C. Open Access Membership

(1) Biomed Central (BMC)

D. New Addition(s) in 2015-2016:

During the year 2015-2016 Library subscribed new Database:

- Book(s) added in 2015-2016 : 139 nos.
- Thesis added : 31 nos.
- Bound Volumes of Journal added : 400 nos.

E. Available Back Volume Journals:

Elsevier Backfiles on Science Direct	Wiley Blackwell Journal Back files
1. Biochemistry, Genetics and Molecular Biology	1. Biotechnology, Biochemistry and Biophysics
2. High Energy Physics	2. Physics
3. Cell Press	3. Immunology
	4. Microbiology

F. e-Books added from 2013-2014

E-Books
Oxford Scholarship Online Physics Titles
• OSO Con Framework Quantum Field
• OSO Conductor Insulat Qua Phas Trans
• OSO Luminesc Spectroscopy Of Semico
• OSO Many-Body Phy With Ul Cold Gases
• OSO Nicolas-Louis De La Cai Astr Geo
• OSO Niels Bohr & The Quantum Atom
• OSO Non-Equilibrium Ther & Stat Mech
• OSO Quant Theo Small To Large Scales
• OSO Stellar Magnetism 2e
• OSO Story Of Semiconductors

G. Scientific Softwares Available:

Sl. No.	Software(s)	Publishers
1.	Grammarly@edu writing support Suite	Kite India
2.	iThenticate: Plagiarism detection Software	iThenticate
3.	Pathway Studio Mammal Desktop	Elsevier
4.	Metamorph (Molecular Devices), Multiuser subscription.	Molecular Devices
5.	Gaussian09 for (Multiprocessor) Windows Version for 2 Users, Gauss VIEW 5 Windows Version for 2 users	Scube Scientific Software Pvt. Ltd.
6.	SPSS Software--- (2 users)	IBM India Pvt.Ltd.
7.	Sigma Plot 12- Five user perpetual license-1 Set	Systat Software Incorporation
8.	Vector NTI static non-expiring academic license A13786 X 2	Invitrogen BioServices India Pvt. Ltd.

H. Resources through NKRC (http://nkrc.niscair.res.in/indexpage.php)

Library has joined with the National Knowledge Resource Consortia (NKRC) since 2008 which is joint consortia of CSIR and DST Institutes for accessing online resources. Through this consortia faculty members/scholars of this institute can access more than 5000+ online resources, SCIFINDER, ACS, Web of Science, Patent databases etc. Library could fulfill faculty / scholar demands for article resources from CSIR / DST Institutes subscribed journals. BI Library also provides article resources to all faculty/ scholars of DST / CSIR Institutes and also other institutes in India. Library is also member of FORSA Consortia.

Services and Management

Collection	Total Nos. as on 31 March 2015
Books Issued	203
Bound Volume Journal Issued	135
Loose Journal Issued	137
No. of Readers	5337
Internet Accessed (in hours)	21032
Photocopies	39020
Download of Articles (from Online Journals) (Approx.)	200000+

Services :

Reader's Service	The library is open to faculty member and scholars for reading and consultation during institute working hours. Faculty members / scholars can access (24x7) E-resources from any of the seven campuses of Bose Institute. Faculty members also can access E-resources from off campuses/ home access (24x7).
Technical Query Service	Library responds to any query related to information regarding research insights, reference management, database(s) access, Software services or any access related issues of subscribed content or using Library OPAC/IDR etc.
Document Delivery Service	Library provides article resources to all faculty/ scholars of DST / CSIR Institutes and also other institutes in India.
Inter Library Loan Service	The library provides 'Inter Library Loan' facility to the users of other libraries mostly research institutes who have Inter Library Loan arrangement(s) with Bose Institute Library. Library also get book through inter library book loan.
Institutional Membership	The library is member of various National and International organization(s) (i) Biomed Central (BMC), (ii) British Council Library, (iii) International Federation of Library Associations and Institutions (IFLA), (iv) International Society of Tea Science (ISTS), (v) Indian Association Of Special Libraries And Information Centres (IASLIC), (vi) Indian Science Congress Association (ISCA) Membership etc.
e - Journals Access	The library provides access to electronic journals subscribed by Library as well as subscribed through National Knowledge Resource Consortia (NKRC).
User Awareness Programme	Library conducts user orientation programmes time to time for the benefit of users and optimal utilization of subscribed resources. User orientation programme also includes "Reference management" for publications, citing references in thesis, using databases, citation report, h-index compilation, using different scientific software, using of anti-plagiarism software, grammar checking software etc.
Reprographic Service	The library provides reprography services to its users. Photocopy services are provided to all research workers of the Instiute. A total 2,90,607 pages of photocopies were given to our faculty and outside users.

Off-Campus access to BI e-resources	This year library has subscribed to RemoteXS hosting service to cater our scientists / researchers for off-campus access facility of journals , e-books etc.
National Digital Library (NDL)	Our library is now working as a part of National Digital Library, a project of IIT, Kharagpur. We have already shared the following resources from our repository: 1 > J C Bose Collection 2 > Annual Reports 3 > BI Newsletters 4 > Science Congress 2012 News We are in the process of sharing other publications of Bose Institute.

Academic Programmes / Seminar Organised by BI Library :

Bose Institute Library regularly organizing number of academic programmes for researchers of Bose Institute as well as nearby research institute(s) for promoting usage of Bose Institute Library subscribed resources as well as NKRC subscribed resources. These workshop(s) / training programme(s) also help scholars to lessen their research time. A good number of training programmes are organsied for using databases, software etc. Library helps to all kind of research endeavor.

1 > On the eve of our centenary celebration Bose Institute Library has organized a " Two day International conference on KOHA" in collaboration with **Bengal Library Association** on **23rd – 24th Jan' 2016** at Lecture Hall, Bose Institute Main Campus.

2 > An author workshop was arranged in collaboration with **Springer Link** on 22/09/15 in Centenary Building seminar hall. A lot of participants were present at the session and enjoyed the talk.

Further Academic Activities:

Library also provides training to library school students like Internship programme to LIS school students, training to Library professionals, advising different libraries for developing modern automated library, organizing training programmes / workshops for LIS professionals etc.

Bose Institute library hosted Internship Programme of "MLIS-5 year Integrated Course" of Department of Library and Information Science, University of Calcutta for two weeks under guidance of Dr. Banhisikha Chaudhuri.

Seminar / Workshop attended:

Dr. (Ms.) Banhisikha Chaudhuri (In-charge, Library) was invited to the "National Workshop on Open Source Software for Library Management" during 13th – 17th June'2015.

Ms. Ananya Raha (JLA) also participated in the workshop.

New Initiative

RFID Project : Stock verification is an important part of any library , particularly for an old establishment like Bose Institute Library. To solve this problem, this year library is going to implement RFID technology which will fully digitize Bose Institute Library. The project has already been initiated and work is going on till date. We expect to finish this project by this financial year.

New Arrival of Books- 2016

Sl No.	Editor/Author	Title of the book
1.	Chan, Kim Seng	Understanding Basic Chemistry Through Problem Solving: The Learner's Approach, 2015 (2 copies) (C.B.)
2.	*Trabocchi, Andrea*	Diversity-oriented synthesis : basics and applications in organic synthesis, drug discovery, and chemical biology, 2013 (C.B.)
3.	*Lundblad, Roger* L.	Chemical reagents for protein modification, 2014 (C.B.)
4.	Cann, Alan J.	Maths from scratch for biologists, 2003 (C.B.)
5.	Pieters, John, ed.	Pathogenesis of mycobacterium tuberculosis and its interaction with the host organism, 2013 (C.B.)
6.	Nicholas J. Gotelli	A primer of ecological statistics, 2013 (C.B.)
7.	Luque, F. Javier; Barril, Xavier, ed.	Physico-chemical and computational approaches to drug discovery, 2012 (C.B.)
8.	Butt, Hans-Jürgen	Physics and chemistry of interfaces, 2013 (M.C.)
9.	Datta, Sambhu N	Theoretical and computational aspects of magnetic organic molecules, 2014 (M.C.)
10.	Atta-ur-Rahman, ed.	Studies in natural products chemistry. Volume 45 (C.B.)
11.	Karty, Joel M.	Organic chemistry : principles and mechanisms, 2014 (C.B.)
12.	Davis, Frank ; Higson, Seamus	Macrocycles : construction, chemistry, and nanotechnology applications, 2011(C.B.)





Workshop

The Workshop is the nucleus of the maintenance activities including the various works at the seven campuses of Bose Institute, headed by the Workshop Superintendent. Workshop is situated at Main Campus and its different wings are i) Mechanical Unit ii) Carpentry Unit iii) Store iv) Electrical Unit (Main Campus and Centenary Campus) & v) Transport. The activities of the said units are as follows.

i) **Mechanical Unit** – The Unit consists of a few numbers of Lathe, Shaping, Drilling, Grinding Machine, Welding Machine etc. The Mechanical Unit has fabricated DNA Gel Apparatus Comb, Rotarod Instrument, Gel Casting Tray, Gradient Maker, various types of detector boxes made up of Perspex for handling Radioactive materials and other scientific activities, the Unit has also repaired various types of Instruments like Pelletizer, Gel Apparatus, the replica of Photosynthetic Bubbler etc.

ii) **Carpentry Unit**- This Unit deals with fabrication of furniture as well as repairing jobs of the various wooden parts as per the requirements of Scientists/ Officers of the Institute. Some significant jobs that have been undertaken like fabrication of wooden parts of Rotarod Instrument for evaluating balance, grip strength and motor co-ordination of the Rodents. This Unit also fabricated the wooden parts of the prototype model of Sir J. C. Bose Instruments like Photosynthetic Bubbler, Crescograph etc. This Unit provided its valuable effort for fabrication of M.S. Racks for the sericulture project in Purulia under "Scheduled Tribe – Specific Rural Biotechnology Programme".

iii) **Store**- Workshop store maintains the inventory of the materials (Civil, Electrical, Mechanical, Plumbing, Building and Furniture related materials etc. required for all seven campuses.

iv) **Electrical Unit:**- This Unit attains all the electrical related problems specifically of Main Campus & Centenary Campus. Except the above this unit also deals with the breakdown problems and execution of new projects in other five nos. campuses.

v) **Transport:**- Workshop Superintendent personally deals with the allocation of internal transports as per requirement of Scientists, different internal officers, outside guests etc. This unit not only look after the day to day maintenance of the Institute Vehicles but also process the bills related to transportation.

The Commendable jobs as well as other maintenance job of Workshop in the year 15-16 are as follows :-

i) Study & monitoring of all the electrical drawings of Unified Campus including planning for execution of substation to give a proper shape of the electrical system.

ii) Study of HVAC & other related issues including various civil part of Unified Academic Campus to ensure that the building should be completed within the stipulated time frame.

iii) Monitoring of the Electrical Installations of the seven campuses.



Acharya Bose and Lady Bose at Iowa University alongwith members of Hindusthan Sabha (1915)
First Row (seated from left)- M. Uddin, S. Basu, J.C. Bose and Abala Bose
Second Row (standing from left)- P.K. Basu, Mr. Bandopadhyay, Mr. Sanyal, Mr. Ahmed, Mr. Das

LIST OF PERSONNEL

Administration

Dr. Sibaji Raha, ***Sr. Professor & Director***

Dr. Samir Ranjan Sikdar, ***Sr. Professor & In-charge, Registrar's Office***

Smt. Noreen Bhattacharjee, ***Deputy Registrar***

Centenary Campus: Tapan Datta (retired on 31.10.15), Subir Sen, Sougata Banerjee, Ashim Kr. Biswas, Sisir Chakraborty, Manick Ch. Das, Baladeb Goswami, Rina Roy, Dhrubajyoti Sen, Mantu Bhattacharjee, Achintya Mukherjee, Kamal Singh, Vinit Tandon, Supriya Das, Satya Swarup Behera, Ananya Malgope, Rubi Sarkar, Sudam Jana, Bably Marick, Rina Das, Debdas Nandi, Somnath Das, Sanjoy Krishna Chaki, Debasis Kaley, Angshuman Bhowmik, Biplab Malakar, Shaubhik Ghosh, Arpita Bose, Mahendra Nath Shee, Hemanta Kumar Sahoo, Goutam Behera, Gouranga Paramanik, Animesh Jana, Ratan Saha, Sumanta Ghosh, Satyabrata Chatterjee, Khoirul Basar Malla, Kanai Hazra, Prafulla Bhunya, Kanak Baran Hazra, Duryodhan Nayak, Bablu Mandal, Sukanta Chakraborty, Subrata Banerjee, Ranjit Das, Sukumar Mandal, Jagabandhu Nayak.

Main Campus: Tarun Kumar Maji, Amitabha Bhattacharjee, Ishani Chatterjee, Chandra Kanta Sasmal, Rajbrat Ram, Sarada Devi, Madhusudhan Marick, Sanat Kr. Dhara, Kalicharan Turi, Munna Turi. Kodan Das, Rajkumari Balmiki.

Acharya J.C. Bose Biotechnology Innovation Centre
(Madhyamgram Experimental Farm)

Faculty: Dr. S. Raha (Director & Chairman), Dr. Gaurab Gangopadhyay (Scientist-In-Charge)

Staff Members: (Office): Mr. Amit Kumar Ghosh, Sudipta Basu.

Staff Members: (Lab.): Mr Asis Kumar Dalal, Priyanka Das (RA), Abhishek Mukherjee (Project), Mr Bapi Dey (Project).

Staff Members: (Field): Mr. Pulak Kumar Roy, Mr. Raj Kishore Lenka, Mr. Rabin Talukdar, Mr. Laxmi Kanta Pradhan, Sk. Inal Ali, Mr. Bhanu Kisku.

Biochemistry Department

Faculty: Prof. B. Bhattacharyya (INSA Sr. Scientist), Prof. Pinakpani Chakrabarti (Sr. Professor & Chairman), Prof. Anuradha Lohia, (Sr. Professor on lien from 02.05.14), Prof. Rajagopal Chattopadhyaya (Professor) Prof. Pradeep Kumar Parrack (Professor), Dr. Subrata Sau (Professor), Dr. Srimonti Sarkar (Associate Professor), Dr. Ajit Bikram Datta (Assistant Professor & Wellcome Trust-DBT India Alliance Intermediate Fellow), Dr. Abhrajyoti Ghosh (DST Ramanujan Fellow).

Students/RA/Project Assistant: Dr. Tanaya Chatterjee (DST Women Scientist), Mr. Sandeepan Sengupta (upto 27.03.16), Ms. Gopa Dhar, Mr. Somnath Datta (upto 31.07.15), Ms. Sayani Sarkar, Mr. Aditya Prasad Behera, Mr. Sukhendu Mondal, Ms. Prerana Agarwal, Ms. Indrani Kar, Ms. Devlina Chakraborty (upto 6.4.15), Mr. Anindya Biswas, Mr. Shankari Prasad Datta, Mr. Soumitra Polley, Mr. Soumitra Polley, Ms. Nabanita Saha, Ms. Atrayee Ray, Ms. Shamila Sarwar, Ms. Ananya Jana, Mr. Supriyo Bera, Mr. Pritam Naskar, Mr. Dibya Mukherjee (upto 17.5.15 transfer to DPB), Mr. Mousam Roy, Ms. Rituparna Goswami (from 24.08.15 to 10.12.15), Mr. Soham Seal (from 24.08.15), Ms. Chandrima Bhattacharyya, Mr. Debabrata Sinha, Mr. Shayantan Mukherji, Mr. Sayandeep Gupta (from 15.06.15), Ms. Ivy Mallick (from 22.06.15).

Staff Members: Mr. Subhash Chakraborty, Mr. Asim Kumar Poddar, Mrs. Debarati Kanjilal, Md. Asraf Ali Molla, Mr. Dulal Chandra Mondal, Ms. Ranubala Das, Mr. Atanu Pramanik, Mr. Tuhin Saha.

Bioinformatics Centre

Faculty: Dr. Pinakpani Chakrabarti, Scientist-In-Charge & Coordinator (DBT), Dr. Tapash Chandra Ghosh, Deputy Coordinator (DBT), Dr. Shubhra Ghosh Dastidar, Asstt. Professor, Dr. Zhumur Ghosh, Asstt. Professor , Dr. Sudipto Saha, Ramalingaswami Fellow.

Students /RA /Project Assistant : Soumita Poddar, Tina Begum, Sandip Chakraborty, Jyotirmoy Das, Kamalika Sen, Arup Panda, Deeya Saha, Atanu Maity, Arijita Sarkar, Sohini Chakraborty, Prerna Priya, Debarun Acharya, Debadrita Mukherjee, Ranjan Kr. Maji, Sarmistha Majumdar, Kakoli Biswas, Tonmoy Jana, Debashree Sarkar, Jesmita Dhar, Aritra Deb, Debarita Paul, Sibun Parida, Souparna Adhikary, Kalyan Reddy, Satyabrata Maity, Subarno Thakur, Rahul Dutta, Anwesha Dutta, Sumit Mukherjee, Anushree Bhattacharya, Sukhen Das Mondal, Aritrika Pal, Debangana Chakraborty, Souvik Sinha, Devlina Chakraborty, Manish Prakash Victor, Saran N, Sreyashi Majumdar.

Staff Members: Mr.Tushar Kanti Bhattacharya, Mrs. Sujata Roy, Sanjib Kr. Gupta, Mr.Jibananda Mondal.

Biophysics Department

Faculty: Dr. Siddhartha Roy, Professor, Dr. Gautam Basu, Professor, Dr. Anirban Bhunia, Assistant Professor, Dr. Subhrangsu Chatterjee, Ramanujan Fellow, Dr. Debjani Roy, Assistant Professor, Dr. Manju Roy, Visiting Scientist, Dr. Samarjit Polley, DBT-Wellcome Trust Fellow, Dr. Moitri Basu, DST-Inspire Faculty.

Students/RA/Project Assistant: Ms. Sarbani Chattopadhyay, Mr. Bankim Mondal, Ms. Paulami Chatterjee, Mr. Anirban Ghosh, Mr. Jagannath Jana, Mr. Rajib Kumer Kar, Ms. Aritreyee Datta, Ms. Soma Mondal, Ms. Jyotsna Sahaji Bhat, Ms. Meghamukta Mukherjee, Ms. Swapna Bera, Ms. Sudakshina Ganguly, Dr. Aparajita Pal, Mr. Anirban Roy, Ms. Ananya Dutta, Mr. Bhisma Narayan Ratha, Dr. Tulika Chakraborty, Dr. Aditya Dev, Dr. Piya Ghosh, Dr. Madhumita Chakraborty. Dr. Gitasree Naiya, Mr. Rubin Dasgupta, Ms. Madhura De, Ms. Basusree Ghosh, Dr. Raka Ghosh, Ms. Humaira Ilyas, Ms. Rajni Show,Ms. Sonali Ghosh.

Staff Members: Basudeb Marick, Barun Majumder, Tanmoy Debnath, Swapan Joghsharma, Sudhir Turi, Nagnarayan Yadav.

Chemistry Department

Faculty: Prof. K. P. Das, Prof.Joyoti Basu (**Chairperson**), Prof. Manikuntala Kundu, Prof. Pradip Das, Dr. Suman Kr. Banik, Dr. Jayanta Mukhopadhyay, Dr. Soumen Roy

Students/RA/Project Assistant : Mr. Srijon Kaushik Banerjee, Ms. Chandreyee Datta, Mr. Prasun Sarkar, Mr. Ayan Chatterjee, Mr. Soumyajyoti Banerjee , Mr. Manish Kumar, Mr. Sanjoy Kr. Sahoo, Mrs. Rajdeep Kaur Grewal, Mr. Saptarshi Sinha, Mrs. Arijita Subuddhi, **Mr. Arun Kr. Sharma, Mr. Arkajyoti Dutta, Mr. Ayan Biswas,** Mr. Amar Ch. Mahata, Miss Suruchi Lata, Mrs. Shreya Sengupta, Mrs. Paulami Rudra, Mr. Kaliprasad Pattanaik (upto 07.07.2015), Ms. Indrani Paul (upto 15.01.2016), Mr. Avijit Ghosh (upto 18.08.2015), Mr. Mayukh Paul (upto 22.04.2015), Mr. Saibal Saha (upto 19.10.2015).

Staff Members: Mr. Tapas Ghosh, Mr. Dipak Ch. Konar, Mrs. Rama Chatterjee, Mrs. Sujata Roy, Mr. Gaurab Roy, Mr. Mrityunjoy Kundu, Mr. Subhas Ch. Paul, Mr. Asoke Kr. Maity, Mr. Sachchidanand Ram

Central Instrumentation Facility

Faculty: Dr. Sujoy K. Das Gupta (Professor & In Charge, Cent. Bldg.), Dr. T. P. Sinha (Professor & In Charge Main Campus).

Supporting Staff (**Cent. Campus**): Jaganmay Guin (retired on 30-11-2014), Jaideb Chattopadhyay (upto 31-08-2015), Ranjan Kumar Dutta, Smriti Ranjan Maji, Mrinal Das, Swaroop Biswas, Sheolee Ghosh Chakraborty, Amarendra Nath Biswas, Pallab Chakraborty, Alpana Bhattacharya.

Supporting Staff (Main Campus): Arup Kumar Sen (upto 30-11-2015), Samir Mukherjee, Prodip Karmakar (Retired on 28-02-2015), Tanima Modak Dhar, Debabrata Polley (Retired on 31-12-2014), Shankar Santra, Sarwasati Sarkar.

Division of Molecular Medicine

Faculty : Dr. Kaushik Biswas, Assistant Professor, Dr. Tanya Das, Professor, Dr. Kuladip Jana, Scientiest-C, Dr. Atin Kumar Mandal, Assistant Professor, Dr. Nripendranath Mandal, Associate Professor, Dr. Subrata Majumdar, Professor, Dr. Anup Kumar Misra, Associate Professor, Dr. Mahadeb Pal, Associate Professor, Dr. Arun Kr. Ray, Emeritus Scientist, Dr. Manju Ray, Emeritus Scientist, Dr. Gaurisankar Sa, Professor, Dr. Parimal C. Sen, Senior Professor & Head, Dr. Parames Ch. Sil, Professor.

Students/RA/Project Assistant : Pinki Nandi, Swatilekha Ghosh, Argha Adhikari, Abhijit Sarkar, Parna Bhattacharya, Kirti Kajal, Argha Manna, Nikhil Baban Ghate, Supriya Chakraborty, Joyita Hazra, Joydeep Roy, Manjari Kundu, Dr. Anamika Bose, Anupam Adhikari, Bibhabasu Hazra, Jyotirmoy Ghosh, Joydeep Das, Saikat Majumdar, Shravanti Mukherjee, Gautam Guchhait, Abhishek Santra, Pabitra Bikas Pal, Sayantan Banerjee, Abhijit Sau, Poulami Khan, Monoranjan Ghosh, Kuntal Halder, Shibali Das, Barun Mahata, Tamashree Ghosh, Samik Chakraborty, Abir Kr. Panda, Amrita Bhattachajee, Sreeparna Chakraborty, Taniya Saha, Deblina Guha, Soumyadip Paul, Shahana Mitra, Kahkashan Rashid, Somanjana Khatua, Bidisha Paul Chowdhury, Dipankar Chaudhuri, Surav Dutta, Usri Chakraborty, Ajoy Mallik, Shilpi Saha, Dr. Minakshi Mazumdar, Dr. Santanu Kar Mahapatra, Dr. Amrita Dutta, Dr. Pushpak Bhattacharjee, Dr. Anindita Roy, Dr. Nivedita Roy, Dr.Aparajita Ghosh, Sankhadeep Pal, Krishnendu Sinha, Nihar Ranjan Biswal, Shabina Parveen Dr. Nivedita Roy, RA, Dr. Aparajita Ghosh, RA, Dr. Suman Bhandary, RA, Dr. Swatilekha Ghosh RA, Supriya Chakraborty, SRF, Arindam Basu, Kalyan Das,Joyita Hazra (SRF); Soumyadip Paul (SRF); Pooja Mukherjee (SRF); Asif Ali (SRF); Vinod Nelson (SRF), Suvranil Ghosh (JRF), Payel Das (JRF), Satyaki Chatterjee (JRF), Naibedya Dutta (Project assistant); Deepak Bharadwaj (Project assistant). Abhijit Sau (Thesis submitted and degree awarded from Calcutta University),Manas Jana, CSIR-SRF, Tamashree Ghosh, CSIR-SRF, Debashis Dhara, CSIR-SRF, Anshupriya Si, CSIR-JRF, Ishani Bhaumik, CSIR-JRF, Debashis Mazumder, Technical Asstt, Mr. Rhitajit Sarkar (SRF), Mr. Sourav Dutta (SRF), Ms. Usri Chakrabarty (SRF), Mr. Nikhil Baban Ghate (SRF), Mr. Ajoy Mallik (SRF), Mr. Dipankar Chaudhuri (SRF), Mr. Sourav Panja (JRF), Mr. Debabrata Mondal (JRF), Dr. Abhishek Das (RA), Mrs. Tapasree Basu Mallik (JRF) and Mr. Pradip Kumar Mallick (Laboratory Attendant)

Staff Members: Pransanta Pal, Indrajit Ray, Sukumar Maitra, Barindra Nath Mandal, Prabal Kr. Gupta, Uttam Kumar Ghosh, Arindam Basu, Debasish Majumdar, Shanghamitra Das (Sahu), Sourav Samanta, Kalyan Das, Amartya Sen, Ranjit Das, Purnendu Manna, Shankar Prasad Bari, Kanan Singh, Sudhir Turi, Pradip Kr. Mallick (LA-MoES Project), Mr. Ranjit Kumar Das

Division of Plant Biology

Faculty : Dr. Sampa Das, Sr. Professor & Head (till 30.06.2015) and INSA Senior Scientist from 01.07.2015, Dr. Swati Gupta Bhattacharya, Sr. Professor & Head (from 01.07.2015), Dr. Samir Ranjan Sikdar, Sr. Professor, Dr. Debabrata Basu, Professor, Dr. T.K Ghosh, Professor (superannuated on 31.10.2015), Dr. Gaurab Gangopadhyay, Associate Professor, Dr. Pallob Kundu, Associate Professor, Dr. Shubho Chowdhuri, Associate Professor, Dr. A.N. Lahiri Majunder, Raja Ramanna Fellow upto 29.02.2016 and INSA Senior Scientist from 01.03.2016, Dr. Amita Pal, CSIR Emeritus Scientist, Dr. D.N Sengupta, Guest Scientist, Dr. Swati Sen-mandi, ICMR Emeritus Medical Scientist, Dr. P.K Saha, Consultant Scientistup to 12.09.2015, Dr. Anupama Ghosh, DST Inspire Faculty.

Project Scientist:- Dr. Sonali Sengupta (DBT Project: Staff Scientist till 18.06.2015), Dr. Swagata Ghosh (DST Women Scientist), Dr. Rajeswari Mukherjee (DBT RA/BIO-CARE), Dr. Mitali Chatterjee (DBT BIO-CARE Scientist). Dr. Subha Das (DST Young Scientist), Dr. Akansha Jain (DST Young Scientist), Dr. Sudip Saha (DBT RA)

Staff members:_Mrs. Puspita Mukherjee, Mr. Subal Basak, Mr. Ashim Kumar Nath, Mr. Binoy Krishna Modak, Mr. Jayasish Ghosh. Mr. Arup Kumar Dey, Mr. NadiramKayal, Mr. Birendra Kumar Bari, Mr. KisunTuri, Dr. Chaitali Roy, Mr. Chanchal Chakraborty, Mr. Jadab Kr. Ghosh, Mrs. Kaberi Ghosh, Mr. Bipul Kumar Nag, Mr. Siddhartha Roy, Mrs. Sarama Pradhan, Mrs. Moumita Mondal, Mr. Sanjib Das, Mr. Tapas Chakraborty.

Research Associate and Scholars: Dr. Shubhendu Bandopadhyay, Dr. Sourav Bhattacharya, Dr. Avishek Dey, Mr. Pijush Mullick, Mr. Mrinmoy Majumder, Ms. Monia Chatterjee, Mr. Ayan Das, Mr. Arunava Mondal, Ms. Senjuti Sen, Mr. Joydeep Chakraborty, Ms. Jayanti Joddar, Mr. Sourav Bose, Ms. PapriBasak, Ms. Anju Patel, Mr. Dipan Roy, Ms. Payel Bhattacharya, Ms. Sayani Dey, Mr. Amit Paul, Ms. Amrita Mukherjee Ganguly, Ms. Deepti Sarkar, Ms. Sefa Parveen, Ms. Poulami Sarkar, Ms. Payel Ganguly, Ms. Adrita Roy, Ms. BananiMondal, Ms. Sanghamitra Adak, Mr. Sayantan Ghosh, Ms. Shruti Chattaraj, Mr. Rohit Das, Ms. Aishee De, Mr. Rahul Dutta, Ms. Rwitie Mallik, Mr. Dibya Mukherjee, Ms. Pratiti Dasgupta, Ms. Shreya Chowdhury, Mr. Amartya Ghosh, Mr. Soham Mukhopadhyay, Ms. Jinia Chakraborty, Ms. Shrabani Basak, Ms. MeghmaBera, Ms. Priyanka Das, Dr. Soumitra Maiti, Dr. Subhobrata Ghosh, Ms. Niti Yashvardini, Mrs. Marufa Sultana, Mr. Bodhisattwa Saha, Mr. Vivek Arora, Ms. Debarati Dey, Mrs Sayantini Sihi , Ms. Sangita Roy, Ms. Nandini Ghosh, Ms. Kavita Ghosal, Mrs. Bipasha Roy, Mr. Gourab Sircar, Mr. TathagataNath, Ms. KoyelSengupta, Ms. Bijoya Karmakar, Mr. Prabjit Singh, Ms. Moumita Bhowmik, Mr. Debabrata Datta, Mrs. Moumita Biswas Sarkar..

Environmental Science Section

Faculty: Dr. Sibaji Raha, Chairman, Dr Abhijit Chatterjee, Assistant Professor, Dr Sanat Kumar Das, Assistant Professor.

Staff Members: Dr Anandamay Adak, Mrs Ishani Chaudhury, Ms Debolina Seal, Mr Saral Chandra Das

Students/RA/Project Assistant: Dr. Debajyoti Roy, Research Associate, Dr Chirantan Sarkar, Research Associate, Mr Arindam Roy (SRF), Mr. Abhinandan Ghosh (JRF).

Falta Experimental Farm

Faculty: Dr. S.R. Sikdar (Division of Plant Biology), Sr. Professor& In-Charge and Coordinator- Rural Biotechnology Programme.

Staff Members: Shri Sobhan Roy Chowdhury (Senior Technical Assistant on contract), Shri Debarshi Porel and Shri Shuvankar Roy (both are Technicians on contract), Shri Amal Krishna Purkait, Shri Santanu Haldar, Shri Sourav Mondal, Md. Sijarul Hoque, Shri Subal Kayal and Shri Birsingh Mahato (all six are Master Trainers in the "Scheduled Tribe Specific Rural Biotechnology Programme"), Sk. Ansar Ali (Helper-G).

Microbiology Department

Faculty : Dr. Sujoy K. Dasgupta, *Professor & Chairman*, Dr. Tapan K. Dutta, *Professor*, Dr. Wriddhiman Ghosh, *Associate Professor*.

Students : Sri Prithwiraj Kirtania, Masrure Alam , Sm. Shreya Ghosh, Sri Soumik Basu, Sri Arindam Dutta, Sri Prasenjit Pyne, Sri Sourav Samaddar, Soumita Dutta, Sm. Soniya Chatterjee, Dr. Joydeep Chakrabarty (terminated on 30/03/15), Sri Chayan Roy, Sm. Niketa Bhawinghka, Sm. Neha Gupta, Sm. Rimi Roy (upto 31/12/14), Shrestha Ghosh (from 01/08/13), Satamita Deb, Rameez M.J.,Sabyasachi Bhattacharya (from 16/06/14), Apurba Sarkar (from 08/12/14), Subhrangshu Mandal (from 01/09/14).

Staff Members: Provat K. Chattopadhyay, Saifullah Gazi, Debashis Sarkar, Prabir Halder, Dilip Bhattacharyya, Ramesh Prasad, Robin Paul, Narayan Patali.

Physics Department

Faculty: Dr. Sibaji Raha, Sr. Professor, Director, Dr. Indrani Bose, Sr. Professor (CSIR Emeritus Scientist), Dr. Dipankar Home, Sr. Professor, Dr. Barun Kumar Chatterjee, Sr. Professor & Chairman, (Chairmanship terminated on 31.01.2016), Dr. Tripurari Prasad Sinha, Sr. Professor & Chairman, (w.e.f. 01.03.2016), Dr. Swapan Kumar Saha, Sr. Professor, Dr. Sanjay Kumar Ghosh, Sr. Professor, Dr. Somshubhro Bandyopadhyay, Associate Professor, Dr. Dhruba Gupta, Associate Professor, Dr. Rajarshi Ray, Associate Professor, Dr. Supriya Das, Associate Professor, Dr. Achintya Singha, Associate Professor, Dr. Partha Sarathi Joarder, Associate Professor, Dr. Soumen Roy, Associate Professor, Dr. Siddharth Kr. Prasad, Asstt. Professor, Dr. Saikat Biswas, Asstt. Professor.

Students/RA/Project Assistant: Dr. Rupa Sarkar, Dr. Mandira Sinha, Dr. Anindita Banerjee, Dr. Subhrangshu Ghosh, Mr. Sayan Biswas, Mrs. Sudipa Upadhyay, Mr. Soumitra Maity, Mr. Subhasis Samanta, Mr. Kinkar Saha, Mr. Rama Prasad Adak, Mr. Sujoy Saha, Mr. Sadhan Chanda, Ms. Dipanwita Majumder, Mr. Mainak Pal, Mr. Soumya Jyoti Banerjee, Ms. Rajdeep Kaur Grewal, Mr. Saptarshi Sinha, Mr. Anup Pradhan Sakhya, Mr. Saswata Haldar, Md. Sariful Sheikh, Mr. Tara Shankar Bhattacharyya, Mr. Ram Awdhesh Kumar, Mr. Ritwik Maity, Mr. Pranay Biswas, Mr. Saronath Halder, Mr. Prasenjit Deb, Mr. Rathijit Biswas, Mr, Diptak Biswas, Mr. Prasenjit Deb, Mr. Pratapaditya Bej, Mr. Abhishek Banerjee, Mr. Rupamoy Bhattacharyya, Mr. Shyam Bihari Mehta, Mr. Avik Banerjee, Ms. Sumana

Bhattacharyya, Ms. Pracheta Singha, Mr. Dipanjan Nag, Ms. Sananda Raychaudhuri, Ms. Pooja Bhattacharjee, Mr. Som Kanjilal, Mr. Souradeep Sasmal, Mr. Debarshi Das.

Staff Members: Mr. Sankar Prasad Singha, Mr. Shyamsundar Mallick, Dr. Subhasis Banerjee, Mr. Manas Dutta, Mr. Subrata Das, Mrs. Rita Chakraborty, Mr. Sujit Basu, Mr. Kanak Baran Hazra, Mr. Kaushik Maiti, Mr. Sumanta Ghosh, Mr. Bansi Dutta, (retired on 29.02.2016), Mr. Rajkumar Mourya, Mr. Amarnath Hela, Mr. Ranjit Das.

SMS (DRDO): Dr. Amitabha Mitra, Investigator-in-Charge, Mrs. Ayona Chakraborty, Research Scientist, Mr. Arun Kumar Dasgupta, Consultant (Admn.).

IRHPA – II: Research Scientist & Technical Assistants: Dr. Ajay Kumar Singh, Dr. Sandhya Dey (Mandal), Dr. Atanu Maulik, Mr. Soumendra Singh, Mrs. Sumana Singh, Ms. Debleena Sil, Mr. Bivek Gurung, Mr. Sabyasachi Majhi

INSA Senior Scientist Fellow: Prof. Probir Roy.

ALICE - II: Technical Assistant: Mr. Sanjoy Mukherjee.

J. C. Bose Centre

(Publication and Museum)

Staff Members: Tarun Kumar Maji, Ishani Chatterjee, Chandra Kanta Sasmal

Library

Dr. Arun Kumar Chakraborty (**Librarian : on lien from 15/12/14**), Dr. (Ms.) Banhisikha Chaudhuri (In-charge, Library: from 16/12/14), Ms. Ananya Raha, Ms. Sumita Dey (On lien), Ms. Gopa Dasgupta, Ms. Tanusri Bhattacharya, Mr. Gautam Mukherjee, Mr. Dipak Dutta, Mr. Mrityunjoy Jogsharma, Mr. Dinanath Das

Workshop

Mr. Raju Chandra Paul, Workshop Superintendent.

Main Campus: Mr. Fulchand Sardar, Helper G Workshop retired on 30/04/15 and Mr. Bidyut Kr. Mondal Accoutant retired on 31/01/2016.

Existing Staff members at the Main Campus: Mr Bholanath Saren, Mr Abdul Rahaman Molla, Mr Panchanan Santra, Mr Panchugopal Karak, Mr Sk. Md. Farruck, Mr W.D. Rozario, Mr Rajkumar Das, Mr Pranab Banerjee, Mr Brahmdeo Prasad, Mr Subrata Basak, Mr Sanjoy Santra, Mr. Kodan Das, Mr. Jyotimoy Sarkar (Assistant).

Centenary Campus: Mr. Ramprasad Ray (Consultant Electrical Engineer), Mr. Ashit Banerjee, Mr. Murari,Mohan Shee, Mr. Baidya Nath Murmu.



The Symbolic Wooden Door at the entrance to the
Museum at Bose Institute


STATEMENT
OF
ACCOUNT
FOR THE YEAR
2015-16

AUDITORS REPORTS
To the Members of the Council

1.0 We have audited the attached Balance Sheet as on 31st March, 2016 and the Income & Expenditure Account for the year ended as on date of BOSE INSTITUTE, 93/1, APC Road, Kolkata 700009. These financial statements are the responsibility of the Management of the Institute. Our responsibility is to express an opinion on these financial statements based on our audit.

We have conducted our audit in accordance with auditing standards generally accepted in India. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by, the management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

2.0 On the basis of our audit as indicated in the preceding paragraph and subject to our audit observation as set out in Annexure I and together with the Principle Accounting Policies and Notes on Accounts of the Institute (as set out in Schedule 24) we report that :-

i) we have obtained all the information and explanations, which to the best of our knowledge and belief were necessary for the purpose of our audit.

ii) in our opinion, proper books of account as required, have been maintained so far as appears from our examination of those books

iii) the Balance Sheet, Income & Expenditure Account and the Receipts & Payments Account dealt with by this report are in agreement with the books of account.

iv) in our opinion and to the best of our information and according to the explanations given to us, the said accounts, give a true and fair view in conformity with the accounting principles generally accepted in India :-

a) in case of the Balance Sheet, of the state of affairs of the Institute as on 31st March, 2016 and

b) in case of the Income & Expenditure Account, of the Deficit for the year ended on that date.

c) In case of Receipts' & Payments Account of the cash transactions of the Institute for the year ended as on that date

For C. Ghosh & Co.

Chartered Accountants
(Registration No. 322547E)

Place : Kolkata

Date : 26th September, 2016

Mahuya Ghosh

Partner
(Membership No : 058150)

AUDIT OBSERVATIONS
(Forming part of Audit Report)

Annexure I

1. Delays in deduction and payment of TDS noted, resulting in possible claims from the Income Tax department on account of defaults.

   There are also certain old Statutory balances (both Debit and Credit balances) which requires reconciliation and adjustment.

2. STDS Liability unpaid as at the year end amounts to ₹ 0.23 Lacs

3. As per the Ministry of Law and justice Department of legal Affairs Judicial section order No. 26/(1)/2014/judl, there is a predefined rate of legal charges which needs to be paid to the counsel. Our observation in this regard are as follows :

   - The rate paid for legal charges to the advocates was higher than the specified rate in the order.
   - As the bills of the advocate fees do not contain the categorization of the counsel, (as mentioned in the order) we are unable to quantify the excess amount charged.
   - The unit do not have contracts with the advocates dealing the cases.
   - List of Legal suits pending against the Institute was not provided to us - thus we are unable to quantity on Crystallized as well as Contingent Liability, if any

4. Assets acquired from "Institute Development and Modernization Fund" amounting to ₹ 666.58 Lacs held under the head "Investment from Earmarked Funds" has not been capitalised.

   Similarly, Work In Progress includes certain non moving items totaling to ₹ 37.02 Lacs (Dr) which requires thorough reconciliation to ascertain whether the assets have been already put into use but not as yet Capitalised.

   Without a detailed Fixed Assets Register in place, the adequacy and correctness of valuation of the assets is difficult to ascertain. Further, Impairment of assets if any has neither been identified nor provided for. The above observations may have an effect on the year's revenue and the Fixed Assets position of the Institute. (Refer AS 9, AS 10 and AS 28 issued by the ICAI)

5. Receipts of Capital Grant and expenses incurred against the same has been routed through Revenue Account, which is not in accordance with AS 12.

6. Internal Audit has not been carried out in the Institute which in our opinion should be implemented considering the nature, complexity and size of the activity of the Institute.

7. The Institute has quite a number of staff on contracted employment, who are not being paid either Provident Fund or ESIC. Future liability on account of statutory requirements, if any has neither been determined nor provided which may have an effect on years revenue and Net Current Assets of the Institute

8. Accounting for Retirement Benefits towards Gratuity and Leave Encashment for the employees has neither been ascertained nor provided for in the Financial Statements as per requirement of AS 15 issued by the ICAI. However Institute contends that since the entire fund for Retirement Benefits is received from DST, on the basis of Budgeted provision duly approved by the Finance Committee every year, such provision in this respect is not required.

9. Expenses are generally accounted for in the Financial Statements on cash basis which is not in accordance with the requirement of AS 9 issued by the ICAI.

10. Without review of the Old outstanding balances of ₹ 15.34 Lacs (Dr) and ₹ 135.65 Lacs (Cr) included in Current Assets / Liabilities, possible impact on the years revenue and the Net Current Assets position as at the year end of the Institute is indeterminate at this stage.

BOSE INSTITUTE
KOLKATA

BALANCE SHEET AS AT 31ST MARCH, 2016

(Amount in ₹)

	Schedules	As At 2015-16	As At 2014-15
CORPUS/CAPITAL FUND AND LIABILITIES			
Corpus /Capital fund	1	1,82,56,98,637.52	1,23,85,39,435.85
Reserves and surplus	2		
Earmarked/Endowment funds	3	51,04,03,997,97	48,68,88,506.76
Secured loans and borrowings	4		
Unsecured loans and borrowings	5		
Deferred credit liabilties	6		
Current liabilities and provisions	7	61,64,36,643.65	52,18,47,449.54
Total		**2,95,25,39,279.14**	**2,24,72,75,392.15**
ASSETS			
Fixed Assets	8	88,98,93,735.89	87,53,84,440.22
Investments -from earmarked/endowment Funds	9	32,87,38,759.42	31,10,39,956.42
Investments-others	10	12,25,76,673.46	11,83,37,043.25
Current assets,loans,advances etc.	11	1,61,13,30,110.37	94,25,13,952.26
Miscellaneous expenditure (to the extent not written off or adjusted)			
Total		**2,95,25,39,279.14**	**2,24,72,75,392.15**
Significant accounting policies	24		
Contingent liabilities	25		

Place : Kolkata
Date : 26/09/2016

Signed in terms of our separate Report of even date.

Sd/- (Samir Ranjan Sikdar) Senior Professor & Incharge-Registrar's Office	Sd/- (Siddhartha Roy) Director (Officiating)	Sd/- (Subir Sen) Accounts Officer	For C. Ghosh & Co. Chartered Accountants
Sd/- (A. K. Biswas) Audit & Finance Officer	Sd/- (A. Mukherjee) Accounts Officer	Sd/- (Manik Chandra Das) Accountant	Sd/- (Shaubhik Ghosh) UDC

BOSE INSTITUTE

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31.03.2016

(Amount in ₹)

	Schedules	For the year ended 2015-16	For the year ended 2014-15
INCOME		₹	₹
Income from Sales and Services	12	61,14,240.00	73,80,954.00
Grants/Subsidies	13	57,50,00,000.00	55,96,58,000.00
Fees/Subscriptions	14		
Income from Investments (Income on Investment, from earmarked /endowment Funds transferred to Funds)	15	2,26,93,020.60	2,96,46,611.54
Income from royalty, publication etc .	16		
Interest Earned	17		
Other Income	18	12,26,346.60	15,92,530.67
Increase/ (decrease) in stock of Finished goods and work-in-progress	19		
Total (A)		**60,50,33,607.20**	**59,82,78,096.21**
EXPENDITURE			
Establishment Expenses	20	41,73,67,186.98	38,27,97,022.90
Other Administrative Expenses	21	15,71,95,633.60	19,46,52,091.49
Expenditure on Grant, Subsidies etc.	22		
Interest	23		
Fund for capital Expenditure	23A	3,58,36,738.67	7,28,26,440.62
Depreciation (Net Total at the year end corresponding to Schedule 8)		6,30,00,579.00	5,94,38,582.00
Total (B)		**67,34,00,138.25**	**70,97,14,137.01**
Balance being excess of Income over Expenditure (A-B)		–6,83,66,531.05	–11,14,36,040.80
Transfer to Special Reserve (Specify each)			
Transfer to /from General Reserve			
Previous year expenses of ST_Rural and Cpf Expenses of IRHPA		94,22,035.00	
Last Year Unspent Balance / Overspent Balance		–15,61,22,788.62	–4,46,86,747.82
Balance of Unspent Balance After Adjustment		–14,67,00,753.62	
Balance being Surplus/(deficit) carried to corpus /capital fund		–21,50,67,284.67	–15,61,22,788.62
Significant accounting policies	24		
Contingent liabilities & Notes to Accounts	25		

Place : Kolkata
Date : 26/09/2019

Signed in terms of our separate Report of even date.

Sd/- (Samir Ranjan Sikdar) Senior Professor & Incharge-Registrar's Office	Sd/- (Siddhartha Roy) Director (Officiating)	Sd/- (Subir Sen) Accounts Officer	For C. Ghosh & Co. Chartered Accountants
Sd/- (A. K. Biswas) Audit & Finance Officer	Sd/- (A. Mukherjee) Accounts Officer	Sd/- (Manik Chandra Das) Accountant	Sd/- (Shaubhik Ghosh) UDC

SIGNIFICANT ACCOUNTING POLICIES & NOTES ON ACCOUNTS

Schedule : 24

1.0 Change in Accounting Policy:

The Statement of Accounts has been drawn in the specified form applicable to Central Autonomous Bodies (NPOs) and Similar Institutions from the Financial Year 2013-14. To adopt the changes some account heads are clubbed or splitted and represented differently to suit the requirements of new format. The Balance Sheet has been drawn by consolidating Statement of Accounts of Council and the Governing Body with schedules thereon without incorporating the consolidated transactions in the Income and Expenditure Account. Further, the transactions of the Governing Body have not been incorporated in the books of Council. This principle of accounting has been consistently followed from year to year. In case of Governing Body, Pension Fund, Regional Sophisticated Instrumentation Centre and Indo FAIR Coordination Centre, since no format was prescribed for Annual Accounts, they are maintained in the same format as before. The accompanying financial statements have been prepared on historical cost convention and conform to the fundamental accounting assumptions.

2.0 Fixed Assets:

2.1 Land at Madhyamgram

The Institute got possession of 18.73 acres out of 40.99 acres land allotted for Experimental Farm by Govt. of West Bengal. The Governing Body of the Institute decided on 31.07.1989 not to claim the balance land in dispute from the Government considering other related factors.

2.2 Fixed Asset Register

The Institute has taken initiatives to prepare a comprehensive Fixed Asset Register with the help of an agency. The process is almost in the completion stage. This initiative will also cover the assets acquired in the year 1991-92 from "Institute Development and Modernisation Fund" (provided by Planning Commission). As the Fixed Asset Register will become ready after the finalisation of accounts for the financial year 2015-16, therefore the nomenclatures and order mentioned in Schedule 8 (old form schedule 4) is taken into account.

2.3 Work-in-Progress

The particulars of fixed assets, under construction/installation are given in Schedule 8 (old form schedule 4). Construction of Animal House has been completed and taken into Schedule of Fixed asset and Depreciation has been charged accordingly.

2.4 Import in Progress

Import in Progress has been amounted for on the basis of bank advice on the date of actual payment.

2.5 Valuation of assets

a. The valuation of Fixed Assets has been made at cost less depreciation for the years 1990-91 till date.

b. The assets related to terminated projects have been identified up to 2005-06. Further identification of the assets relating to the years 2006-07 to 2013-14 is in progress and will be included in the Fixed Asset Register.

c. The identification of assets, impaired if any, as required in AS-28 issued by ICAI, has not been done.

d. Journals with high and prolonged impact are considered as Fixed Asset.

3.0 Depreciation:

3.1 Depreciation on Councils fixed assets has been incorporated in accumulated net balances as on 1990-91 and subsequent additions till 2013-14. The total depreciation upto 31st March 2013 has been deducted from the Capital fund of the Institute. But as per the requirements of new format depreciation for the year 2013-14 is charged to Income & Expenditure Account, and as per the requirement of new format depreciation for the year 2014-15 (and further) is charged to Income & Expenditure Account

3.2 The depreciation is calculated on Written Down Value Method as per the following rates irrespective of dates of putting the same in use:

1.	Building	-	10%
2.	Equipment	-	15%
3.	Books & Journals	-	10%
4.	Furniture	-	10%
5.	Vehicles	-	15%
6.	Air Conditioner	-	10%
7.	Electric Installation	-	10%
8.	Internet	-	60%

4.0 Revenue Recognition & Grant in Aid:

4.1 During financial year 2015-16, Grant-in-Aid for Council has been received under the head General, Salaries and Capital. Grant-in-Aid under General and Salaries have been treated as revenue grant. All incomes other than Government Grant and Bank Interest

are accounted for on cash basis. Govt. Grants are accounted for on accrual basis provided the order sanctioning the Grant is received before the end of the financial year.

4.2 The Institute has a system of accounting in respect of expenses for items like Salary, Stipend payable to Research Scholars under Sponsored Project Account, Gratuity, Leave Salary, Rates & Taxes etc. on cash basis. Liabilities for amount payable to suppliers for materials, services and other expenses are accounted for on accrual basis.

4.3 Consumable Stores are charged to expenditure for purchases.

4.4 Revenue expenditure on Scheme/Project and on specific grant are recognised in the accounting period in which the corresponding expenditure and grant arise. Net excess of receipts over expenditure of grants-in-aid schemes, sponsored by various agencies are represented in bank balances.

4.5 Government Grants received during the year are shown in the Income & Expenditure Account and surplus/deficit during the current year is reflected in the Balance Sheet.

5.0 Retirement/Post Retirement and Staff Benefits:

5.1 The interest on loans, being recoverable after realisation of principal amount is accounted for as and when it becomes receivable and the said interest is credited to the House Building Advance Fund. This is done as per Central Govt. Guidelines.

5.2 The Institute has General Provident Fund, Contributory Provident Fund and Pension Schemes.

5.3 Leave encashment, Gratuity, Provident Fund Contribution and Pension are accounted for on cash basis.

6.0 System of Fund Accounts:

6.1 The suggestion of Jt. Secretary and F.A. Dept. of Science and Technology, Govt. of India in the Finance Committee meeting held on 24.09.1996 for managing the Provident Fund through Trust Committee is yet to be implemented.

6.2 Although by virtue of the provision 9 of the Bose Institute Employees Pension Scheme Regulations approved by the Dept. of Science and Technology, Govt. of India and Rule 3.3 of the Bose Institute Contributory Provident Fund Rules, the Pension Fund, General Provident Fund and Contributory Provident Fund vest with the Bose Institute, separate Statement of Account with Income and Expenditure Account & Balance Sheet in respect of GPF and CPF are maintained in New prescribed format but.

7.0 Earmarked Funds:

Earmarked Funds shall be treated as a liability on their creation.

Income on investments out of Earmarked Fund is recognised and credited to Earmarked Fund wherever accrued. Any expenditure of a revenue nature which is incurred specifically on selected Scheme/Project it charged to the relevant Earmarked Fund.

8.0 Foreign Currency Transactions:

Transactions in foreign currency are recorded at the exchange rate applicable on the date of transaction.

9.0 Research and Development Costs:

Research and Development costs are charged to the Income & Expenditure Account for the year in which these are incurred.

10.0 Advances:

A sum of ₹ 6,43,638.00 included under "Advance Council" is shown in the Balance Sheet under the head Advances (Schedule-11) which include a sum of ₹ 5,26,874.00 pending recovery/adjustment prior to 2013-14.

11.0 Contingent Liability:

Legal expenses include the cost to defend the court cases lodged against the Institute; contingent liability for such cases is not ascertained.

12.0 Previous year's Figures:

The previous year's figures have been re-grouped and re-arranged in conformity with the figures of current year. Expenses incurred in connection with the Scheduled Tribe Specific Rural Biotechnology Programme and IRHPA Project for the Accounting Year 2013-14 and 2014-15 (Refer Sch-21) in the Income and Expenditure Account is now adjusted with the Income and Expenditure Account balance of Bose Institute Council Account for 2015-16, as these are not related with BI council expenses and corresponding adjusments are given in the respective project accounts of Scheduled Tribe Specific Rural Biotechnology Programme and IRHPA.

BOSE INSTITUTE

RECEIPT AND PAYMENT ACCOUNTS FOR THE YEAR ENDED 31.03.2016 (COUNCIL A/C)

(Amount in ₹)

Receipts	Schedule no	Amount (₹)	Payments	Schedule no	Amount (₹)
Opening Balance	1	136,991,536.24			
Transfer of Council Revenue		9,422,035.00	Transfer of Council Revenue		
Grant in aid	2	575,000,000.00	Establishment Expenses	9	417,367,186.98
Grant in aid for Unified Campus		700,000,000.00	Grant in aid for Unified Campus		-
Income From Services	3	6,114,240.00	Other Income	5	-
Interest Earned	4	23,049,417.60	Laboratory Expenses	10	55,758,803.78
Other Income	5	869,949.60	Other Adminstrative Expenses	11	101,436,829.82
Advances	6	26,381,824.00	Advances	6	538,839,386.00
Depreciation fund transfer			Building	12	156,622.00
Import of Equip. Work in Progress			Other Assets	13	35,680,116.67
Intellectual Property Dev. Fund			Capital Work in Progress	14	41,118,195.00
Interest on HBL			Import of Equip. Work in Progress		
Depreciation on Building	12		Fund for Capital Expenditure		
Depreciation on Other Assets	13		Interest on HBL		
Receivable From Security Staff			Depreciation on Fixed Asset (Fund)		
Receivable From Party			Other Development Work		3,788,246.00
Other TDS Receivable			Other TDS Receivable		
RSIC UNIT		8,619.78	TDS on Interest (Receivable)		
			Prof. S.M.Sarkar Lecture Fund Investment		4,308.09
Co-Operative		23,924,370.00	Employees Welfare Fund Investment		19,484.12
Group Insurance		337,242.25	Other Fund in Fixed Deposit		
International Symposium on			Co-Operative		23,912,800.00
IASTA 2010			Group Insurance		306,289.25
Prepaid Insurance			Other Development Work		
Development Fund			Bank Suspense		
Grant in aid (Receivable)			Accrued Interest		57,230.60
Accrued Interest		308,382.00	Receivable From Employees		63,407.00
			Receivable From Party		35,577.00
ST SPECIFIC RURAL BIOTECHNOLOGY PROGRAMME			TDS (Receivable)		43,306.00
			RSIC UNIT		
			ST SPECIFIC RURAL BIOTECHNOLOGY PROGRAMME		
Inter Unit Account			Inter Unit Account		
Scheme/Project		11,986,168.85	Scheme/Project		30,678,982.49
IRHPA (Prof. S. Raha)			Scheme/Project Grant in aid		1,287,296,419.00
FAIR		-	IRHPA (Prof. S. Raha)		
Scheme/Project Grant in aid		1,197,721,510.00	FAIR		7,240.00
Governing Body		86,162.00	Governing Body		143,380.00
IRHPA (Prof. A.Lohia)			IRHPA (Prof. A.Lohia)		
FAIR			ST SPECIFIC RURAL BIOTECHNOLOGY PROGRAMME		371.00
Review Meeting of Life Science Fellows Ramanujan		750,000.00	FTNMR UNDER INSTITUTE HEAD		1,727,692.00
			Review Meeting of Life Science Fellows Ramanujan		505,342.00
Sundry Creditors		218,115.00	Sundry Creditors		14,623,425.00
Statutory Liabilities	7	70,526,817.60	Statutory Liabilities	7	68,834,597.60
Other Liability	8	4,078,215.00			
Earmarked Funds	8A	5,836,688.21	Earmarked Funds	8A	
			Other Liability	8	28,712,566.00
			Closing Balance	1	142,493,489.73
		2,793,611,293.13			**2,793,611,293.13**

Place : Kolkata
Date : 26/09/2016

Signed in terms of our separate Report of even date.

Sd/-	Sd/-	Sd/-	For C. Ghosh & Co.
(A. Mukherjee)	(Manick Das)	(Shaubhik Ghosh)	Chartered Accountants
Accounts Officer	Accountant	UDC	

BOSE INSTITUTE
KOLKATA

Receipt and Payment accounts for the year ended 31.03.2016 (Projects)

Particulars	Sch. No.	Amount (₹)	Particulars	Sch. No.	Amount (₹)
OPENING BALANCE	1	477,440,111.72			
RECEIPT OF PROJECTS	2	268,303,037.00	PAYMENTS OF PROJECTS	2	364,953,956.82
RECEIPT OF IRHPA-S RAHA	3	-	PAYMENTS OF IRHPA-S RAHA	4	-
RECEIPT OF IRHPA-A LOHIA	5	-	PAYMENTS OF IRHPA-A LOHIA	6	-
RECEIPT OF FAIR (IFCC)	7	242,554,930.00	PAYMENTS OF FAIR (IFCC)	8	178,958,099.81
RECEIPT OF ST-RURAL	9	52,832,753.00	PAYMENTS OF ST-RURAL	10	44,738,426.00
CMS		38,150.00	CMS		96,000.00
ARREAR P TAX					
CPF EMPLOYEE CONTRIBUTION		176,609.00	CPF EMPLOYEE CONTRIBUTION		298,214.00
CPF EMPLOYER CONTRIBUTION		176,609.00	CPF EMPLOYER CONTRIBUTION		298,214.00
CPFV		120,000.00	CPFV		190,000.00
I TAX (PARTY)		808,440.00	I TAX (PARTY)		919,015.00
I TAX (SALARY)		1,708,825.00	I TAX (SALARY)		1,708,825.00
LABOUR WELFARE CESS		100,000.00	LABOUR WELFARE CESS		133,551.00
LIABILITY (2014-15)		-	LIABILITY (2014-15)		1,353,839.00
LIABILITY (2015-2016)		692,388.00	LIABILITY (2015-2016)		274,555.00
OVER HEAD		5,183,968.00	OVER HEAD		5,183,968.00
PAYABLE TO STAFF		3,298,034.00	PAYABLE TO STAFF		917,153.00
P TAX		58,850.00	P TAX		57,790.00
SALES TAX		300,000.00	SALES TAX		352,000.00
SECURITY DEPOSIT		500,000.00	SECURITY DEPOSIT		500,000.00
STALE CHEQUE		55,065.00	STALE CHEQUE		64,543.00
MISC INCOME			MISC INCOME		
PICKUP SERVICE			PICKUP SERVICE		
BANK CHARGES			BANK CHARGES		
RECEIVABLE FROM SCHOLARS		29,000.00	RECEIVABLE FROM SCHOLARS		62,453.00
MATTER OF EXCELLENCE			MATTER OF EXCELLENCE		
PM NATIONAL RELIEF FUND			PM NATIONAL RELIEF FUND		
GRANT-IN-AID RECEIVABLE		960,637.00	GRANT-IN-AID RECEIVABLE		
Inter Unit Account			Inter Unit Account		
BOSE INSTITUTE (COUNCIL)		1,317,975,401.49	BOSE INSTITUTE (COUNCIL)		1,209,707,678.85
IRHPA DR A LOHIA		-	IRHPA DR A LOHIA		-
IRHPA PROF.SIBAJI RAHA			IRHPA PROF.SIBAJI RAHA		
FAIR (IFCC)		136,605,000.00	FAIR (IFCC)		86,605,000.00
			CLOSING BALANCE	1	612,544,526.73
		2,509,917,808.21			**2,509,917,808.21**

Place : Kolkata
Date : 26/09/2016

Signed in terms of our separate Report of even date.

Sd/-
(A. Mukherjee)
Accounts Officer

Sd/-
(Debdas Nandy)
OS

For C. Ghosh & Co.
Chartered Accountants

AUDITORS' REPORT GOVERNING BODY

1.0 We have audited the attached Balance Sheet as on 31st March, 2015 and the Income & Expenditure Account for the year ended as on date of **BOSE INSTITUTE (Governing Body)**, 93/1, APC Road, Kolkata 700009. These financial statements are the responsibility of the Management of the Institute. Our responsibility is to express an opinion on these financial statements based on our audit.

We have conducted our audit in accordance with auditing standards generally accepted in India. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by, the management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

2.0 On the basis of our audit as indicated in the preceding paragraph and subject to our audit observation as set out in Annexure I of the Governing Body we report that :-

a) we have obtained all the information and explanations, which to the best of our knowledge and belief were necessary for the purpose of our audit.

b) in our opinion, proper books of account as required, have been maintained so far as appears from our examination of those books

c) the Balance Sheet and the Income & Expenditure Account dealt with by this report are in agreement with the books of account.

d) in our opinion and to the best of our information and according to the explanations given to us, the said accounts, give a true and fair view in conformity with the accounting principles generally accepted in India :-

i) in case of the Balance Sheet, of the state of affairs of the Governing Body as on 31st March, 2016 and

ii) in case of the Income & Expenditure Account, of the Surplus for the year ended on that date.

For C. Ghosh & Co.
Chartered Accountants
(Registration No. 322547E)

Place : Kolkata

Date : 26th September, 2016

Mahuya Ghosh

Partner
(Membership No : 058150)

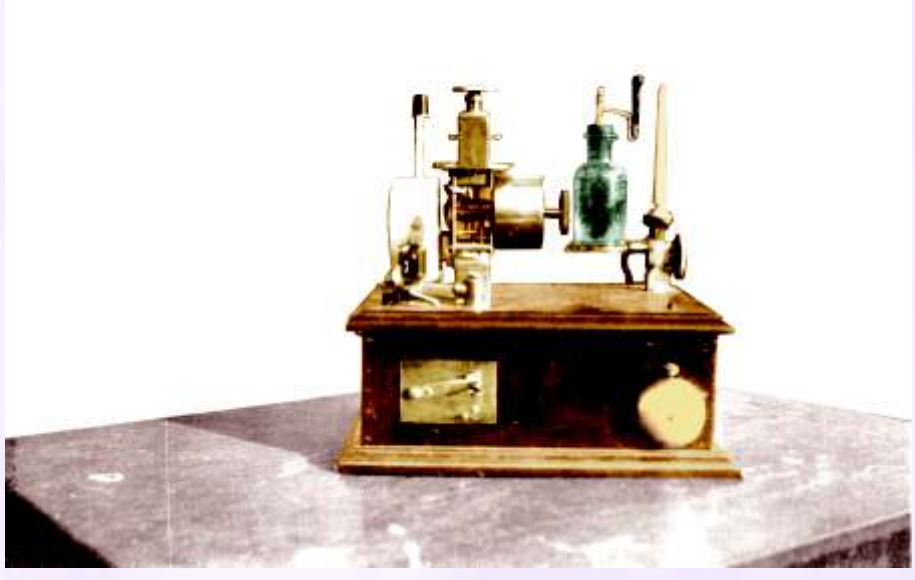
AUDIT OBSERVATIONS
(Forming part of Audit Report)

1. Fixed Assets Register has not been compiled for the Fund. Further, impairment of assets if any has neither been identified nor provided for. This will have an effect on year's revenue and the Fixed Assets of the Institute. (Refer AS 28 issued by the ICAI)

2. There are certain non moving balances which needs thorough reconciliation which might otherwise have an adverse impact on the years revenue and the Net Current Assets position of the Governing Body, the amount which is indeterminate at this stage.

   Cash Closing Certificate was neither made available to us nor the same could be physically verified by us.

   Investment in 7.5% Preference shares of CESC, were also not produced to us for verification.



BOSE INSTITUTE (GOVERNING BODY)

93/1, ACHARYA PRAFULLA CHANDRA ROAD, KOLKATA - 700009

BALANCE SHEET AS AT 31ST MARCH 2016

	Schedule No.	As on 31/03/2016	As on 31/03/2015
FUNDS & LIABLITIES		(₹)	(₹)
CAPITAL FUND			
AS PER LAST ACCOUNT		23,17,833.36	23,17,833.36
ACHARYA JC BOSE CENTENARY FUND			
AS PER LAST ACCOUNT		15,99,768.40	15,99,768.40
SPECIAL FUND	1	30,02,629.96	30,22,629.96
DEPOSITS & OTHER LIABILITIES	2	12,25,458.66	11,68,210.66
	TOTAL	**81,45,690.38**	**81,08,442.38**
PROPERTIES & ASSETS			
FIXED ASSETS			
AS PER LAST ACCOUNT	3	23,74,712.85	23,74,712.85
INVESTMENTS			
AS PER LAST ACCOUNT	4	56,87,253.67	52,59,661.67
RECEIVABLE & DEPOSITS			
AS PER LAST ACCOUNT	5	32,795.00	32,795.00
CASH & BANK BALANCES	6	11,61,429.84	10,47,505.84
INCOME & EXPENDITURE A/C			
EXCESS OF EXPENDITURE OVER INCOME		(11,10,500.98)	(6,06,232.98)
	TOTAL	**81,45,690.38**	**81,08,442.38**

INCOME & EXPENDITURE STATEMENT FOR THE YEAR ENDED 31ST MARCH 2016

Particulars	2015-16 (₹)	2014-15 (₹)
INCOME		
INTEREST ON TERM DEPOSIT	5,25,888.00	4,33,169.00
INTEREST ON SAVINGS BANK	4,060.00	21,110.47
TOTAL	**5,29,948.00**	**4,54,279,47**
EXPENDITURE		
SALARY & WAGES	21,600.00	21,600.00
ACCOUNTING CHARGES		–
AUDIT FEES	3,450.00	3,420.00
BANK CHARGES	630.00	618.00
EXCESS OF INCOME OVER EXPENDITURE FOR THE YEAR	5,04.268.00	4,28,641.47
TOTAL	**5,29,948.00**	**4,54,279.47**
INCOME BROUGHT DOWN AND ADJUSTED WITH LAST YEAR	5,04,268.00	4,28,641.47
BALANCE BROUGHT DOWN FROM LAST A/C (DEBIT)	(6,06,232.98)	(1,77,591.51)
BALANCE TAKEN TO BALANCE SHEET (DEBIT)	(11,10,500.98)	(6,06,232.98)

Place : Kolkata
Date : 26/09/2015

Signed in terms of our separate Report of even date.

Sd/-	Sd/-	Sd/-	For C. Ghosh & Co.
(Samir Ranjan Sikdar)	(Siddhartha Roy)	(A. Mukherjee)	Chartered Accountants
Senior Professor &	Director (Officiating)	Accounts Officer	
Incharge-Registrar's Office			

AUDIT OBSERVATIONS
(Forming part of Audit Report)

AUDITORS' REPORT

1.0 We have audited the attached Balance Sheet as on 31St March, 2016 and the Receipts and Payments Account of Bose Institute, Indo - FAIR Coordination Centre of P 1/12, CIT Scheme VIIM, Kolkata 700 054 for the year ended as on 31~t March 2016. The financial statement is the responsibility of the Management. Our responsibility is to express an opinion on these financial statements based on our audit.

We have conducted our audit in accordance with auditing standards generally accepted in India. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by, the management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

2.0 On the basis of our audit as indicated in the preceding paragraph of the Centre along with the Notes on Accounts we report that :-

i) we have obtained all the information and explanations, which to the best of our knowledge and belief were necessary for the purpose of our audit.

ii) in our opinion, proper books of account as required, have been maintained so far as appears from our examination of those books

iii) the Balance Sheet and the Receipts & Payments Account dealt with by this report are in agreement with the books of account.

iv) in our opinion and to the best of our information and according to the explanations given to us, the said accounts, together with the notes to accounts thereon give a true and fair view in conformity with the accounting principles generally accepted in India :-

a) in case of the Balance Sheet, of the state of affairs of the Governing Body as on 31st March, 2016 and

b) in case of the Receipts & Payments Account, of the Cash Flows for the year ended on that date.

For C. Ghosh & Co.
Chartered Accountants
(Registration No. 322547E)

Place : Kolkata

Date : 26th September, 2016

Mahuya Ghosh

Partner
(Membership No : 058150)

BOSE INSTITUTE - IFCC

Notes on Accounts

1. The facility for Anti-Proton and Ion Research (FAIR) is a global facility being created in Darmstadt, Germany under a multi-country partnership. FAIR project will be managed by FAIR company (FAIR GmBH). FAIR will be one of the largest accelerator facilities in the world and also one of the mega science projects recommended by the Steering Committee on Science & Technology set up by the Planning Commission for the 11th Five Year Plan. FAIR project is taken up as part of DAE & DST joint collaboration ·under a MoU signed between DAE & DST in April 2006.

   A joint declaration was signed on 7.2.2007 by the Minister for Science & Technology and Earth Sciences, Govt. of India and the Federal Minister for Education & Research, Federal Republic of Germany concerning the participation in construction and operation of the international facility for Anti-proton and Ion research. A joint statement was issued by the Chancellor of Republic of Germany and Prime Minister of India on 30.10.2007 in this regard. On 4.10.2010, the international agreement on the construction of FAIR was signed by nine countries namely Germany, Finland, France, India, Poland, Romania, Russia, Slovenia and Sweden. India's contribution to the FAIR consortium has been estimated at 42.79 million Euro at July 2010 prices which is equivalent to ₹ 260.00 Crore (Approximately). According to the MoU between DAE & DST, the overall cost of ₹ 260.00 crore is to be borne equally by DAE & DST.

   Bose Institute, Kolkata has been designated as the Indian shareholder in the FAIR Company and the Nodal Indian institution for management of the FAIR progranmle in India. The assets created from Indian participation will not come under the purview of Bose Institute and they will also not be shown in its Balance Sheet. Keeping in mind all the above accounting of FAIR project is Unique and it is maintained in the old format as before, without changing in format for Central Autonomous Institutes.

2. Department of Science and Technology (DST) under the Ministry of Science and Technology, Govt of India vide Memo No. SR/MF/PS-01/2011 dtd 04/03/2011 mentioned under Clause 11 that a "financial aspect will be issued in due course" but the same has not been received till date. However the present Executive Council takes both operational and financial decisions.

BOSE INSTITUTE (IFCC)
KOLKATA

BALANCE SHEET AS AT 31ST MARCH 2016

As on 31st March 2015 (₹)	Liabilities	As on 31st March 2016 (₹)	As on 31st March 2015 (₹)	Assets	As on 31st March 2016 (₹)
307,122.00	Fund for Creation of Asset	3,07,122.00	54,732.00	Shares in FAIR GmbH	54,732.00
			252,390.00	Office Equipment	2,52,390.00
	Unspent Grant				
3,37,61,341.51	Grant from Department of Science and Technology **(Schedule-1)**	11,97,07,250.10	30,000.00	Advance to Dr. R K Bhandari	
2,28,71,564.00	Grant from Department of Atomic Energy **(Schedule-2)**	4,20,22,471.60			
2,46,94,325.00	Interest Earned **(Schedule-3)**	3,31,86,967.00		**Bank Balances**	
5,618.00	Audit Fees Payable	5,750.00	2,70,794.51	S.B. A/c - Union Bank of India	49,09,891.70
7,480.00	Payable to Bose Institute	14,720.00	8,10,69,534.00	Fixed Deposits	14,00,27,267.00
•				Receivable from Bose Institute	5,00,00,000.00
8,16,47,450.51		**19,52,44,280.70**	**8,16,47,450.51**		**19,52,44,280.70**

STATEMENT OF EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2016

For the year ended 31st March 2015 (₹)	Particulars	For the year ended 31st March 2016 (₹)
7,130.00	Advertisement Expenses	–
3,454.00	Ad-hoc Bonus	3,454.00
5,618.00	Audit Fees	5,832.00
1,045.73	Bank Charges	404.81
–	Consultancy	49,600.00
42,124.64	Contingency Expenses	5,877.00
99,354.00	Honorarium Expenses	–
2,87,532.00	Meeting Expenses - IFCC	2,47,339.00
4,50,000.00	Overhead Charges	–
45,000.00	Conveyance Expenses	–
13,73,365.00	Salary	13,55,000.00
1,67,574.00	Student Support	2,18,724.00
8,714.65	Telephone Expenses	1,500.00
27,20,308.00	Travelling Expenses	17,85,668.00
–	Workshop	5,52,988.00
52,11,220.02		**42,26,386.81**

Place : Kolkata
Date : 26th September, 2015

Signed in terms of our separate Report of even date.

For C Ghosh & Co.
Chartered Accountants

Sd/-	Sd/-	Sd/-	Sd/-	Sd/-
(Accountant)	(Accounts Officer)	(Accounts & Administrative Officer)	(Sr. Prof. & In. Charge)	(Director, Officiating)
Bose Institute	Bose Institute	Bose Institute IFCC	Registrar's Office, BI	Bose Institute

BOSE INSTITUTE (IFCC)

KOLKATA

Receipt and Payment Accounts for the year ended 31.03.2016 (FAIR)

Particulars	(₹)	Particulars	(₹)
Opening Balance			
S.B A/c Union Bank of India	2,70,794.51		
Fixed Deposits	8,10,69,534.00		
GRANT FROM D.S.T (Grant amount of Rs. 5,00,00,000.00 is receivable from Bi-Scheme A/C)	10,17,00,000.00		
GRANT FROM D.A.E (IFCC Exp.)	3,49,05,000.00		
Interest on SB A/c	51,317.00		
Interest on FD (Term Deposits)	84,41,325.00		
Advance	2,86,000.00	Advance	2,86,000.00
Liability for Audit Fees	5,832.00	Liability for Audit Fees	5,700.00
Profession Tax	7,240.00	Profession Tax	7,240.00
TDS (Party: ₹ 1285076.00 + Salary: ₹ 114845.00)	13,99,921.00	TDS (Party: ₹ 1285076.00 + Salary: ₹ 114845.00)	130,048.00
Sundry Creditors(CSIR-CMERI)	87,20,000.00	Sundry Creditors (CSIR-CMERI)	87,20,000.00
Travelling Expenses	4,26,055.00	Travelling Expenses	22,11,723.00
		Meeting Expenses - IFCC	2,47,339.00
		Audit Fees	5,832.00
		Ad-hoc Bonus	3,454.00
		Bank Charges	404.81
		Contingency Expenses	5,877.00
		Consultancy	49,600.00
		Salary	13,55,000.00
		Student Support	2,18,724.00
		Telephone Expenses	1,500.00
		Workshop	5,52,988.00
		Power Converter (In-Kind)	1,77,85,211.00
		Vaccum Chamber (In-Kind)	4,958.00
		Beam Stopper (In-Kind)	94,91,628.00
Inter Unit Account		**Inter Unit Account**	
Bose Institute (Council)	7,240.00	Bose Institute (Council)	–
Scheme/Project	8,66,05,000.00	Scheme/Project (Grant from DST of ₹ 5,00,00,000.00 is receivable from Bi-Scheme A/C)	13,66,05,000.00
		Closing Balance	
		S.B A/c Union Bank of India	49,09,891.70
		Fixed Deposits	14,00,27,267.00
	32,38,95,258.51		**32,38,95,258.51**

Place : Kolkata
Date : 26th September, 2016

Signed in terms of our separate Report of even date.

For C Ghosh & Co.
Chartered Accountants

Sd/-
(Accounts Officer)
Bose Institute

Sd/-
(Accounts & Administrative Officer)
Bose Institute IFCC

Sd/-
(Director, Officiating)
Bose Institute



Students pondering over the puzzles of probability



Use of microscope to study the intricate biological structures

COMPLIANCE REPORT

Compliance Report of Bose Institute on the Audit Observations for the Financial Year 2015-16

Sl. No	Audit Observation	Replies
1.	Delays in deduction and payment of TDS noted, resulting in possible claims from the Income Tax department on account of defaults. There are also certain old Statutory balances (both Debit and Credit balances) which requires reconciliation and adjustment.	Delay in payment of TDS happened in very few cases, but all-out effort was given for deduction and deposition of TDS within due date. Reconciliation of old Statutory balances is under process.
2.	STDS Liability unpaid as at the year end amounts to Rs. 0.23 Lacs	This liability was raised as on 31/03/2016 and duly been paid in next Financial year 2016-17.
3.	As per the Ministry of Law and justice Department of legal Affairs Judicial section order No. 26/(1)/2014/judl, there is a predefined rate of legal charges which needs to be paid to the counsel. Our observation in this regard are as follows : The rate paid for legal charges to the advocates was higher than the specified rate in the order. As the bills of the advocate fees do not contain the categorization of the counsel, (as mentioned in the order) we are unable to quantify the excess amount charged.	In continuation and persuasion of the Agenda item No.5 of the Finance Committee meeting held on 03.06.1994 and subsequent 179th meeting of the Council of Bose Institute held on 27.06.2013 vide agenda item No.14(1), the Council of Bose Institute delegated the following Powers to the Director, BI :- 1. As Bose Institute does not maintain any panel of Lawyers, cases will be referred by Director BI to any Lawyers depending upon the merit, requirement and urgency of the case.

	The units do not have contracts with the advocates dealing the cases.	2. Cases may be referred by Director, BI to any Lawyers/firms not limited to the empanelled Lawyers of the Ministry of Law. However, a suitable agreement between the lawyer and the Institute may be drawn up.
	List of Legal suits pending against the Institute was not provided to us - thus we are unable to quantity on Crystallized as well as Contingent Liability, if any	3. Director, BI was delegated full powers to appoint senior advocates/barrister along with payment of their fees as applicable/charged by these senior Advocates/barrister as and when required depending upon the gravity, urgency and merit of the case. 4. The Director, BI may engage the legal Counsels and Pay Conference fees as per their schedule of charges depending upon the gravity, urgency and merit of the case. However, a committee has been constituted by the Director(officiating) for drawing up internal guidelines and standard operating protocols for office procedures, initially for legal affairs vide order No.R/135/16/1969 dated 16.09.2016.
5.	Assets acquired from "Institute Development and Modernization Fund" amounting to Rs. 666.58 Lacks held under the head "Investment from Earmarked Funds" has not been capitalized. Similarly, Work In Progress includes certain non moving items totaling to Rs. 37.02 Lacs (Dr) which requires thorough reconciliation to ascertain whether the assets have been already put into use but not as yet Capitalized. Without a detailed Fixed Assets Register in place, the	Draft Fixed Asset register of Bose Institute is prepared and verification process is in progress. With the finalization of Fixed Asset register, asset acquired under "Institute Development and Modernization Fund" will be capitalized. Adequacy and correctness of valuation of the assets will be ascertained.

	adequacy and correctness of valuation of the assets is difficult to ascertain. Further, Impairment of assets if any has neither been identified nor provided for. The above observations may have an effect on the year's revenue and the Fixed Assets position of the Institute. (Refer AS 9, AS 10 and AS 28 issued by the ICAI)	Since the accounting of Bose Institute is done in Historical Cost basis, therefore impairment of assets was not considered for.
6.	Internal Audit has not been carried out in the Institute which in our opinion should be implemented considering the nature, complexity and size of the activity of the Institute.	The cadre restructuring process of Bose Institute is under process, in which it is proposed to strengthen the Internal Audit department. Howevwe, DST's Internal Audit wing has last audited in November 2014.
7.	The Institute has quite a number of staff on contracted employment, who are not being paid either Provident Fund or ESIC. Future liability on account of statutory requirements, if any has neither been determined nor provided which may have an effect on years revenue and Net Current Assets of the Institute	Medical facility is extended to the staff on contractual employment as per approval of Council of Bose Institute. Administrative steps are being taken for extension of EPF to contractual employees.
8.	Accounting for Retirement Benefits towards Gratuity and Leave Encashment for the employees has neither been ascertained nor provided for in the Financial Statements as per requirement of AS 15 issued by the ICAI. However Institute contends that since the entire fund for Retirement Benefits is received from DST, no such provision in this respect is required.	Pension and retirement benefit funds are received from the DST on the basis of budgeted provisions duly approved by the Finance Committee every year and also duly ratified by the council of Bose Institute, hence such provision is not followed.
9.	Expenses are generally accounted for in the Financial Statements on cash basis which is not in accordance with the requirement of AS 9 issued by the ICAI.	Since all expenses are matched with the receipt of Grant-in-aid from Department of Science and Technology against budget prepared and approved in advance for a specific financial year, therefore expenses are charged on cash basis only except a few accrued expenses.
10.	Without review of the Old outstanding balances of Rs.15.34Lacs(Dr)and Rs. 135.65 Lacs (Cr) included in Current Assets / Liabilities, possible impact on the years revenue and the Net Current Assets position as at the year end of the Institute is indeterminate at this stage.	Reconciliation of the Old outstanding balances of Current Assets / Liabilities will be done before finalization of annual accounts of 2016-17.



Physical Science hands-on: understanding of the working mechanism of wet cell battery using lemon and potato



Cultural programme organized by participating students

ON GOING PROJECT

On going project during 2015-16

Sl. No.	Name of the Project	Duration	Project Investigator		Opening Balance as on 01.04.15	Grant Received during 2015-16	Other Receipts during 2015-16	Expenditure during the year 2015-16	Debit / Credit Balance as on 31.03.16
1	DBT - "Setting up of National Facility on Interactive Graphics Computer System for Biometecular Modeting, molecular dynamics & structures"	extended upto 31.03.2017	Pror Pinakpani Chakrabarti, B.I.C	381	477991.42	1051200.00	26769.00	628000.89	927,959.53
2	DBT - "Centre of Excellence (COE) at Bose Institute"	upto 31.03.2017	Prof. P. Chakrabarti, B.I.C.	775(A)(B)	2,647,584.76	2,200,553.00	77,975.00	1,612,857.72	3,313,255.04
3	DST - "Award of J.C.Bose Fellowship to Prof. Pinakpani Chakraborti"	03.05.2007 to 02.05.2012 extended upto 02.05.2017	Prof. Pinakpani Chakraborti	795	165,725.36	1,650,000.00		916,701.00	899,024.36
4	RCI - "Studies on Microwave Scattering (SMS)(DRDO)"	Extended upto 02.11.2015	Prof. S. Raha, Physics	803	383,870.15	3,099,978.00	454293	2,667,424.00	1,270,717.15
5	DBT - "Regulation of microRNAtranscription and biogenesis by fungal-stress in tomato"	01.06.2010 to 31.05.2013 extended upto 31.05.2015	Dr. Pallob Kundu, DPB	918	113,252.24	-	-	87,347.00	25,905.24
6A	DBT - "Generation of Salt tolerant rice Plants : A translational approach"	06.10.2010 to 05.10.2015	Prof. A. N. Lahiri Majumdar, DPB	929	(306,108.66)	2,040,602.00	22,597.00	1,409,121.00	347,969.34
6B	DBT - "Generation of Salt tolerant rice Plants : A translational approach"	06.10.2010 to 05.10.2015	"Prof. D. N. Sengupta, Division of Plant Biology"	929	(60,474.00)	643,307.00	7,296.00	582,509.00	7,620.00
6C	DBT - "Generation of Salt tolerant rice Plants : A translational approach"	06.10.2010 to 05.10.2015	"Dr. Shubho Chaudhry, Division of Plant Biology"	929	(89,424.66)	631,000.00	5,395.00	512,005.00	34,965.34
7	DAE - "Raja Ramanna Fellow"	18.04.2011 to 17.04.2014 extended upto 28.02.2016	Prof. A. N. Lahiri Majumdar, DPB	957	3,339.00	541,959.00	-	545,186.00	112.00
8	ICAR(NFBSFARA) - "Development of pod borer resistant transgenic pigeonpea and chickpea"	01.01.2011 to 31.12.2013 extended upto 31.12.2016	Prof. Sampa Das, DPB	971	305,205.10	2,787,507.00	-	2,901,510.00	191,202.10
9	CSIR - "Understanding the molecular mechanism of the energy homeostasis in normal and malignant cells: the role and inter-relationship of creaine kinase and AMP-activated protein kinase"	13.05.2011 to 31.05.2014 extended upto 30.04.2015	Prof. Manju Roy, DMM	972	48,966.00	184,467.00		233,433.00	-

10	Welcome Trust & DBT India Alliance - "Award of Intermediate Fellowship to Dr. Ajit Bikram Dutta"	01.08.2011 to 31.07.2016	Dr. Ajit Bikram Datta, Biochemistry	978	(1,095,005.74)		-	1,186,431.68	(2,281,437.42)
11	CSIR - "Molecular mechanisms of tumor progression : Role of tumor derived products in mediating tumor cell growth, motility and metastasis"	01.07.2011 to 30.06.2014 extended upto 31.07.2015	Dr. Kaushik Biswas, DMM	988	23,955.14	133,333.00		156,646.00	642.14
12	DBT - "Identification of the host cell factors responsible for survival and death of leishmania"	27.09.2011 to 26.09.2016	Prof. Subrata Majumdar, DMM	992	28,043.00	-		-	28,043.00
13	DBT - "Exploration of lichens from Barak Valley of Southern Assam and Arunachal Pradesh (North East India) and isolation phytochemicals and bioprospecting of some selected lichens species"	23.04.2012 to 22.04.2015	Dr. Nripendranath Mandal, DMM	1031	(149,211.88)	517,000.00	4,765.00	372,413.00	140.12
14	DBT - "Sys TB : A network program for resolving the intracellular dynamics of host pathogen interaction in TB infection"	09.01.2012 to 08.01.2017	Prof. Joyoti Basu, Chemistry	1033	569,407.43	-	10,892.00	555,089.00	25,210.43
15	SERB(DST)-IRHPA-II - "Study of cosmic ray interactions and cosmic ray aerosol cloud connection in the context of the regional climate change"	01.08.2012 to 31.07.2017	Prof. Sibaji Raha, Phsics	1042	40,887,193.27			28,337,805.20	12,549,388.07
16	DBT - "Role of DNA dependent protein kinase in transcription control in human cells"	25.06.2012 to 24.06.2015	Dr. Mahadeb Pal, DMM	1050	172,462.81	215,783.00	6,916.00	225,551.00	169,610.81
17	DBT - "Identification and characteriza--tion of 19S proteasomal component of the early diverging eukaryote Giardia lamblia"	29.08.2012 to 28.08.2015	Dr. Srimonti Sarkar, Biochemistry	1051	266,367.38	-	6,441.00	231,013.00	41,795.38
18	DST - "Targeted alteration of MAPK family menbers ERK and p38MAPK/ JNK to channelize oncogenic Ras-induced proliferative-signaling into apoptotic signaling"	28.05.2012 to 27.05.2015	Prof. Gauri Sankar Sa, DMM	1054	333,351.81	-		182,330.65	151,021.16

19	CSIR - "Functional characterization of the lipid-bindling FYVE protein from Giardia lamblia"	01.01.2012 to 31.12.2015	Dr. Srimonti Sarkar, Biochemistry	1067	72,666.81	310,850.00		345,376.00	38,140.81
20	CSIR - "Mechanistic insights into dendritic cell maturation and its role in Leishmania donovani infection : Emphasis on dendritic cell-based anti-leishmanial therapy"	01.01.2013 to 31.12.2015	Prof. Subrata Majumdar, DMM	1068	18,881.00	323,800.00		339,700.00	2,981.00
21	DBT - "The role of two component systems and cell division proteins in mycobacterial physiology"	29.09.2012 to 28.09.2015	Prof. Manikuntala Kundu, Chmistry	1076	(188,716.00)	1,570,400.00	-	1,257,185.06	124,498.94
22	DAE - "Remodeling the cellular calcium homeostasis by ethyl-4-(3-nitro)-phenyl-g-methyl-2-oxo-1,2,3, 4-tetrahydropyrimidine-5-carboxylate (Nifetepimine) : a mechanisistic approach towards cancer regression and immune rejuvenation"	01.04.2013 to 31.03.2016	Prof. P. C. Sen, DMM	1080	85,326.43	869,760.00	-	724,442.00	230,644.43
23	SERB(DST) - "Quantum entanglement & distributed quantum information processing"	21.01.2013 to 20.01.2016	Dr. Somshubhro Bandyopadhyay, Physics	1082	(57,993.00)	1,400,000.00		1,256,892.00	85,115.00
24	CSIR - "Understanding molecular mechanisms of MYMIV-resistance in Vigna mungo through genomic approach"	01.03.2013 to 29.04.2016	"Prof. Amita Pal, CSIR Emeritus Scientist,DPB"	1083	322,453.00	814,589.00		1,070,319.50	66,722.50
25	SERB(DST) FAST TRACK Scheme - "Comprehensive Gromicrobiology of two high temperature hydrothermal systems of India: Paradigms of primitive metabolisms and biogeo-chemical evolution, prospects of of biotechnoogical resource"	07.08.2012 to 06.08.2015	Dr. Wriddhiman Ghosh, Microbiology	1089	(2,534.77)	300,000.00		297,465.00	0.23
26	SERB(DST) FAST TRACK Scheme - "Design, Synthesis and mechnistic insights of novel antimicrobial peptides (AMP) using high resolution NMR spectroscopy: Role of outer membrane permeaility and DNA-binding"	14.01.2013 to 13.01.2016	Dr. Anirban Bhunia, Biophysics	1090	(508.52)	500,000.00		455,009.40	44,482.08

27	DBT - "Host phosphatases and kinases participating in CD40-induced anti-leishmanial vs. pro-leishmanial pathways"	26.03.2013 to 25.03.2016	Prof. Subrata Majumdar, DMM	1095	101,498.00	946,692.00	14,403.00	953,230.00	109,363.00
28	IITM(MoES) - "Study on biosphere-atmosphere exchange of carbon dioxide, water vapor and energy ina tropical high altitude forest canopy at Eastern Himalaya"	15.06.2012 to 31.12.2015	Dr. Abhijit Chatterjee, ESS	1097	228,627.00	1,000,000.00		420,835.00	807,792.00
29	DAE - "Production and molecular characterization somatic hybrid mushroom strains between Agaricus bisporus + Pleurotus florida and Agaricus bisporus + Calocybe indica"	11.09.2013 to 10.09.2016	Prof. S. R. Sikdar, DPB	1099	173,667.00	760,302.00	5,655.00	849,668.00	89,956.00
30	DBT - "Micro-Regulatory Networks in Leukemia Stem cells (RHYI)"	07.02.2013 to 06.02.2016	Dr. Zhumur Ghosh, B.I.C.	1105	140,559.69	923,900.00	3,806.00	1,065,132.34	3,133.35
31	DBT - " Biophysical and structural aspects of oncogenic G-Quartets bound to drugs : screeining, high resolution NMR and low resolution spectroscopy (RGYI)"	13.08.2013 to 12.08.2016	Dr. Subhrangsu Chatterjee, Biophysics	1107	(3,280.00)	606,700.00	4,383.00	717,152.00	(109,349.00)
32	DAE - "Exploration of promoters of bitechnological importance from metagenomic DNA"	24.06.2013 to 23.06.2016	Dr. Tapan Kr. Dutta, Microbiology	1110	53,443.00	797,304.00	5,648.00	798,992.00	57,403.00
33	DAE - "Studies on the binding mechanism of a global virulence regulator SarA of staphylococcus aureus"	01.11.2013 to 31.10.2016	Dr. Subrata Sau, Biochemistry	1111	69,530.40	657,408.00	5,242.00	659,435.00	72,745.40
34	DST - "Targeted delivery of nano-conjugated methylglyoxal ti cancer cells and understanding the bioenergetic difference between normal and malignant cells at the molecular level"	26.09.2013 to 25.09.2016	Prof. Manju Ray, Biophysics	1112	745,312.51	500,000.00	18,273.00	1,526,335.90	(262,750.39)
35	DBT - "In vitro study of input-output robustness of MprAB signaling pathway in Mycobacterium tuberculosis"	24.06.2013 to 23.06.2016	Dr. Suman Kr. Banik, Chemistry	1113	16,527.65	504,101.00	8,733.00	603,650.00	(74,288.35)

36	SERB(DST) - "Molecular mechanisms of HSFI mediated chromatin remodelling during transcriptional inductions of human hsp 70 by stressors"	29.07.2013 to 28.07.2016	Dr. Mahadeb Pal, DMM	1114	74,381.71	700,000.00		666,032.00	108,349.71
37	DBT - "Characterization and design of inhibitors of Mycobecterium tuberculosis transcription"	14.10.2013 to 13.10.2016	Dr. Jayanta Mukhopadhyay, Chemistry	1115	446,859.87	-	15,843.00	175,193.00	287,509.87
38	SERB(DST) - "Mapping the molecular mechanisms of resistance to apoptosis switch over of non small cell lung carcinoma by curcumin : an approach towards chemo sensitization"	01.12.2013 to 30.11.2016	Prof. Tanya Das, DMM	1116	139,262.77	800,000.00		936,758.83	2,503.94
39	MOES - "Pre-seismic geochemical monitoring continuation"	01.06.2013	Prof. Bikash Sinha	1118	(471,788.00)	471,788.00		-	-
40	CSIR - "Diagnosis of mould allergy among inhibitants of urban and rural peoples of the gangetic plains of West Bengal through aerobiological and immunochemical studies"	01.12.2013 to 30.11.2016	Prof. Swati Gupta Bhattacharya, Department of Plant Biology	1123	15,951.00	519,579.00		520,171.88	15,358.12
41	CSIR - "Investigating the role of ARID/HMG4 (Atlg04880) protein in transcription regulation of cold stress responsive genes"	01.10.2013 to 30.09.2016	Dr. Shubho Chaudhuri, DPB	1124	6,542.41	500,000.00		506,492.37	50.04
42	DBT - "Studies on the mould spore diversity as environmental allergen in outdoor and indoor environments of urban and rural areas of Agartala, Tripura"	29.01.2014 to 28.01.2017	Prof. Swati Gupta Bhattacharya, Department of Plant Biology	1125	22,863.00	764,000.00	6,822.00	759,478.00	34,207.00
43	DBT - "Studies on the efficacy of flavonoid and non-flavonoid polyphenols against chronic inflammation induced disease pathogenesis"	03.03.2014 to 02.03.2017	Dr. Kaushik Biswas, DMM	1127	142,653.72	642,000.00	11,758.00	764,490.00	31,921.72
44	DBT - "Setting up of a state-of-the-art 600 MHz FT-NMR with cryoprobe facility at Bose Institute"	01.05.2013 to 30.06.2015	Prof. Gautam Basu, Biophysics	1135	86,889,725.33	-	438,233.00	87,202,549.22	125,409.11
45	SERB- ""Functional Analysis of the DNA polymerase lambda gene and the protein from Indica Rice Cultivars"	08.07.2014 to 07.7.2017	"Prof. D. N. Sengupta, Division of Plant Biology"	1139	793,962.00	-	-	975,593.44	(181,631.44)

46	DBT-" Binning stochastic phenotypic states of cancer cell population in different color box"	02.06.2014 to 01.06.2017	"Prof. Tanya Das, Division of Molecular Medicine"	1150	3,353,290.25	1,061,200.00	139,696.00	1,284,588.09	3,269,598.16
47	DST- "ALICE - A Large Ion Collider Experiment (ALICE) upgrade, operation and utilization"	10.07.2014 to 31.12.2019	"Prof. Sibaji Raha, Department of Physics"	1154	9,546,651.00	442,296.00	-	5,808,026.00	4,180,921.00
48	"CSIR - ""Phenotypic heterogeneity in cell populations: A search for physical principles""	01.09.2014 to 31.08.2017	"Prof. Indrani Bose, CSIR Emeritus Scientist Department of Physics"	1163	318,190.00	240,000.00	-	290,612.00	267,578.00
49	CSIR - "Understanding the evolutionary origin and mechanism of action of a putative primase-polymerase encoded by the mycobacterial plasmid pAL5000"	01.10.2014 to 30.09.2017	"Prof. Sujoy K. Das Guptata, Department of Microbiology"	1165	143,150.00	952,260.00	-	1,022,984.00	72,426.00
50	"SERB - ""Investigating the genome wide changes in Histone H3K27 acetylation and gene expression in rice during cold stress"	01.09.2014 to 31.08.2017	"Dr. Shubho Chaudhuri, Division of Plant Biology"	1168	543,673.80	700,000.00	-	1,007,425.05	236,248.75
51	CSIR - "Exploring membrane-associated NAC-transcription factors (NAC MTFs) in tomato to apprehend membrane mediated signaling during pathogenesis"	01.10.2014 30.09.2017	"Dr. Pallob Kundu, Division of Plant Biology"	1171	133,933.00	366,067.00	-	418,382.00	81,618.00
52	DBT - "Understanding the role of tumor derived glycosphingolipids in carcinogenesis : An invivo approach"	12.11.2014 to 11.11.2017	"Dr. Kaushik Biswas, Division of Molecular Mediciine"	1172	1,232,574.00	842,000.00	23,684.00	2,024,786.57	73,471.43
53	DBT - "Raf1 quality control and development of pathophysiological conditions"	01.11.2014 to 31.10.2017	"Dr. Atin Kr. Mandal, Division of Molecular Medicine"	1173	2,337,698.00	-	48,953.00	2,317,276.59	69,374.41
54	DAE - "The role of the secreted antigen Rv0009 pf Mycobacterium tuberculosis in modulating signaling in macrophages"	24.10.2014 to 23.10.2017	Prof. Joyoti Basu, Chemistry	1174	236,519.00	872,660.00	17,744.00	1,057,041.03	69,881.97
55	CSIR - "Investigation of the archaeal diversity and activity in Sundarbans mangrove sediment, India"	01.01.2015 to 31.12.2017	"Dr. Abhrajyoti Ghosh, Department of Biochemistry"	1177	666,545.00	584,675.00	-	1,089,810.00	161,410.00
56	DBT - "Identification and characterization of micro RNAs (miRNAs) in Penaeus monodon"	24.03.2015 to 23.03.2018	"Prof. Nripendranath Mandal, Division of Molecular Medicine"	1180	1,735,800.00	-	40,753.00	1,555,464.00	221,089.00

57	"ICMR - "Systematic discovery of biomarkers of asthma caused by common environmental allergens using human plasma proteomics, cytokine profiling and network biology - aystem approach to drug discovery"	01.03.2015 to 28.02.2018	"Prof. Swati Gupta Bhattacharya, Department of Plant Biology"	1184	-	1,693,900.00	-	1,584,216.30	109,683.70
58	DBT - "TLR2-dependent engagement of the host cell kinases and phosphatases that dictate disease progression or resolution	30.1.2015 to 29.01.2017	"Prof. Subrata Majumdar, Division of Molecular Medicine"	1192	-	3,020,000.00	76,898.00	2,759,772.00	337,126.00
59	DBT-WB-Assessment of Plant Growth Promoting Bacteria in the Mangrove Rhizosphere and evolution of Plant Growth Promotion Activity on Rice (Oryza sativa)	01-04-2015 to 31-03-2018	"Dr. Abhrajyoti Ghosh, Department of Biochemistry"	1185	-	1,285,840.00	31,836.00	1,149,960.85	167,715.15
60	DST-SERB-Regulation of the mycobacterial stress response by the two-component system SenX3-RegX3 in *Mycobacterium tuberculosis*	03-06-2015 to 02-06-2018	Prof. Manikuntala Kundu, Department of Chmistry	1191	-	1,600,000.00	-	1,414,867.78	185,132.22
61	DBT-NWO-Unravelling the role of PLC in plant drought and heat stress tolerance: Exploring the potential of PI metabolism to improve crop yield	02-09-2015 to 01-09-2018	Prof. A. N. Lahiri Majumder, Division of Plant Biology"	1199	-	6,379,200.00	140,925.00	711,133.00	5,808,992.00
62	DOS-Astrophysical S-factor from nuclear reactions with a rare isotope beam ^{7}Be	06-08-2015 to 05-08-2018	Dr. Dhruba Gupta, Department of Physics	1200	-	1,845,000.00	-	424,576.00	1,420,424.00
63	DBT-PILOT-Role of c-Jun N-Terminal Kinase (JNK) in tumor derived soluble factor mediated T cell apoptosis	29-07-2015 to 28-07-2018	Dr. Kaushik Biswas, Division of Molecular Mediciine	1201	-	1,170,000.00	17,722.00	1,143,118.00	44,604.00
64	DST-SERB-Molecular characterization of developed DNA markers linked to disease resistance/susceptibility in giant blacktiger shrimp, Penaeus monodon	18-12-2015 to 17-12-2018	Prof. N. Mandal, Division of Molecular Mediciine	1218	-	2,720,000.00	-	906,918.00	1,813,082.00
65	DST-SERB-miR-325: A distinct micro - RNA that controls T- regulatory cell development and function	28-10-2015 to 27-10-2018	Prof. Gaurisankar Sa, Division of Molecular Medicine	1222	-	2,500,000.00	-	1,744,743.31	755,256.69

66	DST-SERB-NANO-Development of nano-particle-based directed delivery system for peptide therapeutics	03-12-2015 to 02-12-2018	Prof. Siddhartha Roy, Dept. of Biophysics	1223	-	9,666,000.00	-	2,455,737.36	7,210,262.64
67	MOES-Vertical profiling of the sedimentary microbiome of the Arabian sea OMZ with special reference to carbon and sulfur cycles		Dr. Wriddhiman Ghosh, Dept. of Microbiology	1224	-	880,000.00	-	879,964.00	36.00
68	DST-SERB-Development of Synthetic Transcription Factors against pluripotency to Target Cancer Stem Cells	15-01-2016 to 14-01-2019	Prof. Siddhartha Roy, Dept. of Biophysics	1228	-	3,205,098.00	-	541,500.00	2,663,598.00
69	CSIR-Synthesis of Oligosaccharide Fragments Correspnding To Salmonella Strains and Their Use in the Preparation of Glycoconjugate Derivatives	01-01-2016 to 31-12-2018	Prof. Anup Kumar Misra, Division of Molecular Medicine	1232	-	75,000.00	-	74,676.00	324.00
70	DST-SERB-Evaluating the sensor kinase MtrB of Mycobacterium tuberculosis as a regulator of bacterial physiological responses, and as a potential target for therapy	19-03-2016 to 18-03-2019	Prof. Joyoti Basu, Dept. of Chemistry	1244	-	2,070,000.00	-	-	2,070,000.00
71	DST-Synthesis of the polysaccharide fragments of Streptococcus pneumoniae strains for the preparation of glycoconjugate derivatives	09-10-2015 to 08-10-2018	Prof. Anup Kumar Misra, Division of Molecular Medicine	1248	-	563,333.00	-	563,325.00	8.00
72	DBT-Identifying Systems-level Cellular Networks Involved in Neurotropic Flavi Virus- Host Interaction	07-07-2015 to 06-07-2018	Dr. Sudipto Saha, B.I.C.	1257	-	40,000.00	-	32,951.00	7,049.00
73	Welcome Trust & DBT India Alliance - "Award of Intermediate Fellowship to Dr. Smarajit Polley	01-02-2016 to 31-01-2021	Dr. Smarajit Polley, Dept. of Biophysics	P-1231	-	15,396,428.00	102,198.00	133,320.00	15,365,306.00

99th Foundation Day Celebrated





The 99th Foundation Day of Bose Institute was celebrated on November 30, 2015. **Dr. Thirumalachari Ramasami**, Former Secretary to the Government of India, Department of Science and Technology, New Delhi graced the occasion as the Guest of Honour and delivered the 77th Acharya Jagadis Chandra Memorial Lecture on **Living by Legacy, Leadership and Legendary of Acharya J.C. Bose: India's Challenge.** Prof. Bikash Sinha, Chairman, Bose Institute Council, presided over the programme. Prof. Sibaji Raha, Director, Bose Institute, delivered the Welcome Address and presented the Institute Report. Sir Nilratan Sirkar Prize 2015 was awarded to Ms. Amrita Bhattacharjee, Senior Research Fellow, (Under Prof. Subrata Majumdar) Division of Molecular Medicine and Ms. Shreya Ghosh, Senior Research Fellow, (Under Prof. Sujoy Kr. Das Gupta) Department of Microbiology. Prof. B. B. Biswas Outstanding Student Award 2015 was presented to Mr. Barun Mahata, Senior Research Fellow, (Under Dr. Kaushik Biswas) Division of Molecular Medicine.





Acharya Jagadis Chandra Bose,(*in the year*1900)

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