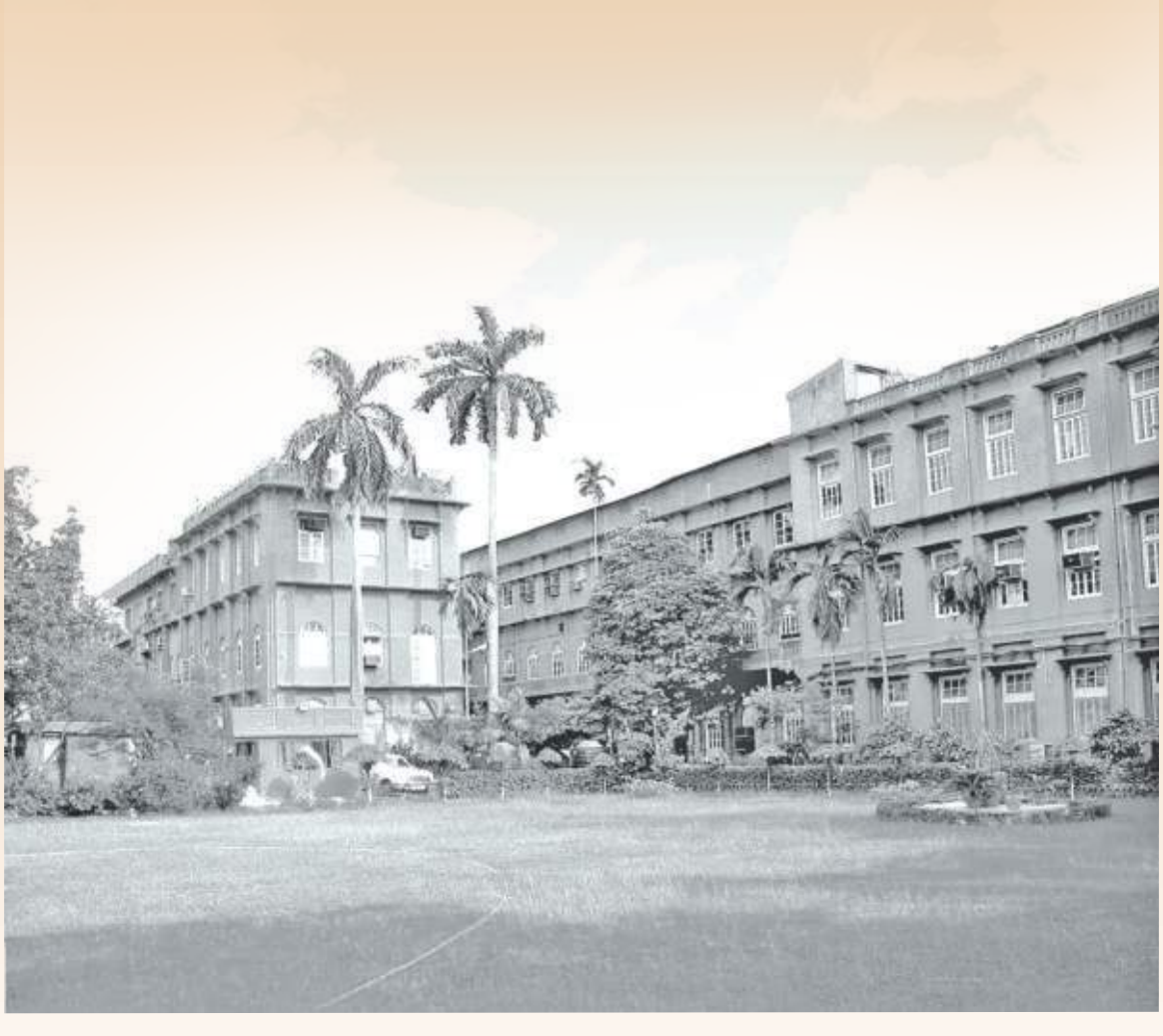
ANNUAL REPORT OF BOSE INSTITUTE

2017-2018



BOSE INSTITUTE
Kolkata

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Published by :
Registrar, Bose Institute

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Printed by :
CALCUTTA GRAPHICS PVT. LTD.
3B, Maniktala Industrial Estate, Ultadanga, Kolkata-700 054
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Contents

101th Foundation Day Celebrated

The 101th Foundation Day of Bose Institute was celebrated on November 30, 2017. **Prof. Ada Yonath**, Department of Structural Biology, Weizmann Institute, Rehovot 76100, Israel and recipient of the Nobel Prize in Chemistry in 2009 delivered the **79th Acharya J.C. Bose Memorial Lecture** on "**Next Generation Environmental Friendly Antibiotics".** Prof. Bikash Sinha, Chairman Bose Institute Council presided over the programme. Prof. Siddhartha Roy, Director (Officiating), Bose Institute, delivered the Welcome Address and presented the Institute Report. Sir Nilratan Sirkar Prize 2017 were awarded to Ms. Shamila Sarwar, (Under Under Prof. Pinakpani Chakrabarti) Department of Biochemistry and Mr. Junaid Jibran Jawed, (Under Prof. Subrata Majumdar) Division of Molecular Medicine. Prof. B. B. Biswas Outstanding Student Award 2017 was presented to Mr. Asif Ali (Under Dr. Mahadeb Pal) Division of Molecular Medicine.

From the Director's Desk

I am delighted to present the Annual Report of Bose Institute for the period 1st April, 2017 to 31st March, 2018. The year 2017 was an eventful one for all of us as we celebrated the centenary of our Institute in a befitting manner by organizing symposia, lectures and outreach programs. We consider ourselves privileged that two presidential visits took place in 2017 in connection with our centenary celebrations. First Shri Pranab Mukherjee, the then Hon'ble President of India, visited and inaugurated our new campus at sector V, Salt Lake, on the 29th of June 2017. Subsequently, the current Hon'ble President Shri Ram Nath Kovind paid a visit to our heritage campus at Rajabazar and delivered the closing ceremony address on November 29th 2017.

On behalf of all members of Bose Institute I would like to express my gratitude to the Department of Science and Technology, Govt. Of India, for financially supporting not only our regular research activities but also the construction of the Unified Academic Campus. I believe that with the creation of the campus, interdisciplinary research activities at Bose Institute will receive a major boost as all the departments and centres will now find a place under the same roof. I acknowledge the contribution made by the implementing agencies, their engineers and architects, and last but not the least, the workers who toiled day and night to create this beautiful building. I am also grateful to the various agencies of the Govt of West Bengal, which includes the Nabadiganta Industrial Township Authority (NDITA), the State Electricity Distribution Company limited (WBSEDCL) and the Fire and Emergency services department, for their cooperation at various stages during the construction of the building.

Bose Institute celebrated the 100th year of its existence last year. A series of conferences, lectures workshops were held which were attended by eminent scientists and personalities from all over the globe. I congratulate all staff members of Bose Institute and of course our dear students, for their tireless efforts towards ensuring the success of the celebration. The events organized were not merely aimed at celebrating the achievements of the past, but also to prepare a road map for the future. Of the many symposia organized, two – namely, 'The History of Science' and the 'Future of Science' were hugely popular. So was the one organized by the Bose Institute Alumni Association, on the seminal contribution made in various areas of research and teaching by the alumni of this Institute.

During the centenary year we had the opportunity to upgrade our facilities through the purchase of several sophisticated equipment such as mass spectrometers, Next Generation Sequencer (NGS) and protein purification systems. The centenary year saw several new collaborative programs emerging which includes SyMeC (Systems Medicine Cluster), with the National Institute of Biomedical

Genomics (NIBMG), and the Indo-UK collaboration program on freshwater management. Needless to say, the Institute continues to contribute significantly to the generation of scientific knowledge as will be evident from the details given in the pages that follow. We are very proud of the fact that Bose Institute has been able to not only retain its multidisciplinary character, but also promote it by consistently publishing in internationally acclaimed journals in diverse areas in the domains of both life science as well as physical sciences.

Despite our outstanding performance in the past, there is scope for improvement. In recent years there has been a steady decline in the faculty strength, due to superannuation of many of our senior members. Currently the faculty strength has hit an all time low, which would go down further in the coming years if not months. The need of the hour is to recruit young and dynamic faculty members, particularly those who are conversant with new and emerging technologies. At the same time the research infrastructure will have to be upgraded further, in order to remain competitive at the national as well as international levels. The Institute will have to plan for new projects, keeping in mind the national priorities as well as the vision of our founder. The administrative infrastructure has to be immediately revamped through the implementation of e-governance as well as paperless transaction procedures. Such ventures would require not only increased funding, but additionally determination and resolve on the part of all members of Bose Institute.

We have to keep in mind that the mission of our Institute is not to just perform scientific research at the highest level but also ensure that the knowledge accrued is disseminated among the general public, particularly the student community. In this area we are fortunate that our Institute has already created a niche through the introduction of several programs such as the North East Students Summer Training on Basic Sciences (NESST BASE). The Scheduled Tribe Specific Rural Biotechnology Program is another such program that has gained substantial recognition and popularity over the years. Last but not the least, one has to mention the success of J.C. Bose Centre, which houses a collection of the instruments used by Acharya J.C. Bose for his research. The centre has become extremely popular among school students and teachers who make frequent visits to learn about the life and works of our founder. It is our duty to ensure that these programs are not only sustained but are also regularly upgraded and expanded.

The challenges that exist are manifold. It is up- to the younger generation of faculty members to rise to the occasion and meet these challenges. This being the 101st year of our existence, it is important that we plan ahead and with due diligence, so that years down the lane we can look back on these days with a sense of pride and satisfaction.

Prof. Sujoy Kr. Das Gupta
Director (Officiating)
Bose Institute, Kolkata
09/10/18

BOSE INSTITUTE

Established : 30th November, 1917

Introduction

Bose Institute was founded by Acharya Jagadis Chandra Bose in 1917 for the advancement of science and dissemination of knowledge. In his foundation day speech the Acharya declared that **"I dedicate today this Institute – not merely a laboratory but a temple".** Thus, our Institute is also known as the Vigyan Mandir or Temple of Science. The vision that our founder had while establishing this Institute is amply clear from the lines that he spoke while founding this Institute:

"Thus the lines of physics, of physiology and psychology converge and meet. And here will assemble those who seek oneness amidst the manifold".

All research programs therefore have interdisciplinary components and collaborations are encouraged. Last year the Institute celebrated 100 years of its existence by holding seminars, discussions and other programs. As a part of the centenary celebration, the Unified Academic Campus was inaugurated by the then Hon'ble President of India, Shri Pranab Mukherjee, on July 29th, 2017. The foundation day celebration concluded with the current Hon'ble President of India Shri Ram Nath Kovind delivering the closing ceremony address at the historic auditorium of the Institute located in our main campus at Rajabazar.

In the beginning, there were only three major departments: Physics, Chemistry and Botany. All the three continue to exist, but with the passage of time many new departments, divisions and centers have evolved. The pursuit of science is a dynamic process and therefore as and when new disciplines emerged changes had to be made in the departmental structure. At present we have four departments: Physics, Chemistry, Microbiology and Biophysics. In addition, there are two divisions: Plant Biology and Molecular Medicine. Also we have three centers named as Center for Astroparticle Physics, the Madhyamgram Innovation Center and finally the Bioinformatics Center. There are currently seven institutional programs, as mentioned below. Each faculty member is associated with at least one of these programs, if not more. There are plans to develop new programs and modify the existing ones as per necessity. The areas of research broadly cover Plant Sciences, Structural Biology, Molecular Biology, Biomedical Sciences, Biotechnology, Quantum Mechanics, Astrophysics and Condensed Matter Physics.

The Institute provides financial and infrastructural support to its faculty members in various forms. The Central Instruments Facility harbors all the major equipments necessary for performing research in the

areas of chemical, physical and biological Sciences. This facility is used not only by the in house scientists, but also by scientists and research scholars from several neighboring institutes and universities. The other facilities that are available at Bose Institute are: a) the translational animal research facility located at the Madhyamgram campus, b) a state-of-the-art workshop capable of designing and fabricating instruments for biological as well as physical research, c) a well stocked and fully digitized library having a huge collection of old and new journals and d) the J.C. Bose museum which houses the original as well as replica versions of several equipments that our founder used in his life time.

The Institute has different campuses, located not only in the city of kolkata but also at various other places within West Bengal. The Main Campus, which is a heritage building, is located at Rajabazar. Most of the research activity goes on in the Centenary Building of the campus located at Kankurgachi. The administrative block is also located here. Research in Astroparticle Physics is carried out at the Salt Lake (Sector V) Campus. The sprawling Unified Academic Campus has been built within the precincts of this campus. Very soon this campus will be the major hub for all activities of the Institute including research, teaching and administration. The Madhyamgram and Falta campuses function as experimental farms. The Falta campus is the nerve center for the S&T Rural Development related project. The Darjeeling campus located at Mayapuri is where research in the area of high altitude physics is performed. Experiments related to Astroparticle physics and Atmospheric sciences are also performed here. The Shyamnagar campus is being developed for a variety of purposes which include the development of various Gas Electron Multiplier (GEM) based detectors.

Teaching and Training programs

Teaching is considered to be an integral part of Bose Institute's activities. Our faculty members teach in the M.Sc-PhD course that the Institute conducts every year in collaboration with Calcutta University. The Institute also conducts an orientation program for the students pursuing research at the Institute. In this program the students are made aware of various research related issues such as lab safety, ethics, societal responsibilities and research methodologies. Dissemination of scientific knowledge is one area in which Bose Institute lays considerable stress. Every year school children from North East India assemble at the Darjeeling campus to learn the basics of physics, chemistry and biology. The basic idea of holding these meetings is to imbibe a sense of curiosity in the minds of the young generation and thus motivate them to take up research as a full time career. The Rural Biotechnology Centre at Falta has been developed to provide the knowhow of basic biotechnology to the rural people to improve their socio-economic status.

The eminence of Bose Institute's scientific research, spanning a wide range of disciplines, is evident from the large number of research publications in competitive peer reviewed international and national journals, and from 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. Every year, a number of our scientists and research scholars participate 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 programs

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:

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**

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. Vacant
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
4. Shri Swami Atmapriyananda

Two eminent and active scientists in the area of research pursued in B.I. nominated by the Governing Body. They may not necessarily be members of the Governing Body.

5. Prof. MRS Rao
6. Prof. JP Khurana

} Two eminent and active Scientists to be nominated by the DST

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

133rd Birthday Celebration of Prof. Debendra Mohan Bose

The 133rd Birthday of Prof. Debendra Mohan Bose was celebrated on November 26, 2017, at the Main Campus Lecture Hall of the Institute. **Prof. Ram Ramaswamy**, Professor & Concurrent Faculty, School of Computational and Integrative Sciences, Jawaharlal Nehru University, New Delhi – 110 067, graced the occasion as Guest of Honour and delivered the **D. M. Bose Memorial Lecture** on the topic **"Chimera States: Spontaneous Symmetry-Breaking in Dynamical Systems".**

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

Participation in Institutional Project I

Dr. Samir Ranjan Sikdar (Coordinator), Dr. Debabrata Basu, Dr. Swati Gupta Bhattacharya, Dr. Gaurab Gangopadhyay, Dr. Pallob Kundu, Dr. Shubho Chaudhuri, Dr. Anupama Ghosh,

Dr. A.N. Lahiri Majunder, INSA Senior Scientist, Dr. Sampa Das, INSA Senior Scientist, Dr. Amita Pal, Sr. Professor, UGC Emeritus Scientist, Dr. D. N. Sengupta (Guest Scientist) Dr. Swati Sen-mandi (Emeritus Medical Scientist)

Project Scientists: - Dr. Swagata Ghosh (DST Women Scientist), Dr. Rajeswari Mukherjee (DBT RA/BIO-CARE), Dr. Subha Das (SERB/DST Young Scientist), Dr. Akansha Jain (SERB/DST Young Scientist), Dr. Priyanka Das (SERB/DST Young Scientist), Dr. Supriyo Chowdhury (DBT-RA). Dr. Sudip Saha (NPDF). Dr. Arpita Basu Chowdhury (NPDF).

Introduction

Genetic factors associated with plants stress responses and development havebeen integrated with transcriptomics and proteomics toexplore many unanswered questions linked with the crop productivity as well as resource management. In this connection, networking of the response regulating genes and its modulating factors which are interfacing between the perceptions of environmental signals and translating that with the expression of traits has endeavoured. The major outcome of significance is deciphering of functions of a number of novel molecular factors during the biotic and abiotic stresses of crops like rice, mustard, tomato, sesame, mungbean and chickpea using state of the art technology.

Dr. Debabrata Basu

Professor

Scientific Reports

Deciphering the role of NAC domain transcription factors on the resistance against 'Black Spot' disease-causing *Alternaria brassicicola* : *in collaboration with Banani Mondal*

Oilseed *Brassicas* are the second most important oilseed crop in India. In this context, *Alternaria brassicicola* is a major threat to the production of oilseed mustard with special reference to *Brassica*

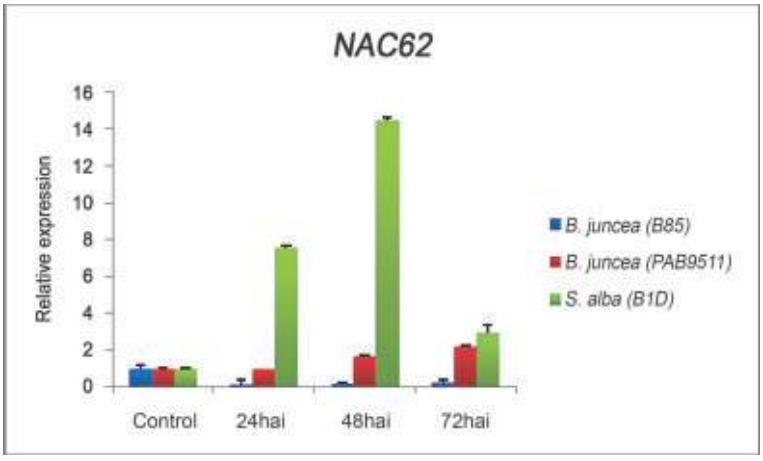


Fig:1. **Expression pattern of *NAC62*** by quantitative real-time PCR in *B. juncea* (B85, PAB9511) and *S. alba* (B1D) upon infection with *A. brassicicola* in different time points, 24hai (hours after inoculation), 48hai and 72hai.

juncea (Indian mustard) which is the predominantly grown oilseed crop in India. The disease caused by this fungal pathogen is called 'Black Leaf Spot' disease and no source of resistance is available in the *Brassica* germplasm. Therefore, the non-host resistance mechanism of *Sinapis alba,* a close relative of *B. juncea* is of prime importance to protect this oilseed crop from this disease. Role of Abscisic acid (ABA) in resistance response against this pathogen has been already establishedfrom our laboratory. In this connection, NAC transcription factors (NAC TFs) are of great importance since many members of this gene family have been identified to be involved in ABA-mediated abiotic and biotic stress responses. In this study, we have taken a Next Generation Sequencing (NGS) based comparative transcriptomic approach to identify the differentially regulated NAC TFs upon challenge with *A. brassicicola* in susceptible *B. juncea* and resistant *S. alba*. 21 NAC TFs were identified from the transcriptome data. A cluster analysis using the protein sequence of NAC domains of the identified NAC TFs indicated that well-representedNACs belong to the class of stress-responsive NAC genes in *Arabidopsis thaliana*. Expression pattern of some selected NAC genes was also monitored under different phytohormone, and abiotic stress treatments and it indicated that the majority of the NAC TFs were either ABA or JA responsive. Induction pattern of these selected NAC TFs was further checked in the partially tolerant accession of *B. juncea* (PAB9511) along with susceptible accession of *B. juncea* (B85) and resistant *S. alba* (B1D) upon challenge with the *A. brassicicola*.One of the members in this class NAC62 exhibited upregulation only in *S. alba* upon infection, but not in the susceptible plants.NAC62 is a membrane-bound protein,and the truncated form

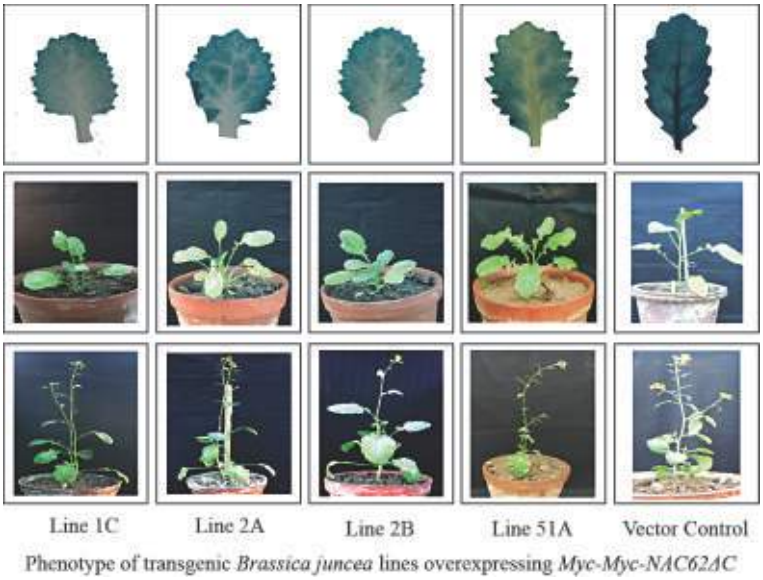


Fig: 2. Phenotypic changes in transgenic B. juncea expressing NAC62ΔC: At initial stages of development the T0 transgenic B. junceaplants showed dwarf phenotype when compared with the vector control plants. Inlatter stages ofdevelopment the plants did notshow prominentdwarf phenotype rather they appear normal when compared to vector controlplants.T1transgenic lines also showed dwarf phenotype and stunted growth compared to the vector control plants.

NAC62ΔC (devoid of the transmembrane domain) is an active form was overexpressed in susceptible *B. juncea* (B85) with a double C-Myc tag.Transgenic *B. juncea* expressing NAC62ΔC, showed the altered phenotype.

Identification of the chitin receptors in resistance response against *A. brassicicola*: *in collaboration with Aishee De*

Receptors are extremely important for recognition of pathogens by plants. In this connection, five differentially expressed LYKs, LYK1, LYK2, LYK3, LYK4 and LYK5 were identified which are downregulated/unchanged in susceptible *B. juncea* (B85) whereas upregulated in resistant *S. alba*. Through deletion of 5'end of the promoter of LYK4, one of the highly upregulated receptor in resistant *S. alba*compared to *B. juncea* on interaction with *A. brassicicola*, have resulted in the identification of a number of chitin responsive motifs, WRKY motifs as well as hormone responsive motifs in the promoter region. On the other hand, transient expression of LYK4 in *B. juncea* and *S. alba* indicate induction of JA responsive genes. In addition to that, the protein-protein interaction between LYK1 and LYK4 both *in-vivo* and *in-vitro* is under process since it has been reported that LYK1 and LYK4 interaction is required for downstream signalling.

Publications

1. Debnath A J, Gangopadhyay G, Basu D and Sikdar S R (2018) An efficient protocol for *in vitro* organogenesis of *Sesamum indicum* L. using cotyledon as explants. 3 *Biotech* 8:146 (https://doi.org/10.1007/s13205-018-1173-7) Impact Factor 1.361 (2017)
2. Sefa P, Mazumder M , Bhattacharya A, Mukhopadhyay S, Saha U, Mukherjee A, Mondal B, Jyoti Debnath A, Das S, Sikdar , S and Basu D (2018) Identification of Anther-Specific Genes from Sesame and Functional Assessment of the Upstream Region of a Tapetum-Specific β-1,3-glucanase Gene. *Plant Molecular Biology Reporter*, Volume 36, Number 2, 149-161.https://doi.org/10.1007/s11105-017-1054-y IF: 2.1 (2017)

Grants-in-Aid Schemes:

Title of the Scheme	Scheme funded by
Development of High Yielding, Non-lodging and Biotic Resistant Varieties of Black Scented Rice of Manipur and Joha Rice of Assam through Biotechnological Intervention	DBT's Scented Rice program for North- East

Dr. Shubho Chaudhuri

Associate Professor

Scientific Reports

Epigenetic regulations during plants response to different environmental or developmental stimuli

Investigating the role chromatin Architectural protein in modulation of chromatin structure *in planta*

This project deals with characterization of a novel class of HMG-box domain containing protein: ARID/HMG. The unique feature of these plant specific proteinsare the presence of two DNA binding domain in their primary structure: AT-rich interaction domain (ARID) and HMG box domain (HMG). ARID domain and HMGB-box domain were known to behave as the architectural proteins in higher eukaryotes. Biochemical characterization from our group [**Plant Molecular Biology. (2016) 92(3), 371-388**] has shown that ARID/HMG can bind to DNA having different topological structures that includes linear DNA, supercoiled form and mono-nucleosome.

AtHMGB15 (At1g04880) which belongs to ARID/HMG protein family from Arabidopsis, shows highest expression in young and mature flowers. Sub-cellular localization shows that AtHMGB15 was majorly found in the nucleus, however some portion of the protein was also found in the cytosol. Knockout mutant of AtHMGB15 shows mutant pollen morphology and retarded pollen tube germination. A comparative transcriptome between wild type and *athmgb15*shows 1581genes were upregulated and 1595 genes down regulated. Bioinformatics analysis has also indicated that a significant number of genes that are affected due to *AtHMGB15* mutation belong to pollenthereby suggesting its rolein flower development pathway.

In an attempt to know the biological function of ARID/HMG proteins we took approach to find its interacting partners by screening yeast-2-hybrid library made from Arabidopsis seedlings. Initial screening shows some interacting partners of ARID/HMG protein. One of the interacting protein AtATL79 shows homology with the member of RING-H2 family proteins. Sequence analysis of the RING domain of AtATL79 indicate the presence of conserved six Cys and two His residue that coordinate two Zn^{+2} ions. AtATL79 is a membrane-bound protein that colocalises with AtHMGB15 in the nucleus. Moreover, AtHMGB15 was found to be polyubiquitinated by AtATL79 both *in vitro* and *invivo*. Our results suggest that theUb/26S proteasome system regulates cellularAtHMGB15 protein levelin different tissues of *Arabidopsis*to regulate the spatio-temperal activity of the protein.

To gain insight into the genome-wide targets of AtHMGB15 and to understand the possible role of AtHMGB15 in chromatin remodelling in during cold stress a ChIP-chip approach was undertaken.The result revealed AtHMGB15 is associated with 5913 loci under control condition, 5246 loci under cold stress 2hrs, 1936 lociunder cold stress 12hrs and 934 lociunder cold stress 24hrs,within the *Arabidopsis* genome. The distribution of the binding sites showed that AtHMGB15 bound to the promoters, within the coding regions and to the downstream regions of genes. Majority of the bound DNA had a higher AT nucleotide content and fit to a consensus motif. Target genes implicated in transcription, chromatin remodeling, cellular processes, and hormone metabolism were enriched. Our results provide a resource for investigating function and possible other general activities of AtHMGB15.

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

Emerging evidence has shown that epigenetic modifications (Histone modifications and DNA methylation) play an important role in the expression of stress responsive genes. Expression analysis

indicates that the OsBZ8 gene is highly induced in Nonabokra plants even in the absence of salt stress, whereas in IR64, the expression significantly increases only during salt stress. Sequence analysis and nucleosomal arrangement within the region −2000 to +1000 of OsBZ8 gene show no difference between the two rice varieties. A comparative study of epigenetic landscape at the OsBZ8 locus of two rice cultivars: Salt sensitive IR64 and Salt tolerant Nonabokraindictaes considerable difference in histone modifications and DNA methylation at the locus between these varieties. In Nonabokra, the upstream region was hyperacetylated at H3K9 and H3K27, and this acetylation did not change during salt stress. However, in IR64, histone acetylation was observed only during salt stress. Moreover, the upstream region of OsBZ8 gene has highly dynamic nucleosome arrangement in Nonabokra, compared to IR64. Furthermore, loss of DNA methylation was observed at OsBZ8 locus in Nonabokra control plants along with low H3K27me3 and high H3K4me3. Control IR64 plants show high DNA methylation and enriched H3K27me3. Collectively these results indicate a significant difference in chromatin modifications between the rice varieties that regulates differential expression of OsBZ8 gene during salt stress **[Plant Molecular biology 2017, 95 (1-2), 63-88]**

Co-ordinated interplay between Polycomb group (PcG) and Trithorax group (TrxG) chromatin proteins regulates the spatiotemporal expression of target genes in higher eukaryotes. Targeting PcG complex to a specific locus is mediated by DNA sequences known as Polycomb response elements (PREs). Interestingly, PREs are also recognition motifs for the TrxG complex; which are involved in gene activation by antagonisingPcG mediated repression. In this study, we have characterised DNA binding property of plant trithorax factor Ultrapetala (ULT1). Sequence analysis of rice ULT1, OsULT1 (Os01g0780800) shows the presence of SAND domain and B–box motif that has the Zinc binding site. DNA binding studies show that OsULT1 binds to thepromoter region of *OsDREB1b* gene at the putative PRE-motif5'GAGAG3'. The DNA binding specificity of OsULT1 protein was mostly contributed by the SAND domain. 5'GAGAG3' is the recognition sequence for GAGA factor (GAF), Pipsqueak (Psq) as well as one of the major site for PRC2 protein FIE occupancy. Interestingly, the rice ULT1 was found to be upregulated in response to environmental cues suggesting its involvement in the transcriptional regulation of stress responsive genes. These results collectively suggest that synchronise interaction between PcG and TrxG complex for PRE/TRE element is evolutionarily conserved mechanism throughout the kingdoms to mediated gene regulation.

Publications

1. Paul A, Dasgupta P, Roy D, Chaudhuri S (2017) Comparative analysis of Histone modifications and DNA methylation at OsBZ8 locus under salinity stress in IR64 and Nonabokra rice varieties *Plant Molecular Biology*, 95 (1-2), 63-88.
2. Patel A, Dey N, Chaudhuri S, Pal A (2017) Molecular and biochemical characterization of a *Vigna mungo* MAP kinase associated with Mungbean Yellow Mosaic India Virus infection and deciphering its role in restricting the virus multiplication. *Plant Science* 2017, 262, 127-140.
3. Sihi S, Maiti S, Bakshi S, Nayak A, Chaudhuri S, Sengupta DN (2017) Understanding the role of DNA polymerase λ gene in different growth and developmental stages of Oryzasativa L.

indica rice cultivars. *Plant Physiology and Biochemistry* 120, 156-168.

4. Yashvardhini N, Bhattacharya S, Chaudhuri S, Sengupta D N (2017) Molecular characterization of the 14-3-3 gene family in rice and its expression studies under abiotic stress. *Planta*, 247 (1) pp 229–253.

Students awarded Ph.D.

Name of the Student (University/Year)	Title of the thesis
Adrita Roy (C.U, 2017)	Investigating the role of ARID/HMG: a novel plant specific high mobility group protein, in plant chromatin remodeling

Grants-in-Aid Scheme

Title of the Scheme	Scheme funded by
*(With Prof ANL Majumber as PI)*Unraveling the role of PLC in plant drought and heat stress tolerance: Exploring the potential of PI metabolism to improve crop yield.	DBT-NOW

Dr. Sampa Das

INSA Senior Scientist

Scientific Reports

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

The important pulse crop chickpea suffers from various biotic and abiotic stresses. Comparative transcript profiling experiments on resistant and susceptible chickpea genotypes,WR315 and JG62, respectively identified several defense related genes, enzymes, transcription factors responsible for resistance response against Foc1.

Among several defense related transcription factors, WRKYs constitute a largeTF family serving several biological functions in plants. However, very little information are available about immune responsive role of WRKY TFs in chickpea. Upon challenging with Foc1, expression profile of WRKY TFs were monitoredin two contrasting genotypes, WR315 and JG62. Along with several other TFs , WRKY40 wasfound to be abundantly expressed in resistant plants and WRKY70 in susceptible plants.MAP Kinase 4 plays a crucial role here to directly interact and phosphorylate WRKY40 and activate defense response in resistant genotype.Several transient and co transfection assay based experiments detected that WRKY70 suppresses the expression of WRKY40 and induces susceptibility in chickpea.

Additionally we explored the functional characteristics and regulation of another novel homeodomain- Leucine Zip containing HD-Zip (I) transcription factor from chickpea, *CaHDZ12,* in response to water-deficit and salt-stress conditions. Transgenic tobacco lines overexpressing *CaHDZ12* exhibited improved tolerance to osmotic stresses and increased sensitivity to abscisic acid (ABA). Transgenic lines were found to be more robust compared to the wild-type plants under drought and salinity stress. Also in *CaHDZ12* overexpressing transgenic chickpea plants, expression of several stress-responsive genes was found to be significantly induced. Silencing of *CaHDZ12* in chickpea resulted in increased sensitivity to salt and drought stresses. Analysis of different promoter deletion mutants identified *CaWRKY70* transcription factor as a transcriptional regulator of *CaHDZ12* expression. *in vivo* and *in vitro* interaction studies detected an association between Ca*WRKY70* and *CaHDZ12* promoter during stress responses. Epigenetic modifications underlying histone acetylation at the *CaHDZ12* promoter region play a significant role in stress-induced activation of this gene. The present study describes a crucial and unique mechanistic link between two distinct transcription factors, WRKY70 and HDZ12 in regulating plant adaptive stress response.

Publications

1) Bhar A, Chatterjee M, Gupta S and Das S (2018) Salicylic Acid Regulates Systemic Defense Signaling in Chickpea During Fusarium oxysporum f. sp. ciceri Race 1 Infection, *Plant Molecular Biology Reporter* 36:162-175DOI :10.1007/s11105-018-1067-1[Impact Factor 1.932].

2) Chakraborty J, Jain A, Mukherjee D, Ghosh S and Das S (2018) Functional diversification of structurally alike NLR proteins in plants.*Plant Science* 269:85-93, DOI 10.1016/j.plantsci.2018.01.008 [Impact Factor 3.437].

3) Das A, Ghosh P and Das S (2018) Expression of Colocasia esculenta tuber agglutinin in Indian mustard provides resistance against Lipaphis erysimi and the expressed protein is non-allergenic *Plant Cell Reports*37849–863, doi.org/10.1007/s00299- 018-2273-x [Impact Factor 3.071].

4) Sen S, Chakraborty J, Ghosh P and Das S Chickpea (2017) WRKY70 Regulates the Expression of a Homeodomain-Leucine AQ1 Zipper (HD-Zip) I Transcription Factor CaHDZ12, which Confers Abiotic Stress Tolerance in Transgenic Tobacco and Chickpea. *Plant and Cell Physiology* 58(11) :1934–1952 [Impact Factor 4.76].

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

i) Delivered lecture on " Plant Genetic Engineering Research in India" as a resource person in Refresher Course in Biotechnology of the faculty members of University and Colleges on 20th November, 2017 at BC Guha Centre for Biotechnology at Calcutta University.

ii) Delivered an invited lecture entitled "WRKY70 interacts with HDZ12, a Homeodomain-

Leucine Zipper transcription factor and induces tolerance to drought and salinity stresses in chickpea" on 10th March, 2018 in a DST PURSE Phase II sponsored 1st International conference on Frontiers in Biological Environmental and Medical Sciences organised by Burdwan University.

iii) Delivered an invited lecture entitled "Safety assessment of a newly designed potential antifungal lectin like protein of agricultural importance" in BIOSAFETY CAPACITY BUILDING WORKSHOP jointly organizedbyAssam Agricultural University, Jorhat & Biotech Consortium India Limited, New Delhi

iv) Delivered lecture on"Fighting against sheath blight of Rice with a magic molecule" in Prof. S.M. Sircar Conference on 17th March 2018 organised by Plant Physiology Forum.

Students Awarded Ph.D.

Name of Student (University, Year)	Title of Thesis
Senjuti Sen (C.U., 2017)	Development of New strategies for management of biotic and abiotic stresses in chickpea (*Cicer arietinum*. L)

Dr. Gaurab Gangopadhyay

Associate Professor

Scientific Reports

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

It is a continuous work for last several years towards the development of an improved sesame genotype with high oil containing enhanced lignan (sesamin and sesamol). The work initiated from an inter-specific hybridization between *Sesamum indicum* (cultivated sesame, the female parent) and *S. mulayanum* (wild sesame, the male parent). Presently the selected recombinants are in F_6 generation. With these recombinants, we are now looking for few candidate genes of the sesame lignan biosynthetic pathway and the genes behind seed coat colour. The rationale is to find an association between oil content, qualities, seed coat phenotype and gene-specific molecular markers. We have observed a significant correlation between sequential up- and down-regulation (analyzed through qRT-PCR in the backdrop of the constitutive gene, actin from *Sesamum*) of three genes (sesamin synthase, ferric reduction oxidase – cytochrome family gene and polyphenol oxidase) in consecutive developmental stages of sesame seed maturation.

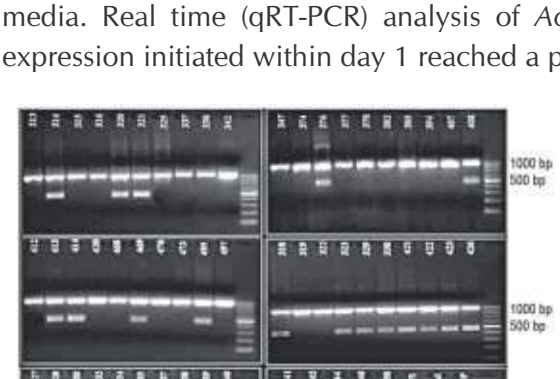
Early expression of *WUSCHEL* is a marker for *in vitro* shoot morphogenesis in tobacco and *Beta*

We have studied the role of growth regulators behind *in vitro* shoot organogenesis and somatic

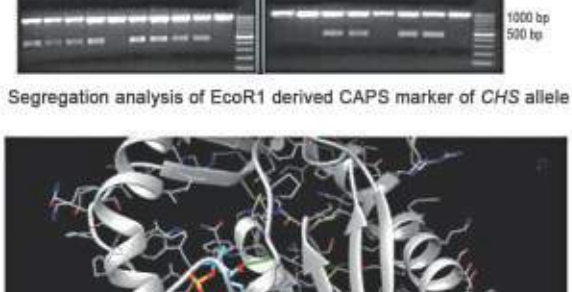
embryogenesis in two plant systems, viz. tobacco (*Nicotiana tabacum* L. var. Jayasri) and *Beta palonga* R.K. Basu & K.K. Mukh. We have also correlated the phenomena of de differentiation with the relative expression of *WUS* (*WUSCHEL*) gene in a time-dependent manner. The results indicated that early *WUS* gene expression is a definite marker for *in vitro* shoot organogenesis in tobacco and *Beta* both in direct and indirect modes of regeneration. Additionally, we have performed a comparative homology modeling and *in silico* structural analysis of WUSCHEL proteins of *B. palonga*, *B. vulgaris*, and *Arabidopsis* to find out the commonality of the ligand binding site. The amino acids of the binding sites were identical (Arginine, Tryptophan, Proline, Asparagine, and Tyrosine) in the three materials under study; except two additional amino acids (Isoleucine and Alanine) in *B. vulgaris*.

Understanding the role of *Somatic Embryogenesis Receptor Kinase* (*SERK*) gene in Pineapple

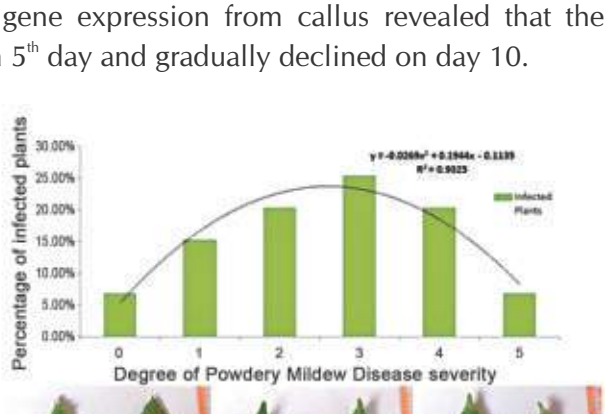
An efficient *in vitro* regeneration system through somatic embryogenesis is a prerequisite for successful plant transformation programme. Members of Somatic Embryogenesis Receptor Kinase (SERK) gene family, viz. *AcSERK1, AcSERK2* and *AcSERK3* are principal regulators behind *in vitro* plant morphogenesis in pineapple. *SERK* is a leucine-rich repeat (LRR) transmembrane protein kinase. For expression analysis of *AcSERK* during somatic embryogenesis in search for the most promising *AcSERK* candidate, proliferating callus of pineapple was grown in basal and regeneration media. Real time (qRT-PCR) analysis of *AcSERK* gene expression from callus revealed that the expression initiated within day 1 reached a peak on 5th day and gradually declined on day 10.



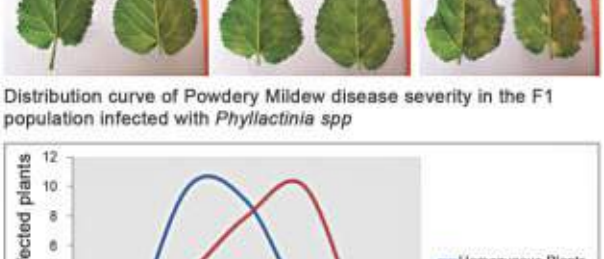
Segregation analysis of EcoR1 derived CAPS marker of *CHS* allele



Docking prediction of ligand (malonyl coA) with templates (protein models of *CHS* alleles).



Distribution curve of Powdery Mildew disease severity in the F1 population infected with *Phyllactinia spp*



Skewing of mean disease score in homozygous and heterozygous population with respect to the *CHS locus*

SCIENTIFIC REPORT

Allele specific CAPS marker development and characterization of chalcone synthase gene in Indian mulberry (Morus spp., family Moraceae): Figures from publication – Arora V, Ghosh M K, Pal S and Gangopadhyay G (2017) PLOS ONE 12(6): e0179189. *https://doi.org/10.1371/journal.pone.0179189*

Publications

1. Arora V, Ghosh M K, Pal S and Gangopadhyay G (2017) Allele specific CAPS marker development and characterization of chalcone synthase gene in Indian mulberry (*Morus* spp., family Moraceae). *PLOS ONE* June 22, 2017 https://doi.org/10.1371/journal.pone.0179189 Impact Factor 2.806.
2. Arora V, Ghosh M K, Singh P and Gangopadhyay G (2018) Light regulation of nitrate reductase gene expression and enzyme activity in the leaves of mulberry. Indian Journal of Biochemistry and Biophysics 55: 62-66. Impact Factor 0.579.
3. Debnath A J, Gangopadhyay G, Basu D and Sikdar S R (2018) An efficient protocol for *in vitro* organogenesis of *Sesamum indicum* L. using cotyledon as explants. 3 Biotech 8:146 (https://doi.org/10.1007/s13205-018-1173-7) Impact Factor 1.361.

Grants-In-Aid Scheme

Title of the scheme	Scheme funded by
Development of transgenic pineapple over-expressing *AcSERK* to combat fungal pathogens	Department of Biotechnology, Govt of West Bengal

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

1. Acted as the Resource person of Plant Science in the North-Eastern States Students' Training on Basic Science 2017 (NESST-BASE 2017) at Mayapuri Campus of Bose Institute, Darjeeling from 29th May – 31st May 2017; compiled and prepared the booklet for the trainees.
2. Organized a Hands-on-Training programme on "Basic and Applied Physical and Biological Sciences for the High School Students" at MEF (Madhyamgram Experimental Farm) as 'the Convener' from 11th to 13th December 2017 as a part of the Centenary Celebration of Bose Institute. Thirty five students of Class XI-XII standard along with their teachers from seven schools in the vicinity of MEF attended this programme. They performed experiments on Microbiology, Physics of Nanomaterials, Plant Biotechnology and learnt techniques to use of animals in drug development/translational medical research. The students also visited the CB and MC of BI, attended lectures on Crop improvement and 'Fun with Mathematics'.

Group Members

Debabrata Dutta, Soumili Pal, Marufa Sultana, Vivek Arora and Gaurab Gangopadhyay presented Poster presentation entitled "Towards broadening the gene pool of few crop plants through molecular and transgenic breeding" in Centenary celebration of Bose Institute during 24th to 28th November 2017.

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

1. Delivered talk entitled "Plant genetic resources as a repository of unique alleles for future crop plants" and chaired a technical session in the National Symposium (2 - 3 November 2017) on "Advances in Biology: Exploitation of Phyto-resources" on 3rd November 2017 at Golpark Rama Krishna Mission, organized by Dr APJ Abdul Kalam Govt. Collge, WB.
2. Delivered talk and chaired the technical session on Molecular Breeding in the 7th Symposium of the DNA Society of India entitled "Importance of DNA Fingerprinting, Cataloguing and Utilization of the Bio resources of the North-East India" from 17th to 18th November 2017, held at IASST (Institute of Advanced Study in Science & Technology), Guwahati. Delivered the talk entitled "Wild and landraces as repository of unique alleles for future crop plants" on 18.11.2017.

Awards / Honors received

i) Invited to act as an expert in an interactive meeting on "Tea Genome Sequencing and Application of Bioinformatics Tool" organized by National Tea Research Foundation (NTRF) on 8th September 2017 at Tea Board, Kolkata.

Dr. Anupama Ghosh

Assistant Professor and DST-Inspire Faculty

Scientific Reports

Survival strategies of corn smut fungus Ustilago maydis during host colonization

One of the major findings within the scope of this project during the past year is the unconventional function of a typical metacaspase protein from the corn smut fungus *Ustilago maydis*. Metacaspases primarily associate with induction and execution of programmed cell death in protozoa, fungi and plants. In the recent past, several studies have also demonstrated cellular functions of metacaspases other than cell death in different organisms including yeast and protozoa. In our recent study we showed similar dual function for the Ustilago maydis metacaspase Mca1. In addition to a conventional role in the induction of cell death, Mca1 has been demonstrated to play a key role in maintaining the quality of the cellular proteome. On one hand, Mca1 could be shown to bring about apoptosis-like phenotypic changes in *U. maydis* on exposure to oxidative stress, on the other hand, the protein was found to regulate cellular protein quality control. *U. maydis* metacaspase has been found to remain closely associated with the insoluble intracellular protein aggregates, generated during an event of stress exposure to the fungus. The study, therefore, provides direct evidence for a role of *U. maydis* metacaspase in the clearance of the stress-induced intracellular insoluble protein aggregates. Furthermore, host infection assays with mca1 deletion strain also revealed a role of the protein in the virulence of the fungus. The figure below (Fig. 1) summarises the unconventional function of the protein.

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 *Ustilago maydis* in the context of their role in manipulating host defense responses. Currently we are focusing on ribonucleases and proteases. Our data showed a differential expression of all the ribonucleases tested so far and some of the proteases investigated 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* indicate their probable role in the virulence of the pathogen. We have generated deletion mutants of many of these candidates in *U. maydis* SG200. Pathogenicity assays with these mutants reveal their attenuated virulence properties further supporting the hypothesis about their involvement in the pathogenic mechanism of *U. maydis*. Further work in the direction of uncovering their pathogenic mechanism is underway.

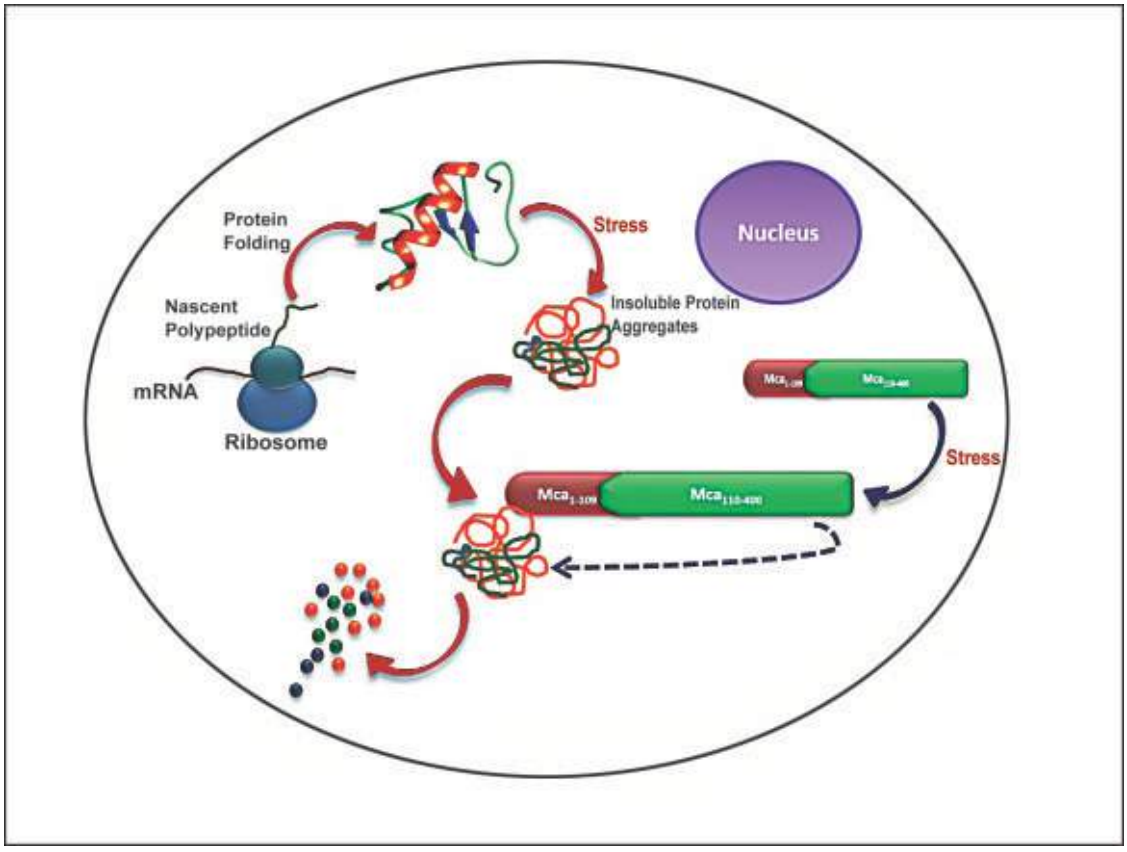


Fig. 1. Schematic representation of the unconventional function of Mca1. Upon exposure to stress many of the cytosolic proteins undergo misfolding and subsequently accumulate as insoluble aggregates. Mca1 through its unstructured N-terminal part associate with the aggregates and by means of its C-terminal protease domain degrades the misfolded proteins. This helps the cell get rid of the insoluble aggregates.

Molecular dissection of the host pathogen interface in the rice-Rhizoctonia solani pathosystem

This project is aimed to study the extracellular proteome of rice in relation to infection by *Rhizoctonia solani*. Through this study we are planning to investigate both the secretome of *R.*

solani AG1-IA during host invasion as well as plant defense proteins involved in plant defense against sheath blight. Our data showed extracellular proteins belonging to different classes are actually involved in the pathogenicity of R. solani towards host plant rice. Among these classes those that are annotated belong to mostly cell wall degrading enzyme category. However, a significant portion of the identified candidates lack any functional annotation and hence need to be further investigated. Currently some of these candidates are being investigated in our laboratory.

Publication

1. Mukherjee M, Gupta S, Saran N, Datta R and Ghosh A (2017) Induction of apoptosis-like cell death and clearance of stress-induced intracellular protein aggregates: dual roles for *Ustilago maydis* metacaspase Mca1. *Molecular Microbiology*, 106 (5), 815-831. [Impact Factor: 3.89].

Grants-In-Aid Schemes

Title of the schemes	Funding agency
(As PI) Survival strategies of the corn smut fungus *Ustilago maydis* during host colonization	DST (DST-INSPIRE Faculty Scheme)
(As Co-PI) Deciphering the in-planta secretome of *Rhizoctonia solani* AG1-IA during infection of rice.	CSIR (Extramural Research Grant)
(As PI) Evaluation of secreted proteases of *Ustilago maydis* as potential effector proteins.	SERB (Early Career Research Award)

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

i) Delivered an invited talk entitled "Stress response in *Ustilago maydis* insights to in-planta survival of the pathogen" in the "10th Conference on Yeast Biology; Model Yeasts to Fungal pathogens" held at JNU, New Delhi and Amity University, Gurgaon during 08th to 11th February 2018.

ii) Delivered an invited talk on "Clearance of intracellular insoluble protein aggregates: an unconventional role for U. maydis metacaspase, Mca1" in the "18th All India Congress of Cytology and Genetics and International Symposium on Translating Genes and Genomes" held at CSIR Indian Institute of Chemical Biology during 29th to 31st January 2018.

Group members

Dibya Mukherjee presented a poster on "Induction of apoptosis-like cell death and clearance of stress induced intracellular protein aggregates: dual roles for *Ustilago maydis* metacaspase Mca1"

in the "10th Conference on Yeast Biology; Model Yeasts to Fungal pathogens" held at JNU, New Delhi and Amity University, Gurgaon during 08th to 11th February 2018 and won a poster award.

Dr. Swati Gupta Bhattacharya

Professor

Scientific Reports

Aerobiological monitoring was carried out for three years using Andersen two stage and Burkard personal sampler for trapping culturable as well as total fungal spores from the air of Habra, West Bengal. It helps to determine the presence of the diversified fungal species and their total concentrations in the air of different sampling areas (educational area, occupational area, and crop field) of Habra. The questionnaire survey and hospitalization records were found to be positively correlated with the total spore load of the study areas. *Aspergillus terreus* and *Aspergillus oryzae* were the most frequently occurring fungal species among the culturable fungi and its allergenicity has been determined through various in vivo and in vitro assays. Histamine release, specific IgE, and skin sensitivity were found in higher amount in susceptible patients. 2D gel blot revealed sixteen spots as immunoreactive. MALDI-TOF/TOF analysis led to the identification of ten allergens. Purification of a Triosephosphate isomerase (TIP) protein was carried on using anion exchange and size exclusion chromatography due to its highest IgE reactivity. Putative IgE binding peptides were synthesized, and they showed significantly high IgE binding and histamine release with hypersensitive patients' sera. This finding unearthed novel allergens from *A terreus* and suggests that TPIis a major allergen concerning immunoreactivity. A 45.434 kDa protein, glucan 1, 3-beta-glucosidase A, was identified as a major allergen of *Aspergillus oryzae* by MALDI-TOF- TOF. Purification of this major allergen is under progress. Another important allergenic species of Aspergillus is *Aspergillus ochraceus*. It was observed as one of the prevalent environmental fungi, and about 27% of patients with fungal sensitization were found to be SPT positive against *A. ochraceus* crude protein. Serological detection and Mass Spectrometry-based identification confirmed glycerol dehydrogenase as a major allergen. In addition to Aspergillus, our research group is also working on Rhizopus oryzae commonly known as black bread mould. This is a ubiquitously present indoor filamentous mould. Two major allergens designated as Rhi o 1 (an aspartic protease) and Rhi o 2 (a cyclophilin A) have been identified from this species. Purification, cDNA cloning, IgE-epitope and T-cell epitope mapping have been done with Rhi o 1. Subsequently, hypoallergenic version of this molecule has been developed which had shown promise in performing specific immunotherapy. Similar work has also been done with Rhi o 2. The conserved IgE-antibody binding region of this allergen has been mapped by san tep-wise gradual truncation of the protein from both terminii.

Pollen grains also contribute significantly in constituting allergy eliciting bioaerosol. Many important outdoor allergens from pollen grains have been characterized. Aeropalynological and clinical studies in Kolkata identified date palm (*Phoenix sylvestris*) sunflower (*Helianthus annuus*) as a most important aero-allergen. Being unsequenced, identification of proteins from date palm was a tedious job, and therefore a manual *de novo* sequencing approach was undertaken which

identified its major allergen as a pollen-specific protein (Figure 1). Immuno-biochemical and proteomic tools were employed to identify IgE reactive proteins from sunflower pollen. Seven sero-reactive proteins were detected by 1D and 2D immuno-blot and identified through mass spectrometry. One of the major allergens of 42 kDa was further purified by anion exchange and gel filtration chromatography and was identified as pectate lyase by mass spectrometry. The biochemical, immunological and structural properties of the purified allergen were studied. The purified allergen showed alpha-helical conformation in CD spectrometry. It was regarded as a major allergen as 64% of sunflower sensitized patients showed allergic response against this protein. This protein induced histamine release from basophils of sensitized patients. This allergen was submitted to WHO/IUIS allergen database by us, and it was accepted as a new allergen Hel a 6. It showed more than 60% sequence similarity with Amb a 1 and Art v 6 (pectate lyase of other plants of the same family). Inhibition ELISA and blot represented 60%-80% of cross-reactivity between these 3 allergens. *Alstonia scholars* (Chhatim) and Delonix regia (Gulmohar) are two allergy causing road side ornamental trees. Pollen grains of these two species were selected, and immuno biochemical studies were performed. Approximately 34% of atopic patients were found to be allergic to *A. scholaris* pollen and 31% atopic individuals were allergic to *D. regia* pollen. In proteomic part, total pollen protein was fractionated by SDS-PAGE and two-dimensional gel electrophoresis. From 1D and 2D immunoblot IgE reactive proteins were identified. These immuno reactive proteins depict the proteins which are responsible for the allergenicity of the respective pollen grains. PAS staining was done to determine if the IgE reactive proteins are glycoprotein or not. Papaya (*Carica papaya*) has also been reported to elicit IgE-mediated hypersensitivity of respiratory and gut mucosa via pollen inhalation and fruit consumption respectively. Certain papaya sensitive patients with food allergy were found to experience recurrent respiratory distresses even after quitting the consumption of papaya fruits. This observation prompted us to investigate the allergen commonly present in fruits and pollen grains of papaya. A discovery approach consisting of immunoproteomic detection followed by molecular characterization led to the identification of a novel papaya allergen designated as Cari p 1. Serological analysis detected this allergen as a 55 kDa IgE-reactive protein commonly present in pollen and fruit proteome. The protein from the pollen was identified as an endo-polygalacturonase by tandem mass spectrometry. The Cari p 1 cDNA was cloned and purified as a recombinant allergen. The recombinant protein remained monomer under physiological condition and displayed pectinolytic activity. Recombinant Cari p 1 reacted with IgE-antibodies of all the patient sera suggesting this protein as a major allergen of papaya. In degranulation assay, rCari p 1 displayed allergenic activity by stimulating histamine release from IgE-sensitized granulocytes. CD-spectroscopy of rCari p 1 revealed the presence of predominantly β-sheet characters. The melting curve of the allergen showed partial refolding from a fully denatured state indicating the possible presence of conformational IgE-epitopes characteristic of inhalant allergens in addition to the linear IgE-epitopes of food allergens. The presence of this allergen in papaya fruit was investigated by immunoblot with anti-Cari p 1 rabbit sera and reconfirmed by PCR. Expression of Cari p 1 was detected in the peel and pulp tissues of papaya fruits at two edible stages of fruit maturation. In an *in vivo* mouse model, rCari p 1 exhibited a comparable level of inflammatory responses in the duodenum and lung tissues explaining the dual role of Cari p 1 allergen in respiratory sensitization via pollen inhalation and sensitization of gut mucosa via fruit consumption (Figure 2). Purified rCari p 1 can

be used as a marker allergen for component-resolved molecular diagnosis. Further immunological studies on Cari p 1 are warranted to design an immunotherapeutic vaccine for the management of papaya allergy.

Prawn and brinjal allergies are one of the most common food allergies. The aim of our work is to the immuno-biochemical characterization of novel allergen from these two food allergen sources.

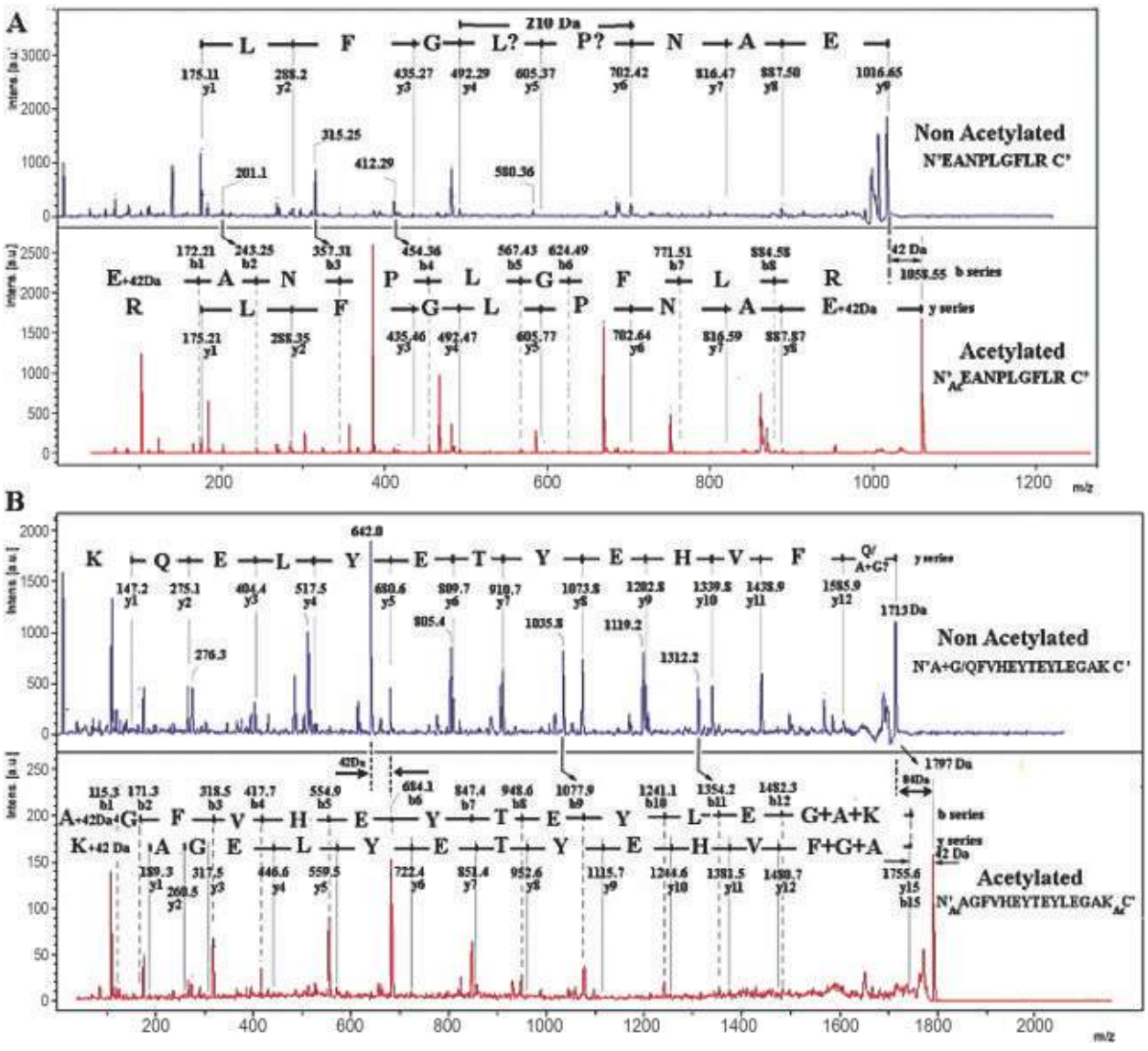


Fig 1: *De novo* sequencing of spot 1 identified as Pollen-specific protein (A) *De Novo* sequencing of the non-acetylated peptide of *m/z* 1016 Da. N-terminal acetylation showing a shift in the 'b' ions and 'y_n' ion by 42 Da suggesting monoacetylation at N terminus. (B) *De novo* sequencing of the non-acetylated peptide of *m/z* 1713 Da. Peptide derivatization by acetylation showing an increase of total mass of peptide by 84 Da. The 'y_1' ion is shifted by 42 Da due to acetylation of lysine at the C-terminus thereby increasing 'y' series by 42 Da. 'b' series are increased by 42 Da due to normal acetylation at N-terminus. Total peptide mass changes by additional 42 Da due to acetylation of a lysine residue along with 42 Da due to N terminal acetylation. Generated sequence is shown alongside.

We have identified Two novel protein profilin and Arginine kinase1 from brinjal(*Solanum melongena*) and prawn (*Machrobrachium rosenbergii*)respectively by 2Dblot followed by MALDI TOF/TOF. After identification, profilin and arginine kinase1 had been overexpressed in a bacterial system using recombinant DNA technology. The allergenic potency of these recombinant proteins was confirmed by western blot using patient sera followed by histamine release assay. Secondary structure and thermal stability of profilin were determined by circular dichroism, and it showed that profilin has a mixed population of α-helix and βsheet. Brinjal Profilin also shows cross-reactivity with other allergenic profilin from different food sources like capsicum, tomato, wheat and rice. The recombinant allergens from both the sources show high allergenic potency, and now can be used as molecular diagnostics for the diagnosis of food allergy

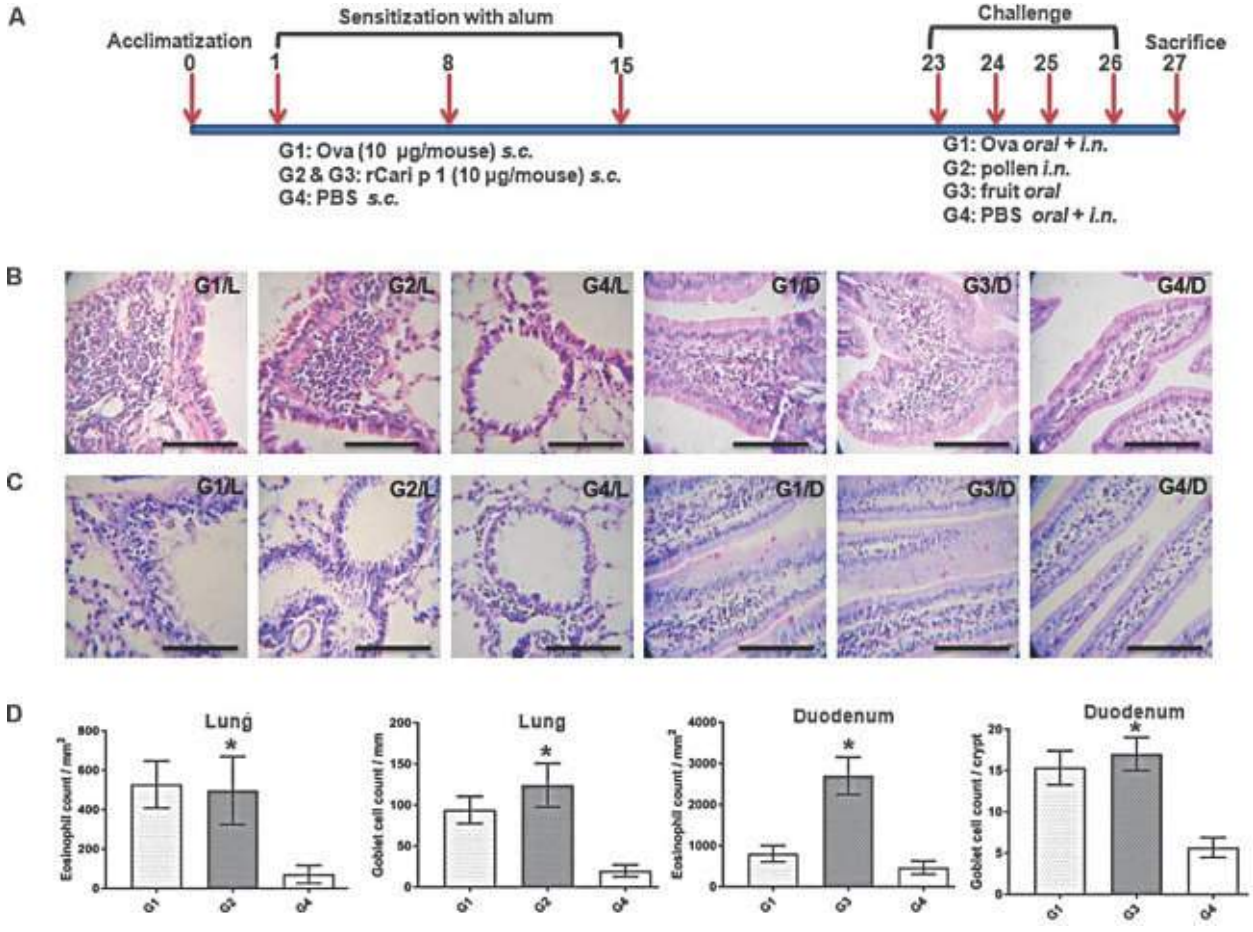


Fig 2: Role of rCari p 1 in mouse model of papaya induced respiratory and food allergy: (A)Protocol for mouse model of allergen challenge. Representative histology of mouse lung; L and duodenum; D showing inflammatory changes by H/E staining (B) and mucus secretion by PAS staining (C). The bars represent 100 micron length. (D) Quantification of allergen-challenge associated inflammatory changes in terms of eosinophil infiltration (mean of eosinophil count ± SD as error bar; y-axis) in peribronchial spaces (mm2) of lung and lamina propria (mm2) of duodenum. Quantification of allergen-challenge associated mucus production in terms of goblet cell hyperplasia (mean of mucus secreting goblet cell count ± SD as error bar; y-axis) in bronchial basement membrane (mm) of lung and each crypt of duodenum. Asterisks represent $p < 0.05$ in allergen challenged versus PBS treated mice.

Publications

1. Kaur A, Karmakar B and Gupta Bhattacharya S (2018) Bio -monitoring of airborne fungal spores of indoor and outdoor environments from a suburban area near the Indo-Bangladesh border. *Indian J. Aerobiol*., Vol. 29, No. 1 & 2, pp 12-18.

2. Saha B, Gupta Bhattacharya S (2017) Charting novel allergens from date palm pollen (*Phoenix sylvestris*) using homology-driven proteomics. *Journal of Proteomics* 165:1-10. Impact Factor- 3.8.

3. Sarkar M B, Sircar G, Ghosh N, Das A K, Jana K, Dasgupta A, Gupta Bhattacharya S (2018) Cari p 1, a Novel Polygalacturonase Allergen from Papaya Acting as Respiratory and Food Sensitizer**.** *Frontiers in Plant Science. Front. Plant Sci.* 9:823. doi: 10.3389/fpls.2018.00823 Impact Factor – 4.2.

Awards / Honors received

Group Members

Koyel SenGupta was awarded best abstract Prize from British Society for Allergy and Clinical Immunology (BSACI) Annual Meeting 2017 held at Telford, UK, from 1st October 2017 to 3rd October 2017,

Sangeeta Roy was awarded an exchange fellowship entitled Newton-Bhaba fellowship jointly funded by British Council, UK and DST, India from June 2017 to September 2017 and worked at The University of Manchester, UK.

Participation in Conferences/Symposia/Workshops & Invited talks Delivered at various organizations:

1. Attended and presented an invited talk at 20th Indian Aerobiological conference held at Amravati, Maharashtra from 28hFeb. -2nd March 2018.

2. Attended and presented an invited talk at 105 Indian Science Congress at Manipur from 15th March -20th March.

Group Members

1. Mrs. Sangeeta Roy (SRF) visited The University of Manchester, UK with an exchange fellowship entitled Newton-Bhaba fellowship jointly funded by British Council, UK and DST, India from June 2017 to September 2017 to pursue a part of her doctoral work.

2. Ms. Bijoya Karmakar (SRF) attended and delivered an oral presentation at the AAAAI/WAO Joint Congress, held in Orlando, Florida, the USA from 2nd to 5th March 2018

3. Ms. Nandini Ghosh (SRF) Oral presentation at International Conference on Glycobiology organized by PULSUS group (21st -22nd September 2017) at Houston, USA

4. Ms. Koyel SenGupta (SRF) attended British Society for Allergy and Clinical Immunology (BSACI) Annual Meeting 2017 Telford, UK, from 1st October 2017 to 3rd October 2017, for Poster Presentation. Her poster was awarded best abstract award.

5. All the members participated in an International Symposium on Insight to Plant Biology in the Modern Era (8-10 February 2017) at Bose Institute, Kolkata, India.

Students awarded Ph.D

Name of the student University/Year	Title of the Thesis
Bodhisattwa Saha, (CU, 2017)	Proteomics and Biochemical Studies to Identify IgE Reactive Proteins from some Allergenic palm Pollen Grains of West Bengal
Gaurab Sircar, (CU, 2017)	Aeromycological, Immunobiochemical and Proteomic Analysis On IgE Reacti Molecules From Certain Allergenic Molds
Debarati Dey (CU, 2017)	Assessment of Airborne Fungal Allergens of Kolkata metropolitan: biochemical and immunological approach

Grants-In-Aid Schemes

Title of the schemes	Schemes funded by
Survival strategies of the corn smut fungus *Ustilago maydis* during host colonization	World Wildlife Fund (WWF)
With Dr. Sudipto Saha (Co-PI) Development of Molecular Diagnostics and Immunotherapeutic Vaccines for Prawn and Brinjal Allergy	DBT
With Dr. Sudipto Saha (Co-PI) 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
Studies on mould spore diversity as an environmental allergen in outdoor and indoor environments of urban and rural areas of Agartala, Tripura	DBT
With Dr. Anupama Ghosh (Co-PI) Deciphering the in-planta secretome of *Rhizoctonia solani* AGI-IA during infection of rice	CSIR

Dr. Pallob Kundu

Associate Professor

Scientific Reports

We are investigating the transcriptional and post transcriptional regulatory mechanisms of gene expression cascade activated during biotic stress response in plant. Recent developments in my research studies are highlighted under the each project being pursed.

Insights into mechanisms of regulation of Alternaria stress-responsive microRNA expression and significance of specific miRNA-mRNA interaction in the disease biology

In the genome-wide analysis, we have elucidated Alternaria-stress responsive miRNAs, mRNAs and miRNA-mRNA interacting pairs in tomato and initiated follow up works. We are analyzing the importance of (i) specific transcription factors in MIR gene expression and (ii) specific miRNA-mRNA interaction in the disease biology. Accordingly, we have cloned promoter regions of miR397, miR398, miR6024 and miR167. All of these are Alternaria and multiple other stresses responsive. Stress-related transcription factors such as WRKY and NAC group have crucial roles in these regulations. To elucidate the biological role of these miRNAs, we have also cloned the precursor sequences of these miRNAs in a plant over-expression vector. Transgenic tomato plant over expressing miR6024 has been generated. Their response during challenge with Alternaria will be monitored after we obtain the T1 generation seeds. One of the targets of miR6024, an NBLRR transcript, was cleaved readily in the overexpressing plant and expressed in lower level compared to the level in a control transgenic plant. Further studies are in progress to better understand the role of miR6024. Generation of miR397 and miR398 null lines and overexpression of their modified targets, laccase, and Cu/Zn SOD, which would lack the cognate miRNA target sites are in progress. These studies are not only enriching our knowledge on miRNA and stress biology, would facilitate in designing strategies for introducing resilience in tomato against the early blight disease pathogen.

Analysis of membrane bound NAC transcription factors in tomato(NAC MTFs): insight into the mechanism of regulation of expression and biological functions

Our current research focus is on two NAC MTFs namely, SlNACMTF3 and SlNACMTF5. We have determined the preferred binding sites for SlNACMTF3 via tedious SELEX analysis. In the follow-up analysis, we have searched for the genes that harbor these binding sites and identified several stress-responsive genes have the specific sequence in their promoter region. Validation is in progress. Besides, we have continued investigation on the mechanism of SlNACMTF3 membrane detachment using GFP tagged protein. A new methodology for the study of membrane localization of the GFP-tagged NACMTFs in tomato leaf epidermal peel and release upon stimulus has been developed. Using this method and already established protocol of utilizing onion epidermal peel biochemical studies to dissect the mechanism of SlNACMTF3 membrane detachment is analyzed. Our data indicate that cellular protease, but not proteasome pathway, is involved in this detachment process and gained some clues about the nature of the protease. We have also shown that the identified transmembrane domain alone is capable of carrying GFP to the membrane. Transgenic lines with reduced expression of the MTFs are being generated to analyze the biological role of the identified MTFs.

Publication

1 Jodder J, Das R, Sarkar D, Bhattacharjee P, Kundu P (2018) Distinct transcriptional and processing regulations control miR167a level in tomato during stress. *RNA Biol*. 2018 Jan 2;15(1):130-143. [Impact factor: 3.9].

2 Jodder J, Basak S, Das R and Kundu P (2017) Coherent regulation of miR167a biogenesis and expression of auxin signaling pathway genes during bacterial stress in tomato, *Physiological and Molecular Plant Pathology*100 (97-105). [Impact factor: 1.54].

Proceedings

1. Sarkar D, Jodder J, Dey S, Bhattacharjee P, Das R, Chowdhury S, Basak S and Kundu P (2017) Integrated miRNA and mRNA transcriptomic reveals response regulators of Alternaria stress in tomato, *Proc. of one day symposium on 'New Horizons in Biotechnology (NHBT 2017)'* held on 17-18th February 2017 at Haldia Institute of Technology, Haldia, West Bengal.

Grants-in-Aid Schemes

Title of the schemes	Schemes funded by
Exploring membrane-associated NAC-transcription factors (NAC MTFs) in tomato to apprehend membrane-mediated signaling during pathogenesis.	CSIR
*With Dr. D.N. Sengupta (PI)*Functional analysis of the DNA polymerase lambda gene and the protein from indica rice cultivars,	DST, SERB
*With Prof. Amita Pal (PI)*Genome wide transcriptome analysis to identify MYMIV-stress related genomic resources of blackgram, WB	DBT
With Prof. Anirban Bhunia (PI), Foreign PI: Martin Malmsten Antimicrobial Peptides Against Crops Disease	DST

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

i) Delivered an invited lecture on "Integrated miRNA and mRNA transcriptomic reveals response regulators of Alternaria stress in tomato" in 'New Horizons in Biotechnology (NHBT 2017)' held on 17-18th February 2017 at Haldia Institute of Technology, Haldia, West Bengal.

ii) Delivered an invited lecture on "Exploring tomato stress-responsive miRNAs and their regulatory circuit" at IISC, Bangalore, 18th September, 2017.

iii) Delivered an invited lecture on "Crop improvement: traditional and biotechniological means"to students from local schools participated in Students training programme at MEF at Bose Institute on13th Dec, 2017.

iv) Delivered an invited lectureon "Genetic improvement of crop plants" to teachers from Kendriya Vidyalaya at Bose Institute on 29th Dec, 2017.

Group Members

1. Deepti Sarkar presented a poster titled "Genome-scale analysis of miRNA-mRNA interactions during Alternaria infection in tomato" in symposium "Insight to plant biology in the modern era" held at Bose Institute, Kolkata during 8 - 10 February 2017.
2. Payel Bhattacharjee presented a poster titled "Identification and functional characterization of membrane bound NAC transcription factors (SlNACMTFs) in tomato" in symposium "Insight to plant biology in the modern era" held at Bose Institute, Kolkata during 8 - 10 February 2017.
3. Shrabani Basak presented a poster titled"Regulation of tomato metacaspases during development and stress" in 23rd INPEC Meeting: Protein structure, function and engineering held at the Unified Campus, Bose Institute, Kolkata during November 9-11.
4. Jayanti Jodder presented a poster titled "Distinct Transcriptional and Processing Activity Regulate Tomato miR167 Biogenesis During Stress" in symposium "Insight to plant biology in the modern era" held at Bose Institute, Kolkata during 8 - 10 February 2017.

Seminars / Symposia organized at Bose Institute

1. International symposium on Insight to Plant biology in the Modern Era, 8-10 Feb, 2017, held at Bose Institute, Kolkata
2. 100 years of Bose Institute: Acharya J C Bose and beyond, 21st Nov, 2017. Organized by Bose Institute Alumni Association in collaboration with Bose Institute to celebrate the centenary of Bose Institute.

Awards / Honors received

Group Members

- Ms. Shrabani Basak received "Best Poster Award" in 23rd INPEC Meeting: Protein structure, function and engineering held at the Unified Campus, Bose Institute, Kolkata during November 9-11.
- Dr. Arpita Basu Chowdhury, Received DST N-PDF fellowship.

Dr. A.N. Lahiri Majumder

INSA Senior Scientist

Scientific Reports

In collaboration with Dr Sambit Datta, Dr Milan Sengupta , Ms Papri Basak , Ms Sanghamitra Adak and Mr Abhishek Mukherjee

A. Identification of essential amino-acids in the catalytic site of the rice L-*myo*-inositol 1-phosphate synthase

Phylogenetic analysis of 172 homologous sequences of a highly conserved enzyme, L-*myo*-inositol 1-phosphate synthase or MIPS from evolutionarily diverse organisms was performed which revealed presence of six phylogenetically conserved blocks, out of which four embrace the catalytic core of the functional protein. Specific chemical modification of Lys residues known to be important for MIPS catalysis, were performed with MIPS *Oryza sativa* (*Os*MIPS1). Following this study, *Os*MIPS mutants with deletion or replacement of lysine residues in the conserved blocks were made. Based on the enzyme kinetics performed on the deletion/replacement mutants, phylogenetic and structural comparison with the already established crystal structures from non-plant sources, an evolutionarily conserved pentapeptide stretch was identified at the active pocket which contains the two most important lysine residues essential for catalytic activity.

B. Phosphoinositides in plant stress tolerance

Phosphoinositides and phospholipase C both play key roles in plant growth, development and stress tolerance. In the present study, an attempt is being made to elucidate the mechanism of regulation of stress -tolerance by PI-PLCs by cloning the various PLCs in suitable expression vectors and introgression in transgenic rice system in imparting stress tolerance primarily to elucidate functioning of PIs and PI-PLCs in response to biotic and in particular abiotic stresses in plants.

Publications

1. Basak P, Maitra-Majee S, Das JKumar, Mukherjee A, Dastidar S Ghosh, Pal Choudhury P, Majumder AL (2017) An evolutionary analysis identifies a conserved pentapeptide stretch containing the two essential lysine residues for rice L*myo*- inositol 1- phosphate synthase catalytic activity**.** *PLOS ONE* | https://doi.org/10.1371/journal.pone.0185351.
2. Das P, Datta S, Kumar Samanta M, Mukherje A and Majumder AL (2017) Phosphoinositides and Phospholipase C Signalling in Plant Stress Response - A Revisit, *Proc Indian Natn Sci Acad* 83 No. 4 December 2017 pp. 845-863.
3. Mukherjee G, Saha C, Naskar N , Mukherjee A, Mukherjee A , Lahiri Susanta, Majumder AL, Seal A (2018) An Endophytic Bacterial Consortium modulates multiple strategies to improve Arsenic Phytoremediation Efficacy in *Solanum nigrum, Scientific Reports* | *8:6979* | DOI:10.1038/s41598-018-25306-x.

Participation in Conferences/ Symposia/ Workshops & Invited talks Delivered at various organizations:

1. Delivered the Key Note address on "Advances in Biology : Exploitation of Phyto-resources" in the National Seminar organized by the West Bengal State College at Kolkata in November 2,2017.

2. Delivered invited talk on "Genomics and Biotechnology : Applications in Plant Biology Research" in the Academic Refresher course at the Calcutta University on Nov 22, 2017 .
3. Delivered an invited talk in the One-day seminar on "Public understanding of Science" organized by NASI & ISNA at Kolkata.

Grants- in Aid- Schemes

Title of the Project	Project funded by
(*With Dr. Subho Choudhuri as Co-PI*)	
1. Unraveling the role in plant drought and heat stress tolerance : Exploring the potential of PI metabolism to improve crop yield	DBT-NWO
(*As PI*)	
2. Inositol & phosphoinositide metabolism in relation to plant abiotic stress tolerance	INSA
(*With Dr Rajeswari Mukherjee as PI*)	
3. Research support grant on "An approach towards gene mining and bio-prospecting of mangrove gene pol: Special reference to *Porteresia* and/or *Salicornia*".	DBT BioCare
(*With Dr Priyanka Das as PI*)	
4. Analysis of salt-tolerance in grape vine through transcriptomic and proteomic approach and functional validation of key genes responsible for salinity tolerance in transgenic Arabidopsis.	DST

Dr. Amita Pal

UGC Emeritus Fellow

Scientific Reports

Screening and Identification of long non-coding RNAs from RNA-seq data of blackgram (*Vigna mungo*) Cv.T9

Black gram is one of the primary legumes cultivated throughout India, Cv.T9 being one of its common high-yielding cultivar. We have identified long non-coding (lnc) RNA from the NGS data and developed a pipeline for prediction of novel lnc RNAs from the sequenced data. The raw data

generated during sequencing are available at the Sequence Read Archive (SRA) of NCBI with the accession number- SRX1558530. During analysis 305 lncRNAs were found to be similar with the established lncRNAs of other plants. Highest similarities were found with *Glycine max* (Fig. 1).

Till date tools for predicting function of novel lncRNAs of plants are limited; hence, in the present study we made an attempt to establish the function of lncRNAs: as natural antisense transcripts, target mimics of micro RNAs and splicing associated functions of lncRNAs by employing computational techniques. NATsdb was used for prediction of natural antisense transcripts from lncRNAs by means of BLAST. LncRNA sequences, transcripts obtained from transcriptome data of Cv. T9 and miRNA data obtained from deep sequencing were used for prediction of common miRNA targets. Both lncRNAs and the transcripts were compared for prediction of common miRNA targets. Common hits were considered as putative miRNAs which may have target mimics in form of lncRNAs.

86 miRNAs were found to have common targets in both

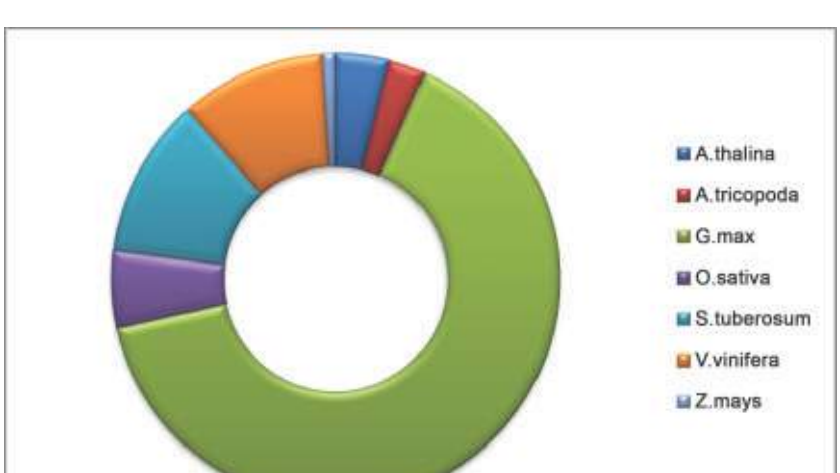


Figure 1: Doughnut representing similarity of known lncRNAs with lncRNA of different plants from CANTATAdb

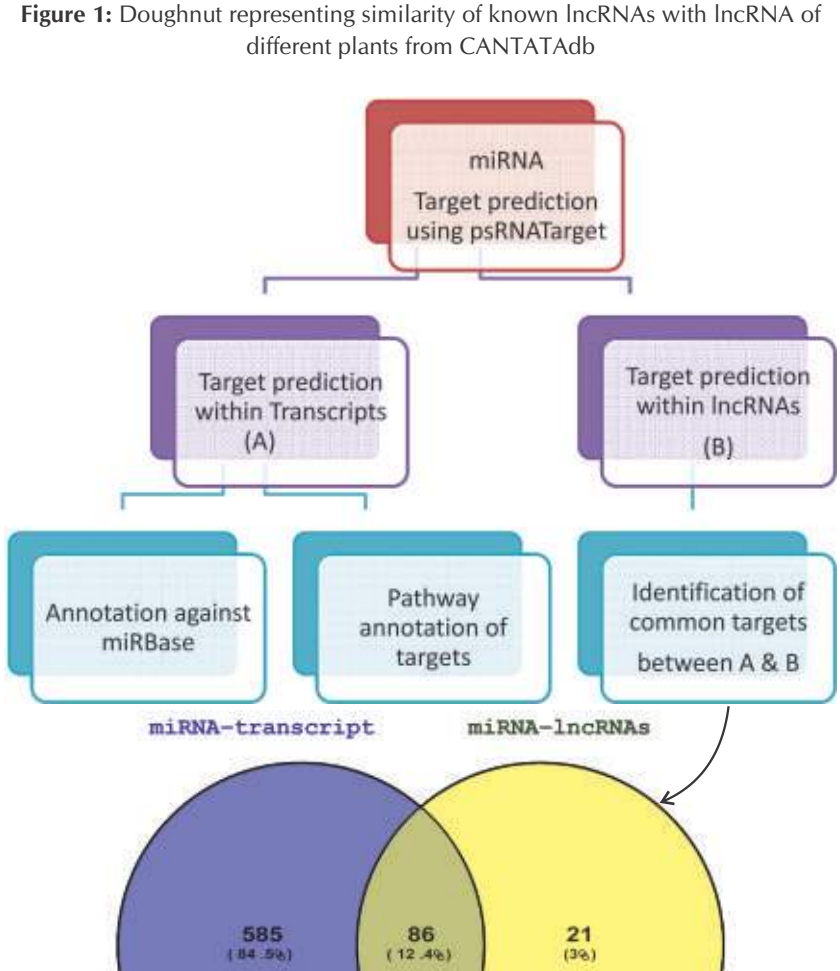


Figure2: miRNA Target mimic prediction scheme

mRNA transcripts and lncRNAs (Fig. 2). Local BLAST was performed against CANTATAdb, 113 lncRNAs were found to share homology with splicing associated lncRNAs.

Publications

1. Dutta S, Biswas P, Chakraborty S, Mitra D, Pal A and Das M (2018) Identification, characterization and gene expression analyses of important flowering genes related to photoperiodic pathway in bamboo. BMC Genomics19:190https://doi.org/ 10.1186/s12864-018-4571-7.
2. Patel A, Dey N, Chaudhuri S, Pal A (2017) Molecular and biochemical characterization of a *Vignamungo* MAP kinase associated with Mungbean Yellow Mosaic India Virus infection and deciphering its role in restricting the virus multiplication. Plant Science, 262:127–140. DOI:10.1016/j.plantsci.2017.06.005.
3. Singh PK, Ganguli S, Pal A (2018) Screening and identification of putative long non coding RNAs from transcriptome data of a high yielding blackgram (*Vigna mungo*), Cv. T9. Data in brief 17: 459-462. https://doi.org/10.1016/j.dib.2018.01.043.
4. Singh PK, Patel A, Ganguli S, Pal A (2017) Molecular modeling and simulation of three important components of Plant Pathogen Interaction cascade in *Vigna mungo*. Bioinformation 13(10): 323-326.

Name of Student (University, Year)	Title of Thesis
Lucina Yeasmin (Ramakrishna Mission Vivekananda University, 2017)	Genetic diversity assessment of bamboo species growing in South 24 paraganas and East Midnapore districts of West-Bengal.

Students awarded Ph.D:. (*As Co- supervisor*)

Grants-in-Aid Schemes:

Title of the Scheme	Scheme funded by
(As Co-PI)	
Identification and functional characterization of genes regulating unique flowering behavior in tree bamboo.	CSIR
Genomewide transcriptome analysis to develop strategies for quality improvement of blackgram.	DBT (W B)
Genome wide transcriptome analysis to decipher molecular mechanism of MYMIV-resistance in *Vigna mungo*.	UGC (Emeritus Scheme)

Participation in Conferences/ Symposia/ Workshops & Invited talks Delivered at various organizations:

1. Served as resource person in the 'Certificate Course in Advanced Plant Tissue Culture' organized under the CSIR-IICB Skill Development Programme 2017-18.
2. Chaired a technical session" in the 18th AICCG Meeting held in the IICB from 29th to 31st January, 2018.

Group Members

Pankaj Kumar Singh

i) presented posters on "Molecular characterization of VmMAPK1 and deciphering its role in restricting MYMIV multiplication in tobacco" in the 18th AICCG Meeting held in the IICB from 29th to 31st January, 2018.

ii) delivered a talk on"Identification and functional prediction of long non coding RNAs (lncRNAs) from transcriptomedata of blackgram(*Vigna mungo*)" in the UGC-CAS VII sponsored National Seminar on "New Horizons of Integrative Biology", held at the Calcutta University, Kolkata-700019 on 30th March, 2018.

Awards and Honours

Elected Editor of 'The Nucleus' journal, Springer

Dr. Samir R. Sikdar

Professor & Coordinator,
Rural Biotechnology Programme

Scientific Reports

Proteomic and transgenic approach for developing aphid tolerance in *Brassica juncea*

Aphid tolerance level among ten *Brassica juncea* cultivars was performed last year, and it was found that cv. Ashirwad as the most tolerant and cv. Pusa Mahak as the most susceptible lines. Proteomic analysis between these two lines was done in the backdrop of wild crucifer *Rorippa indica*. With the help of high performance proteomic tool (Liquid-Chromatography Mass Spectrometry; LCMS), we were able to identify more than thousand proteins during the aphid attack. From this study, we identified at least 42 proteins as defence related. Among these proteins 34 are common in all of the plants, rest of the 8 proteins are solely expressed after the aphid infestation in *R. indica*. The validation of their expression at gene level is under study.

Besides, we found that the HSPRO2, a defence related gene from *Rorippa indica* (KF431829) is biologically safe and hence the gene was successfully transformed into susceptible *Brassica juncea* plants through *Agrobacterium*-mediated transformation for development of aphid tolerant *B. juncea* lines. CD spectroscopic analysis showed that secondary structural component of the protein

constituted abundance of helices. Generation advancement and analysis of segregation pattern revealed Mendelian segregation ratio for the RiHSPRO2 gene. Histochemical staining for GUS expression assay and Western blotting with anti-RiHSPRO2 antibody of total protein from plants of T1 lines confirmed expression of the gene in transgenic plants. Evaluation of transgenic plants for aphid tolerance showed mean aphid survivability percentage was in the range of 58.33% to 45% for the T1 lines expressing RiHSPRO2 compared to the vector control wherein 76.67% aphids survived. *In planta* aphid bioassay depicted a decrease in the surge of the aphid population. The mean aphid fecundity was 59.2% to 45.6% in the plants of T1 line compared to the control plant.

Publications:

1. Debnath AJ, Gangopadhyay G, Basu D and Sikdar SR (2018) An efficient protocol for in vitro direct shoot organogenesis of *Sesamum indicum* L. using cotyledon explant. 3 *Biotech* 8(3): 146.
2. Mallick P, Chattaraj S and Sikdar SR (2017) Molecular characterizations of Somatic hybrids developed between *Pleurotus öorida* and *Lentinus squarrosulus* through inter-simple sequence repeat markers and sequencing of ribosomal RNA-ITS gene. 3 *Biotech* 7(5):298.
3. Sarkar P, Jana K and Sikdar SR (2017) Overexpression of biologically safe *Rorippa indica* defensin enhances aphid tolerance in *Brassica juncea*. *Planta 246* (5): 1029-1044.

Grant-In-Aid Scheme

Title of the Scheme	Scheme funded by
Proteome analysis during *Lipaphis erysimi- Rorippa indica* interaction to identify putative proteins responsible for aphid tolerance and their interacting partners	CSIR

Participation in Conferences/Symposia/Workshops & Invited Talks delivered at various organizations:

(i) Delivered an invited talk on "Scheduled Tribe Specific Rural Biotechnology Programme: Rain water harvesting and its uses" in a one day seminar organised by NASI Kolkata Chapter on "Safe Water, Sanitation and Conservation" held during January 16-17, 2018 at Ramananda College, Laulara, Puncha, Purulia.

(ii) Delivered an invited talk on "Scheduled Tribe Specific Rural Biotechnology Programme with special reference to Mushroom Spawn production and Mushroom Cultivation" in a one day workshop on "Mushroom Cultivation" organised by Department of Botany, Schottish Church College, Kolkata, on 20th February 2018.

(iii) Delivered a talk on "Scheduled Tribe Specific Rural Biotechnology Programme" on 11th August 2017 at Sunderban Shramajibi Hospital, Sarberia, South 24 Parganas.

(iv) Delivered an invited talk in a one day seminar on "Sustainable Organic Farming" on "Scheduled Tribe Specific Rural Biotechnology Programme with special reference to sustainable organic farming, vermicompost production, mushroom cultivation and bee-keeping" at Santipur library auditorium he on 2nd February 2018 organised by an NGO, "Santipur Marami", Santipur, Nadia.

(v) Organised as Organising Secretary a three day conference on "Rural Biotechnology Programme and Economic Development of Scheduled Tribe People, Present Status & Future" organised by Falta Experimental Farm, Bose Institute as a part of Centenary Celebration of Bose Institute from 11-13 February, 2018.

Awards and Honours Received

i) Nominated Fellow of West Bengal Academy of Science & Technology in 2018.

ii) In 2017 "Ebela" the Bengali newspaper (ABP Publication Group, Kolkata) honoured Dr. S.R. Sikdar as one of the 10 citizens of West Bengal with "Ami Amar Mato Samman" as recognition for harvesting and utilizing rain water for drinking and other purposes for last 16 years and implementing this technology in the rural tribal areas through Bose Institute's Scheduled Tribe-Specific Rural Biotechnology Programme.

DISTINGUISHED LECTURE

Distinguished talk delivered by **Dr. Sankar Adhya,** NIH, USA on "A DNA Centric View of Gene Expression from Chromosome" during January 25, 2018 at 3:00 PM in the Lecture Hall of the Main Campus of the Institute on the occasion of Centenary Celebration of the Bose Institute.

II. Structural Studies and Biophysical Problems

Participation in Institutional Project II

Dr. Gautam Basu (Coordinator), Dr. Pinakpani Chakrabarti, Dr. R. Chattopadhyaya, Dr. Jayanta Mukhopadhyay, Dr. Anirban Bhunia, Dr. Ajit Bikram Dutta, Dr. Subhrangsu Chatterjee, Dr. Siddharta Roy

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

Professor and Co-ordinator

Scientific Reports

Structure Function of GluRS : *in collaboration with Ajitbikram Dutta*

We had previously crystallized GluRS from *E. coli* but due to poorly diffracting crystals, the structure could not solved. We have now solved the structure. Analysis of the structure and its correlation with functional idiosyncrasy is ongoing. In addition, we have also solved the crystal structure of GluRS from the thermophilic bacterium *Methylacidiphilum fumario*licum. Co-crystallization of the M. *fumario*licum with tRNA is in progress. The structures will soon be deposited to pdb.

NMR studies of small molecule – DNA interaction: *in collaboration with Prof. T. Govindraju, JNCSAR, Bangalore*

We have been investigating the mode of DNA binding and the DNA-bound structures for two newly developed NIR turn-on probes, QCy-DT and TC. We have probed the interactions of TC and QCy-DT with a short self-complementary sequence D1 (5'-CGCGAATTCGCG-3') and N1 (5'-CGCGAAATTTCGCG-3') using ^{1}H NMR spectroscopy and fluorescence spectroscopy. The DNA-bound structure of QCy-DT has been solved and is in the process of deposition to pdb. The DNA binding mode of QCy-DT was found to be complex and slow revealing several subtleties associated with fluorescence enhancement and minor groove binding by QCy-DT. A manuscript is being written.

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

Invited lectures

i. Delivered an invited lecture at district school program for middle school students of West Bengal, JBNSTS, Kolkata, July 14, 2017.

ii. Delivered an invited lecture at the 55th Annual Meeting of the Biophysical Society of Japan, Kumamoto, Japan, September 20, 2017

iii. Delivered an invited lecture at SCBDD-2017 "Chemical Biology and Drug Discovery ", Bose Institute, Kolkata, October 31, 2017.

iv. Delivered an invited lecture at District level residential science camp, Sekendarpur Rai K. P. Pal Bahadur High School, Khanakul, Hoogly, December 14, 2017.

v. Delivered an invited lecture at Salter's Camp (Science Camp for School students), IISER, Kolkata, December 20, 2017

vi. Delivered an invited lecture at district school program for middle school students of West Bengal, JBNSTS, Kolkata, February 20, 2018.

vii. Delivered an invited lecture at a Workshop on CRISPR Cas9 based Genome Editing, IGIB, New Delhi, March 13, 2018.

Talks delivered by BI faculty at other Institutes

i. Delivered an invited Colloquium lecture at Indian Association for the Cultivation of Science, Kolkata, March 12, 2018.

Dr. Anirban Bhunia

Associate Professor

Scientific Reports

Membrane-protein/peptide Interaction Study Using Nuclear Magnetic Resonance (NMR) Spectroscopy

Dr. Bhunia uses both solution and solid state NMR spectroscopy extensively along with other biophysical techniques for the study of membrane-protein/peptide interactions. Particularly, his work concerns areas such as the development of novel antimicrobial peptides for multi-drug resistant bacteria, understanding neurodegenerative diseases like Alzheimer and Parkinson and design of inhibitors against them and the study of the problem of amyloidogenesis. In addition, he also uses live cell NMR experiments to understand antimicrobial activity.

Publications

1. Chowdhury R, Ilyas H, Ghosh A, Ali H, Ghorai A, Midya A, Jana NR, Das S S, Bhunia A (2017) Multivalent Gold nanoparticle - Peptide Conjugates for Targeting Intracellular Bacterial Infection. *Nanoscale* 9(37), 14074-14093.
2. Ghosh A, Bhattacharyya D, Bhunia A (2018) Structural Insights of a Self-assembling 9-Residue Peptide from the C-terminal tail of the SARS Corona Virus E-protein in DPC and SDS Micelles: A Combined High and Low Resolution Spectroscopic Study. *BBA – Biomembrane* 1860, 335-346.
3. Ghosh A, Pradhan N, Bera S, Datta A, Krishnamoorthy J, Jana N R, Bhunia A (2017) Inhibition and Degradation of Amyloid Beta (Aβ40) Fibrillation by Designed Small Peptide: A Combined Spectroscopy, Microscopy and Cell Toxicity Study. *ACS Chem Neuroscience* 8, 718-722.
4. Mukherjee S, Kar RK, Nanga RPR, Mroue KH, Ramamoorthy A, Bhunia A (2017) Accelerated Molecular Dynamics Simulation Analysis of MSI-594 in Lipid Bilayer. *Phys Chem Chem Phys*. 19, 19289-19299.
5. Singh S, Datta A, Bruno B, Davoudi M, Schmidtchen A, Bhunia A, Malmsten M (2017) Conformational aspects of high content packing of antimicrobial peptides in polymer microgels. *ACS Applied Material and Interface* 9(46), 40094-106.

Dr. P. Chakrabarti

Professor

Scientific Reports

Antimicrobial activity of ZnO nanoparticles against *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.** While exploring the possibility of using zinc oxide (ZnO) nanoparticles (NPs) in cholera treatment, we previously found that ZnO NPs reduce fluid accumulation in mouse ileum induced by the cholera toxin (CT) protein. To uncover the mechanism of action of ZnO NPs on CT activity, we used classical (O395) and El Tor (C6706) *V. cholerae* biotypes in growth and biochemical assays. We found that a ZnO NP (size < 100 nm), concentration of 10 μg/ml did not affect the growth rates of these two strains, nor did we observe that ZnO NPs reduce the expression levels of CT mRNA and protein. It was observed that ZnO NPs form a complex with CT, appear to disrupt the CT secondary structure, and block its interaction with the GM1 ganglioside receptor in the outer leaflet of the plasma membrane in intestinal (HT-29) cells and thereby reduce CT uptake into the cells. In the range of 2.5–10 μg/ml, ZnO NPs exhibited no cytotoxicity on kidney (HEK293) and HT-29 cells. It appears that ZnO NPs prevent the first step in the translocation of cholera toxin into intestinal epithelial cells without exerting measurable toxic effects on HEK293 and HT-29 cells.

Publications

1. Chakraborti S, Chakraborty S, Saha S, Manna A, Banerjee S, Adhikary A, Sarwar S, Hazra TK, Das T and Chakrabarti P (2017) PEG-functionalized zinc oxide nanoparticles induce apoptosis in breast cancer cells through reactive oxygen species-dependent impairment of DNA damage repair enzyme NEIL2. *Free Radical Biology & Medicine*, 103, 35-47.
2. Jana TK, Pal A, Mandal AK, Sarwar S, Chakrabarti P and Chatterjee K (2017) Photocatalytic and antibacterial performance of α-Fe_2O_3 nanostructures. *Chemistry Select* 2, 1-11 (DOI: 10.1002/slct.201700294).
3. Maji A, Beg M, Mandal AM, Das S, Jha PK, Kumar A, Sarwar S, Hossain M and Chakrabarti P (2017) Spectroscopic interaction study of human serum albumin and human haemoglobin with *Mersilea quadrifolia* leaves extract mediated silver nanoparticles having antibacterial and anticancer activity. *J Mol Struct*, 1141, 584-592.
4. Sarwar S, Ali A, Pal M and Chakrabarti P (2017) Zinc oxide nanoparticles provide anti-cholera activity by disrupting the interaction of cholera toxin with the human GM1 receptor. *J Biol Chem*, 292 18303-18311.

Dr. Subhrangsu Chatterjee

Associate Professor

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.

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)

US20160023996 (US Application granted)

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, Mondal S, Sengupta P, and Chatterjee S S Chatterjee* (2017) In Silico Screening and Binding Characterization of Small Molecules toward a G-Quadruplex Structure Formed in the Promoter Region of c-MYC Oncogene. *ACS Omega 2* (8), pp 4382–4397.
2. Bhunia D, Mondal P, Das G, Saha A, Sengupta P, Jana J, Mohapatra S, Chatterjee S, Ghosh S (2018). Spatial Position Regulates Power of Tryptophan: Discovery of a Major-Groove-Specific Nuclear-Localizing, Cell-Penetrating Tetrapeptide. *J Am Chem Soc.* Feb 7;140(5):1697-1714. IF = 14.4
3. Jana S2,*, Jana J 1 ,*, Patra K2, Mondal S1, Bhat J 1, Sarkar A 2, Sengupta P 1, Biswas A 3, Mukherjee M 1, Tripathi S P, Gangwal R 5, Hazra J 6, Sangamwar A T. 7 Mukherjee G 4, Bhattacharjee S 2*, Mandal D P 2* and Chatterjee S *(2017) LINCRNA00273 promotes cancer metastasis and its G-Quadruplex promoter can serve as a novel target to inhibit cancer invasiveness. *Oncotarget* Nov 17;8(66):110234-110256. IF = 5.2.
4. Jana J, Mondal S, Bhattacharjee P, Sengupta P, Roychowdhury T, Saha P, Kundu P, Chatterjee S (2017) Chelerythrine down regulates expression of VEGFA, BCL2 and KRAS by arresting G-Quadruplex structures at their promoter regions. *Sci Rep*. Jan 19;7:40706.IF = 5.2.
5. Jana J, Sengupta P, Mondal S and Chatterjee S * (2017) Restriction of telomerase capping by short non-toxic peptides *via* arresting telomeric G-quadruplex. *RSC Advances* 7, 20888.IF = 3.2,
6. Mukherjee M, Jana J and Chatterjee S *(2017) Small Molecule impedes Insulin fibrillation; a new role of Phenothizine Derivative. *Chemistry Open* Dec 7;7(1):68-79.IF = 3.0.
7. Sengupta P, Chattopadhyay S, Chatterjee S* (2017) G-Quadruplex surveillance in BCL-2 gene: a promising therapeutic intervention in cancer treatment. *Drug Discov Today*. pii: S1359-6446(17)30245-3. IF = 6.4.
8. Taye N, Alam A, Ghorai S, Chatterji DG, Parulekar A, Mogare D, Singh S, Sengupta P, Chatterjee S, Bhat MK, Santra MK, Salunkhe PB, Finston SK, Chattopadhyay S*(2018) SMAR1 inhibits Wnt/β-catenin signaling and prevents colorectal cancer progression. *Oncotarget*. Apr 20;9(30):21322-21336. IF = 5.2.

Dr. Tanaya Chatterjee

DST-Women Scientist

Scientific Reports

Structure and function of *Vibrio cholerae* accessory cholera enterotoxin in presence of gold nanoparticles: Dependence on morphology

Accessory cholera enterotoxin (Ace) is a classical enterotoxin produced by *Vibrio cholerae*, the causative agent for cholera. Considering the crucial role of Ace in pathogenesis of cholera, we explored

the modulation of structure/function of Ace using gold nanoparticles (AuNPs) of different size and shape – spherical (AuNS10 and AuNS100, the number indicating the diameter in nm) and rod (AuNR10). Biophysical data revealed degradation of Ace by AuNR10 and AuNS100, not by AuNS10. The feature of AuNR10 having high aspect ratio, but with the same transverse diameter as that of AuNS10 enabled us to explore the importance of morphology on modulation of protein structure/function. The equilibration time for adsorption shows dependence on the radius of curvature, being largest for AuNR10. *In vivo* experiments revealed the efficacy of AuNR10 and AuNS100 for reduced fluid accumulation, indicative of the loss of activity of Ace.

Modelling of growth kinetics of *Vibrio cholerae* in presence of gold nanoparticles

We have carried out the antibacterial efficacy of AuNPs of different size and shape against the classical (O395) and El Tor (N16961) biotypes of Vibrio cholerae, the etiological agent responsible for cholera. Growth kinetics was monitored by measuring optical density at different time intervals and fitted by non-linear regression of modified Buchanan model. Sigmoidal growth curve for VcO395 indicated the existence of single phenotype population and was affected by AuNR10 only. Growth of *Vc*N16961 was affected by all three AuNPs indicating the vulnerability of El Tor biotype. Interestingly, *Vc*N16961 exhibited the occurrence of two phenotypic subpopulations – one with shorter (vulnerable Type 1) and the other with extended (tolerant Type 2) lag phase. Apart from AuNR10, antimicrobial efficacy of AuNS10 was better compared to AuNS100.

SCIENTIFIC REPORT

Publications

1. Chatterjee T, Chatterjee B, Saha T, Hoque KM and Chakrabarti P (2017) Structure and function of *Vibrio cholerae* accessory cholera enterotoxin in presence of gold nanoparticles: Dependence on morphology. *Biochim. Biophys. Acta*, 1861, 977-986.
2. Chatterjee T, Chatterjee BK and Chakrabarti P (2017) Modelling of growth kinetics of *Vibrio cholerae* in presence of gold nanoparticles: effect of size and morphology. *Scientific Reports*, 7: 9671.

Grants- in -Aid Schemes

Title of the scheme	Funding agency
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

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

i) Delivered an oral presentation at the 42nd Annual Meeting of the Indian Biophysical Society, IISER, Pune, March 9-11, 2018.

Seminars/ Symposia Organized at Bose Institute:

i) The Bioinformatics Centre of Bose Institute organized an one-day Conference on Biological Big Data Analysis on September 15, 2017.

ii) **Conference organized (in protein structure) under the Centenary Celebration**

The 23rd INPEC Meeting: Protein Structure, Function and Engineering (INPEC 2017), Unified Campus of Bose Institute, November 9-11, 2017.

Dr. Rajagopal Chattopadhyaya

Professor

Scientific Reports

Crystal structure of *Colocasia esculenta* lectin solved with mannose:

The structure and its solution were described in some detail in last year's annual report. 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. The manuscript describing this crystal structure was being written from December 2017 onwards.

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

i) Delivered lectures at the third Glycobiology World Congress, June 26-28, London, UK and presented the crystallographic and biophysical investigations from his group on the *Colocasia esculenta* lectin.

ii) Delivered lecture at the International Conference on Cancer Biology, on the anticancer activities of various Indian plant extracts, on September 18-19, Philadelphia, USA.

Students awarded Ph.D.

Name of Student (University/ Year)	Title of thesis
Indrani Kar (C.U., 2018)	Influence of Plant Extracts on Fenton-Reaction Mediated DNA Damage and Studies on RecA

Dr. Ajit Bikram Datta

Associate Professor

Scientific Reports

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

Conjugation of ubiquitin to diverse substrates is a remarkably conserved post-translational modification of all eukaryotes. Research in the last two decades have established that ubiquitination

plays critical roles in almost all cellular processes including proteostasis, transcription regulation, genome fidelity via DNA repair, and cell-cycle progression. It is therefore imperative that defects in ubiquitination pathways have been found to cause diverse diseases that includesneurodegenerative disorders and various types of cancers. Ubiquitin itself is a small 76 amino acid polypeptide that shows remarkable sequence conservation across species. In fact, ubiquitin from Baker's yeast and human differ only in two amino acid positions. Similarly, ubiquitin conjugation pathways are also conserved across organisms.Three enzymes, namely activating E1, conjugating E2 and ubiquitin E3 ligases, ubiquitinates a diverse variety of substrate proteins in a spatio-temporally regulated manner. In the first step, the activating E1 protein activates the C-terminal carboxyl group of ubiquitin in an ATP-dependent manner. In the next step, this activated ubiquitin molecule is transferred to one of the forty conjugating E2s via formation of a thioester intermediate. In the final step of the reaction, E3 ligases interact with the E2~Ubiquitin thioesters to transfer the ubiquitin to their specific substrates via isopeptide bond formation with ε-NH2 group of lysine sidechain. Human genome codes for about 1000 E3 enzymes, which, in combination with the forty E2s modify the wide variety of substrates. Thus the spatio-temporal specificities of E3-E2 and E3-substrate interaction and their regulations are crucial to elicit the desired the biological reaction.

We have undertaken multiple research projects to understand diverse aspects of ubiquitination machinery and their regulation that are briefly described below along with achievements in the year 2017-2018.

A) Structural Basis of E2 discrimination by RING E3 ligases

Binding of E2 to E3 enzymes is a crucial step of ubiquitination as E3s dictate the substrate specificity while E2s determine the modification topology. It was generally accepted that the E2 residues that constitute the E3-binding surface are exclusively responsible for dictating the E3:E2 specificity. In the last year we observed that ZNRF1, a human RING E3 ligase, binds to its cognate E2, Ube2N, with an unprecedented affinity of ~40 nM. We had also determined the crystal structure of ZNRF1:Ube2N complex at 1.47 Åresolution that helped us to delineate the basis of this unprecedented high affinity. We observed that Ube2N contains a arginine residue (Arg14) that forms salt-bridge interactions with Glu183 of ZNRF1 and thus mutating this Arg14 in Ube2N reduced the affinity its affinity towards ZNRF1. We further observed that mutation of no other residue in the binding surface of Ube2N could cause such reductions in their affinity. We extended this work further to understand the basis of E2 discrimination by ZNRF1. In particular, we were interested to understand why ZNRF1 fails to bind Ube2B, another E2, that apart from containing the Arginine as in Ube2N also has a conserved E3 binding interface. Interestingly, our experiments led to us to conclude that a glutamic acid to aspartic acid substitution away from the binding site brought subtle changes in Ube2B structure leading to its poor affinity towards ZNRF1 (Figure 1a). Thus, mutation of the Asp to Glu led Ube2B to bind ZNRF1 with Ube2N-like affinity (Figure 1b & c). We further observed that the effect of this Asp residue is not ZNRF1 specific, rather Ube2B shows a restricted E3 binding due to this conserved substitution. Conversely, we found that mutating Glu to Asp in other E2s also reduced their affinity towards their cognate E3s.

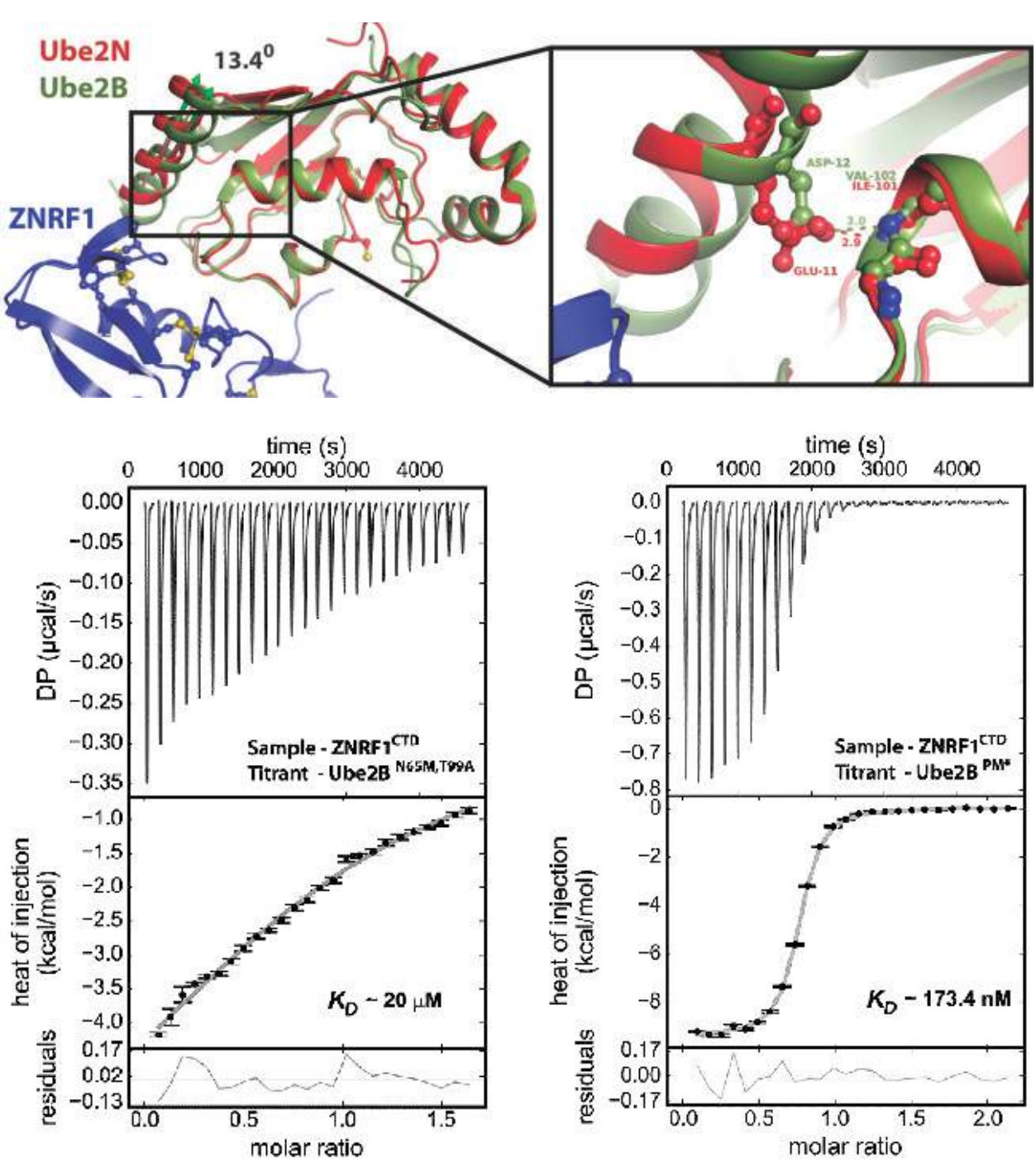


Figure 1.(**A**) A structural alignment highlighting the subtle difference between Ube2N (red) and Ube2B (green). ZNRF1 bound to Ube2N is shown in blue. The inset shows that the difference in the orientation of the N-terminal helices occurs due to the Glu to Asp substitution. (B &C) Isothermal titration calorimetry showing that correcting the surface in Ube2B resulted in poor affinity towards ZNRF1, whereas introduction of the Asp to Glu mutation allowed the E2 to bind ZNRF1 with high affinity.

B) Residue specific insights into the activity of E3 ligases

Research carried out by multiple groups with quite a few RING E3 ligases revealed that these E3s critically require a tryptophan residue at their E2 binding site for ubiquitination activity. Interestingly, there also exist examples of active E3 ligases that lack that specific tryptophan residue in the corresponding position. To solve this apparently conflicting information, we resorted to database analyses and found that most monomeric RING E3s contain this tryptophan whereas almost all of the dimeric E3s lack that residue (Figure 2a). This remarkable correlation between the oligomeric status of a protein and conservation of a particular amino acid led us to hypothesize that the presence of the tryptophan is most likely detrimental for the dimeric E3s. To test this, we carried out experiments with multiple RING E3s, both monomeric as well as dimeric to find that indeed introduction of the Trp residue makes dimeric E3s hyperactive as this enables them to bind both the E2 and the ubiquitin moieties of E2 ~ Ubiquitin thioester conjugates with high affinity. On the other hand, most monomeric E3s interact only weakly with the ubiquitin and therefore compensates that with strong E2 affinity via the presence of tryptophan. Thus introduction of the tryptophan alleviates the need of dimerization for dimeric E3 ligase RNF4 and allows it to undergo ubiquitination as a monomer (Figure 2b).

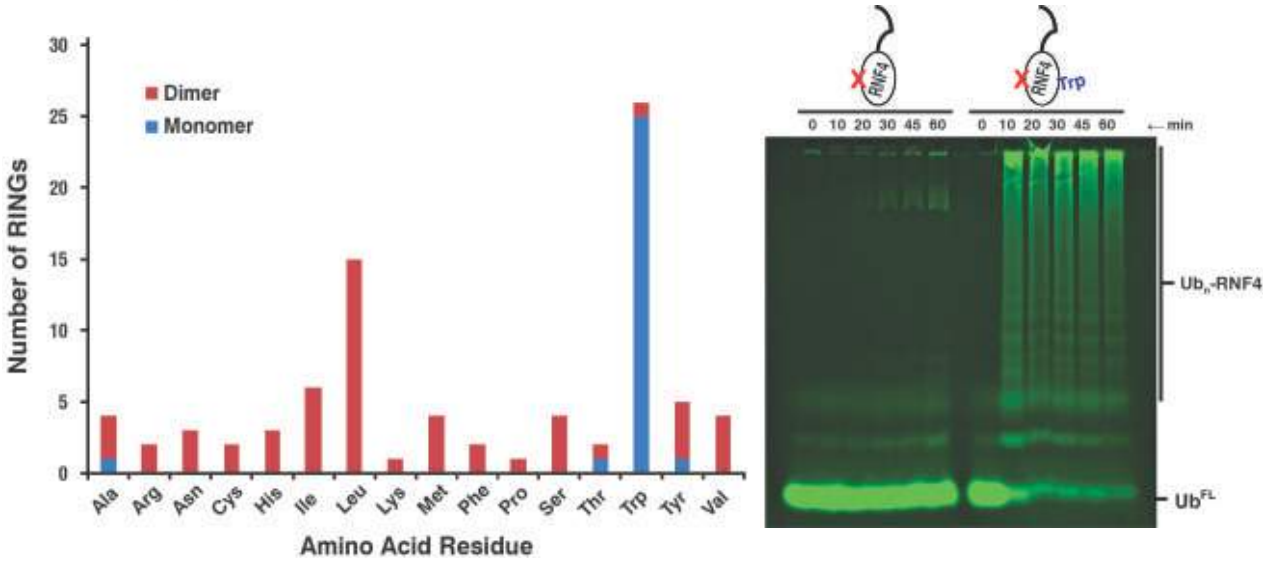


Figure 2.(**A**) RING E3 ligases classified according to the amino acids found in their E2-binding site. All monomeric RINGs are represented with blue while the dimeric ones with red. (**B**) Monomeric wtRNF4 is inactive (absence of smear) whereas the same protein shows robust ubiquitination activity upon introduction of the E2-binding tryptophan.

Publication

1. Behera AP, Naskar P, Agarwal S, Banka PA, Poddar A, **Datta AB** (2018) Structural insights into the nanomolar affinity of RING E3 ligase ZNRF1 for Ube2N and its functional implications. *Biochem J*. 475(9):1569-1582. doi: 10.1042/BCJ20170909.

Dr. Jayanta Mukhopadhyay

Associate Professor

Scientific Reports

The 'σ cycle' in *Bacillus subtilis*

A "σ cycle" in which the initiation factor σ associates with RNA polymerase (RNAP) to permit transcription initiation and dissociates from RNAP to permit transcription elongation, has been proposed to occur, and to be an essential step for σ exchange, with all principal σ factors from all bacteria. These proposals were based on studies of the principal σ factor of *Escherichia coli*, σ^{70}, which generally, albeit not obligatorily, released from RNAP upon the transition from transcription initiation to elongation. Here, we show that, in contrast to *E. coli* ^{70,} the *B. subtilis principal factor,* σ^{A}, is not released and is retained on RNAP throughout transcription elongation. We show further that a mutant *E. coli* σ^{70} derivative lacking region 1.1 (σR1.1) is not released and is retained on throughout transcription elongation. We further show that *B. subtilis* σ^{A} and the mutant *E. coli* σ^{70} derivative lacking R1.1 interact much more tightly than wild-type *E. coli* σ^{70}. Our results indicate that the "σ cycle" is neither a universal nor an obligatory phenomenon in bacteria

Dr. Smarajit Polley

Assistant Professor

Scientific Reports

We intend to understand cellular events in finer details using a number of experimental approaches including (but not limited to): cryo-Electron Microscopy, X-ray crystallography, Mass spectrometry, Chemical biology, Molecular biology, and cellular and *in vitro* biochemistry. Our primary focus at this moment is to understand the underlying structural and biochemical bases of signaling modularity displayed by eukaryotic protein kinases. We are also trying to understand what structural features in some eukaryotic transcription factors make them go awry by interacting with other proteins in the cells that give rise to a disease state.

Grants-in-Aid Schemes:

Title of Scheme	Scheme funded by
Understanding the Biochemical and Structural Basis of Signaling Modularity of Kinases in Their Biological Context.	Wellcome Trust/ DBT India Alliance

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

1. Invited talk at EMSI (Electron Microscopy Society of India) 2017 meeting; July 17-19, 2017 at Mahaballipuram.

2. Invited talk at EMSI 2017 Post-conference workshop; July 20, 2017 at Mahaballipuram.
3. Invited talk at Acharya Prafulla Chandra Roy Memorial Lecture; August 3, 2017 at Mugberia College, PurbaMedinipur.
4. Invited talk at The 23rd INPEC Meeting: Protein Structure, Function and Engineering; November 9-11, 2017 at Bose Institute.

***Seminars / Symposia organized at Bose Institute*:**

1. The 23rd INPECMeeting: Protein Structure,Functionand Engineering; November 9-11, 2017 at Bose Institute, Member (Organizing Committee).
2. International Symposium on Systems, Synthetic and Chemical Biology (SSC2017); December 5-7, 2017 at Bose Institute, Joint Treasurer.
3. Indo Japan Conference on Epigenetics and Human Disease, February 7-9, 2018 at Bose Institute, Member (Organizing Committee).

III. Computational Biology

Participation in Institutional Projects III

Dr. Tapas Chandra Ghosh (Coordinator), Dr. Gautam Basu, Dr. R. Chattopadhyaya, Dr. Tapan Dutta, Dr. Debjani Roy, Dr. Pinakpani Chakrabarti, 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

Professor

Scientific Reports

Machine learning models to classify hormone-related cancers: *in collaboration with Dr. Debamitra Chakravorty*

Supervised machine learning techniques and Analytical Hierarchical Process (AHP) were applied for the first time on four paired cancer genomic datasets covering androgenic cancers and leukemia. It was observed that the AHP method outperformed many machine learning algorithms for most of the cancer datasets. Interestingly, synonymous mutations and position of mutations in a gene were found to be the most important features in classifying all the four paired cancer datasets. **Best classification accuracy was obtained for breast and leukemia dataset (AUC: 0.96).** Further, observation of a high rank difference between a common gene, belonging to different cancer types,

implied the existence of mutation type dependent differentiation. Correlating high priority genetic lesions with biological and signal transduction pathways further showed myriad of differences and similarities among androenic cancers and leukemia. Our results show the existence of cross cancer heterogeinity related to mutational types and can be used to develop targetted therapies.

Identification of novel inhibitors against S100A4 receptor causing Oral Cancer: *in collaboration with Dr. Vishwambhar Bhandare and Dr. Debamitra Chakravorty*

Collection of small molecule drug like compounds were carried from Zinc 15 database and Commercially available compounds (CAC) libraries. A total of 43,03,101 (CAC) and 186,90,369 (Zinc 15) compounds were subjected to ligand screening. The ligands were initially screened for their ADME and toxicity properties using Schrodinger Suite. Screening using Qikprop for Lipinski, ADME and toxicity, reactive groups screened 152,70,224 small molecules. Further these molecules have been subjected to Virtual screening using the Glide interphase of Schrodinger suite. The results from the XP docking would be analyzed further to explore the intermolecular interactions and binding affinity between the S100A4 and the ranked hits.

Dr. P. Chakrabarti

Professor and Coordinator

Scientific Reports

Structural changes accompanying protein-DNA complex formation

To delineate features that characterize protein-protein interactions is a long-standing theme in our group. We have extended the work to protein-DNA interaction, and analyzed the unbound (U) and the bound (B) forms of proteins in 66 binary protein-DNA complexes. Proteins binding DNA undergo greater structural changes on complexation (in particular, those in the enzyme category) than those involved in protein-protein interactions (PPI). While interface atoms involved in PPI exhibit an increase in their solvent-accessible surface area (ASA) in the bound form in the majority of the cases compared to the unbound interface, protein-DNA interactions indicate increase and decrease in equal measure. In 25% structures, the U form has missing residues which are located in the interface in the B form. Consideration of flexibility cannot distinguish the interface residues from the surface residues in the U form.

Publication

1. Podder S, Chakravarty D and Chakrabarti P (2018). Structural changes in DNA-binding proteins on complexation. *Nucleic Acids Res*. 46, 3298-3308 (doi: 10.1093/nar/gky170).

Students Awarded PhD:

Name of Student (University/ Year)	Title of Thesis
With Prof. B. Bhattacharya as co-guide Gopa Dhar (C.U., 2017)	Interaction of small molecules with proteins and peptides involved in macromolecular assembly

Grants –in- Aid Scheme:

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

Participation in Conferences / Symposia / Workshops & Invited Talks delivered at various organizations:

1. Presented papers/attended at
   (i) The National Conference, Breaking barriers through bioinformatics & computational biology. IIT Delhi, July 31-Aug 1, 2017.
   (ii) IUCr Satellite Meeting, Crystallography and Society, Pune, August 29-30, 2017.
   (iii) the 23rd INPEC Meeting: Protein structure, function and engineering, Bose Institute, November 9-11, 2017.
   (iv) the Guha Research Conference, Kumarakom, December 2-6, 2017.
   (v) National Workshop on Structural applications on high throughput data analysis, University of Kalyani, February 20-21, 2017.
2. Chaired (vi) keynote address at the 24th Congress and General Assembly of IUCr, August 21-28, 2017.
3. Delivered (vii) JC Bose Medal (INSA) oration at Bidhan Nagar College, December 19, 2017.

Group Members:

Shamila Sarwar attended the 42nd FEBS Congress, From Molecules to Cells and Back, Jerusalem, Israel, September 10-14, 2017.

Dr. Tanaya Chatterjee, Dr. Swapan Jana, Shamila Sarwar, Jesmita Dhar, Supriyo Bera, Manish Sarkar attended the 23rd INPEC Meeting: Protein structure, function and engineering, Bose Institute, November 9-11, 2017.

Dr. Shubhra Ghosh Dastidar

Associate Professor

Scientific Reports

Structural dynamics of biomolecules, understanding the molecular mechanism and making applications

The primary 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. In recent time we have focused our investigations on the allosteric activation of Bcl2 family of proteins, which have a regulatory control on the apoptosis. We are also working in the Tubulins and microtubules to understand their mechanism of control apoptosis. We address those scientific questions which the experimental probes are yet to answer and therefore we use computational methods to carry out the investigations. The following is a brief outline of the recent achievements:

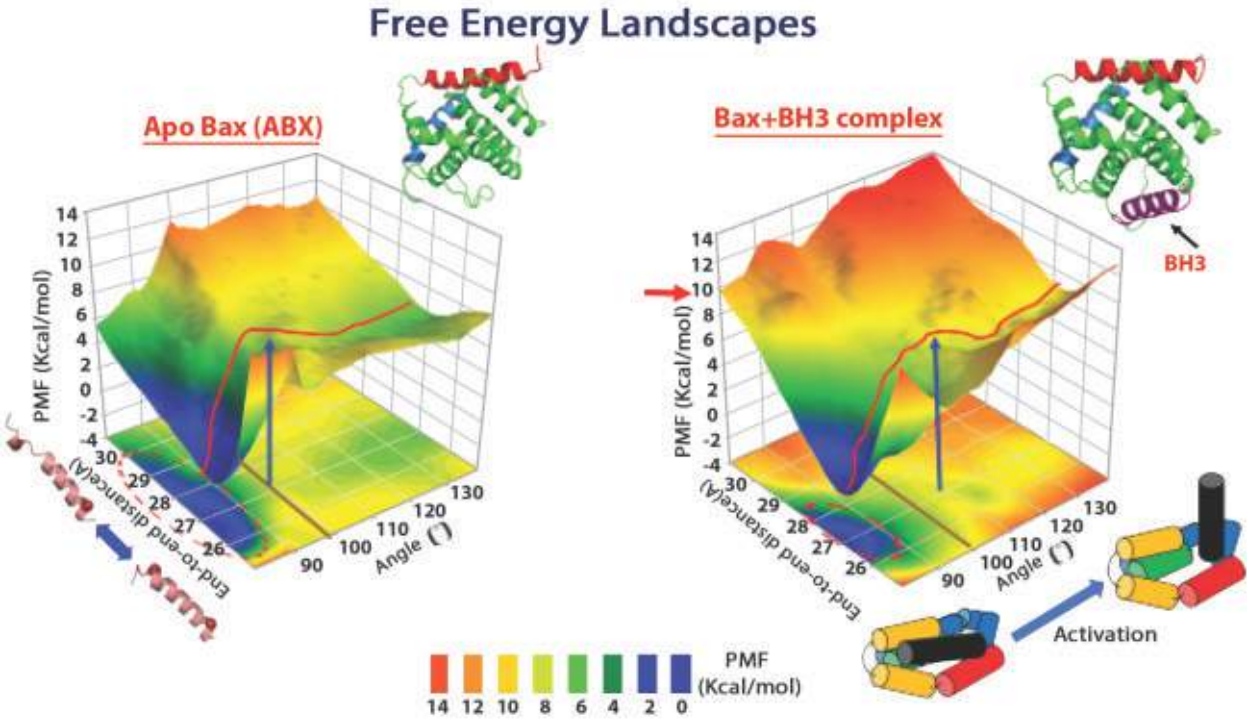


Figure 1: Free energy (PMF) landscapes of the activation of BAX and the comparison between the nature of landscapes for the Apo and liganded BAX. (J Chem Inf Model. 2018)

As shown the Fig 1, the free energy (PMF) landscape of the release of the helix for the binding pocket of BAX, which is the process of its activation, was computed using Molecular dynamics based method. The same was done for the apo BAX and also for the BAX when it is associates a BH3 peptide on the rear side of the binding pocket. The computation reveals that the BH3 binding

helps the activation by reducing the energy barrier for the helix release process. This mechanistic insight adds to the fundamental understanding of the meolcular mechanism that controls apoptosis.

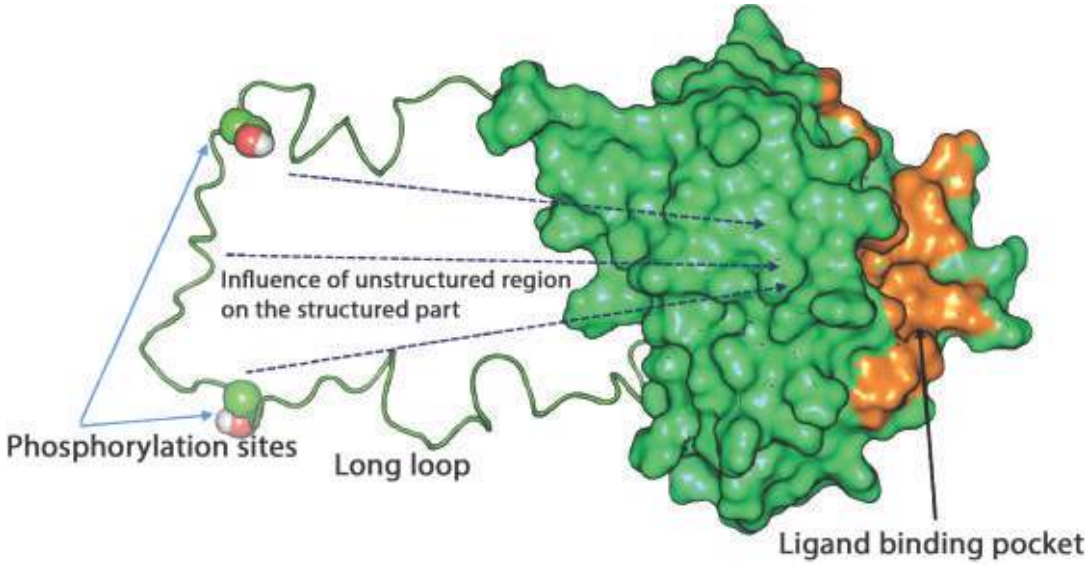


Figure 2: Bcl-xl has an unstructured regions attached to its structured region. The unstructured region contains phosphorylation sites (Serine residues) and has the capacity to influence the ligand binding pocket through allostery. (Proteins. 2017)

As shown in Fig 2, it was computationally predicted that the long and disordered region of Bcl-xl allosterically influence the ligand binding pocket. This influence is dominated by the electrostatic interactions and the phosphorylation of certain serine residues on the flexible loop strengthens the allosteric influence. This mechanism was first predicted form the computation and later experimentalists found it to me correct [Nature Chemical Biology 14, 458–465 (2018)]

Publications

1. Basak P, Maitra-Majee S, Das JK, Mukherjee A, Ghosh Dastidar S, Pal Choudhury P, Lahiri Majumder A (2017). An evolutionary analysis identifies a conserved pentapeptide stretch containing the two essential lysine residues for rice L-myo-inositol 1-phosphate synthase catalytic activity, *PLoS One*. 12(9):e0185351.
2. Priya P, Maity A, Ghosh Dastidar S (2017). The long unstructured region of Bcl-xl modulates its structural dynamics, *Proteins*. 85(8):1567-1579.
3. Sinha S, Maity A, Ghosh Dastidar S (2018) BIM Binding Remotely Regulates BAX Activation: Insights from the Free Energy Landscapes. *J Chem Inf Model*.;58(2):370-382.

Grants-in-Aid Scheme

Title of the Scheme	Scheme funded by
Mechanistic insight into the ligand induced perturbation on the intrinsic dynamics and, conformational sampling of the α,β dimer of Tubulin: Applications to combat cancer	SERB

Participation in Conferences / Symposia / Workshops & Invited Talks delivered at various organizations:

(i) One of the organizers of the international conference 'INPEC 2017' held at Bose Institute during Nov 9-11, 2017 as a part of the centenary celebration.

(ii) Attended ACS industry symposium during 13-15 December, 2017 held in **Mumbai**, India.

(iii) Delivered Oral presentation at the international conference 'CMTPI 2017' held in Goa, during Oct 27-30, 2017.

Dr. Tapash C Ghosh

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 (2017-18) are as follows:

Expression level provides important clues about gene function. Previously, various efforts have been undertaken to profile human genes according to their expression level. Intrinsically disordered proteins (IDPs) do not adopt any rigid conformation under physiological conditions, however, are considered as an important functional class in all domains of life. Based on a human tissue-averaged gene expression level, previous studies showed that IDPs are expressed at a lower level than ordered globular proteins. Here, we examined the gene expression pattern of human ordered and disordered proteins in 32 normal tissues. We noticed that in most of the tissues, ordered and disordered proteins are expressed at a similar level. Moreover, in a number of tissues IDPs were found to be expressed at a higher level than ordered proteins. Rigorous statistical analyses suggested that the lower tissue-averaged gene expression level of IDPs (reported earlier) may be the consequence of their biased gene expression in some specific tissues and higher protein length. When we considered the gene repertory of each tissue we noticed that a number of human tissues (brain, testes, etc.) selectively express a higher fraction of disordered proteins, which help them to maintain higher protein connectivity by forming disordered binding motifs and to sustain their functional specificities. Our results demonstrated that the disordered proteins are indispensable in these tissues for their functional advantages.

Publication

1. Panda A, Acharya D, Ghosh TC (2017) Insights into human intrinsically disordered proteins from their gene expression profile. *Mol. Biosyst.* 13 (12): 2521-2530

Students awarded Ph.D.

Name of student (University, Year)	Title of Thesis
Jyotirmoy Das CU, 2017	In-silico studies of Micro RNA regulations in higher eukaryotes from the perspective of molecular evolution
Deeya Saha CU, 2017	Studies on overlapping genes: From evolutionary perspective

Talks delivered by BI faculty at other Institutions

1. November 2017 at Nagaland Central University, Nagaland, India
2. December 2017, Society for Molecular Biology and Evolution (SBME) Satellite Meeting at Kaziranga, Assam, India
3. March 2018, International Centre for Theoretical Science (ICTS) programme on "Third Bangalore School on Population Genetics and Evolution" at Bangalore, India.

Member of Editorial Board

BMC Genomics (From 2010 -)

Evolutionary Bioinformatics (From 2013-)

Dr. Zhumur Ghosh

Assistant Professor

Scientific Reports

A. 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 have elucidated the potential miRNA-mRNA pairs (using in-house target binding protocol) within these dataset. Subsequent experimental validation are ongoing. (b) Ovarian teratocarcinoma (OVTC) arises from germ cells and comprises 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.

B. Elucidated the complex crosstalk between cancer stem cells and non-stem cancer cells in high grade serous ovarian cancer.

C. Developed miRTPred which is a computational pipeline for predicting miRNA targets, available at http://bicresources.jcbose.ac.in/zhumur/mirtpred

E. Publications

In Journals

1. Parida S, Chakraborty S, Maji R K, Ghosh Z (2018) Elucidating the gene regulatory networks modulating cancer stem cells and non-stem cancer cells in high grade serous ovarian cancer. Genomics. 2018 Feb 6. pii: S0888-7543(18)30015-6. doi: 10.1016/j.ygeno.2018.01.006.
2. Kaur H, Sarmah D, Saraf J, Kalia K, Borah A, Yavagal D R, Dave K R, Ghosh Z, Bhattacharya P (2018) Noncoding RNAs in ischemic stroke: Time to translate. Ann NY Acad Sci. 2018 (doi: 10.1111/nyas.13612).
3. Parida P K, Mahata B, Santra A, Chakraborty S, Ghosh Z, Raha S, Misra A K, Biswas K, Jana K (2018) Inhibition of cancer progression by a novel trans-stilbene derivative through disruption of microtubule dynamics, driving G2/M arrest, and p53-dependent apoptosis. Cell Death Dis. 2018, 9(5):448. doi: 10.1038/s41419-018-0476-2.

In Conference Proceedings

1. Chakraborty S, Ghosh Z (2017) A comparative transcriptomics approach to probe into the different grades of astrocytoma, *International Symposium on Systems, Synthetic & Chemical Biology* December 5-7, 2017, Bose Institute, Kolkata.
2. Deb A, Sarkar A, Ghosh Z (2017) Complex crosstalk between coding and non-coding RNAs during neural development, *International Symposium on Systems, Synthetic & Chemical Biology* December 5-7, Bose Institute, Kolkata.

F. Grant-in-Aid Schemes

Title of Project	Scheme funded by
Elucidating the GWAS-Associated Genetic Variants within lncRNA candidate loci: Role in Cancer.	SERB
(*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

Group Member

Arijita Sarkar presented her work entitled "Elucidating the role of piRNAs in ovarian teratocarcinoma" at Keystone Symposia "Noncoding RNAs: From Disease to Targeted Therapeutics", February 2017, Alberta, Canada.

G. Awards / Honors received by the members of BI:

(a) Editorial Board Member, *Current Bioinformatics*

(b) Member of the National Academy of Science

Dr. Debjani Roy

Assistant Professor

Scientific Reports

Experimental study of the effect of AD epigenetic repositioning drugs in combination with natural metabolites in neural cells

We are interested in Studying the effect of AD epigenetic repositioning drug i.e. methotrexate in combination with several natural metabolites. The ultimate aim is to identify the pathways in which these drugs are working. Both experimental and computational methods will be involved.

Experimental study of drug-miRNA interactions

Systems level involvement of drug-miRNA will be studied by experimental methods.

Systems level Comparison of Oxidative Stress related diseases

Several oxidative stress related diseases are being studied with the ultimate aim to understand the key regulators of these complex diseases at the systems level.

Network based analysis of antibiotic resistance genes

We are studying the occurrence and abundance of antibiotic resistance genes in several pathogenic microorganisms. We have taken network based approaches to study these genes and their interactors at the systems level.

***In silico* approaches for development of the epitope based peptide vaccine against Chandipura virus envelop glycoprotein**

The purpose of this study is to promote the designing of epitope based peptide vaccine against chandipura virus envelop glycoprotein using computational methods and immunoinformatics tools.

Publications

1. Chatterjee P, Roy D, Rathi N (2018) Epigenetic Drug Repositioning for Alzheimer's Disease based on EpigeneticTargets in Human Interactome, *J.of Alzheimers Disease*. 61(1):53-65. doi: 10.3233/JAD-161104.
2. Chatterjee P, Roy D, Bhattacharyya M, Bandyopadhyay S (2017) Biological networks in Parkinson's disease: an insight into the epigenetic mechanisms associated with this disease, *BMC Genomics*. ep 12;18(1):721. doi: 10.1186/s12864-017-4098-3.

Participation in Conferences / Symposia / Workshops & Invited Talks delivered at various organizations:

a) Delivered talk on "Systems-level insight into Parkinson's Disease: Computational perspectives in biomarker and drug discovery" at the 8th Annual Congress of Neurotalk-2017. May 22-24, 2017. Barcelona, Spain.

b) Delivered talk on Epigenetics in Alzheimer's Disease: The Computational Systems Biology Paradigm for Understanding the Epigenetic-based Markers and Drugs at the Drug Discovery and Therapy World Congress 2017. July 10-13, 2017. The Westin Copley Place, Boston, USA.

Patent

Patent Filed on "Systems level methods for epigenetic drug development for human diseases"

Patent application number:201731039952 dated 09-11-2017.

Dr. Sudipto Saha

Assistant Professor and Ramalingaswami Fellow

SCIENTIFIC REPORT

Scientific Reports

A prediction server for high-throughput screening of small molecules targeting protein-protein interaction

PPIMpred web server was developed in our lab that allows high-throughput screening of small molecules for targeting specific protein-protein interactions, namely Mdm2/P53, Bcl2/Bak and c-Myc/Max.PPIMpred is freely available at http://bicresources.jcbose.ac.in/ssaha4/PPIMpred/

A database of functional sites and biochemical properties of Myc in both normal and cancer cells

MYCbase database was developed. It is a collection of experimentally supported functional sites in Myc that can influence the biological cellular processes. The functional sites were compiled according to their role which includes mutation, methylation pattern, post-translational modifications, protein-protein interactions (PPIs), and DNA interactions. In addition, biochemical properties of Myc are also compiled, which includes metabolism/pathway, protein abundance, and modulators of protein-protein interactions. MYCbase is freely available at http://bicresources.jcbose.ac.in/ssaha4/mycbase

Publications

1. Chakravorty D, Jana T, Mandal SD, Seth A, Bhattacharya A, Saha S* (2017) *MYCbase: A database of functional sites and biochemical properties of Myc in both normal and cancer cells. BMC Bioinformatics* 18(1):224. (IF: 2.45).
2. Jana T, Ghosh A, Mandal SD, Banerjee R, Saha S*(2017) *PPIMpred: a web server for high-throughput screening of small molecules targeting protein–protein interaction. Royal Society Open Science*, 4(4):160501 (IF:2.24).
3. Mawatwal S, Behura A, Ghosh A, Kidwai S, Mishra A, Deep A, Agarwal S, Saha S, Singh R, Dhiman R (2017). *Calcimycin mediates mycobacterial killing by inducing intracellular*

calcium-regulated autophagy in a P2RX7 dependent manner. Biochim Biophys Acta. 2017 Dec;1861(12):3190-3200. (IF: 4.70).

4. Mustfa SA, Singh M, Suhail A, Mohapatra G, Verma S, Chakravorty D, Rana S, Rampal R, Dhar A, Saha S , Ahuja V, Srikanth CV (2017), *SUMOylation pathway alteration coupled with downregulation of SUMO E2 enzyme at mucosal epithelium modulates inflammation in inflammatory bowel disease. Open Biol.* 7(6). pii:170024 (IF:3.48).

5. Subramani E, Rameshbabu AP, Jothiramajayam M, Subramanian B, Chakravorty D, Bose G, Joshi M, Ray CD, Lodh I, Chattopadhyay R, Saha S_, Mukherjee A, Dhara S, Chakravarty B, ChaudhuryK. (2017) *Mycobacterial heat shock protein 65 mediated metabolic shift in decidualization of human endometrial stromal cells. Sci Rep*. 21;7(1):3942 (IF:4.25).

Grants-in-Aid Scheme

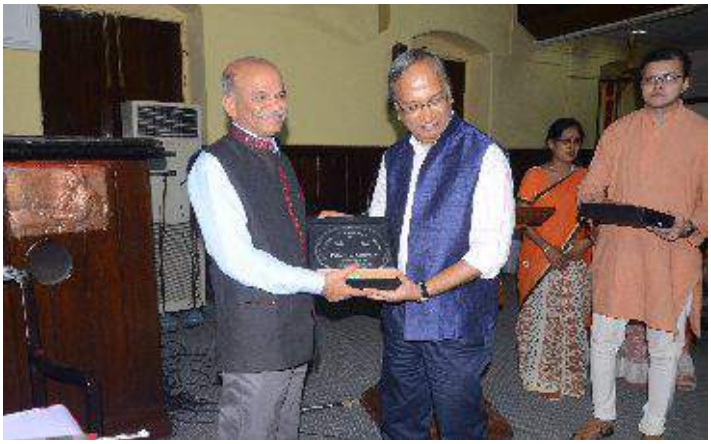
Title of the scheme	*Schemes funded by*
With Dr. Zhumur Ghosh(Joint PI) Systematic identification of regulatory networks in pluripotent cells integrating coding and noncoding world	ICMR

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

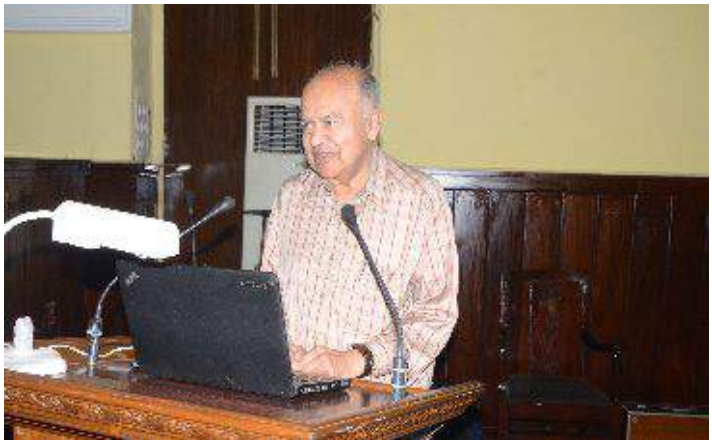
(1) Poster presentation on "Integration of transcriptomics and Pluripotent Integrated Regulatory Network (PIRN) for predictive signatures of lung cancer"at EMBO Symposia on Big data in biomedicine, February 25-27, 2018, in New Delhi, India.

(2) Invited talk on "Systematic discovery of novel linear motifs mediating protein-protein interactions"" onthe occasion of the Silver Jubilee of Machine Intelligence Unit at Indian Statistical Institute Kolkata,February 15, 2018, Kolkata, India

Centenary Celebration Lecture on 'History of Indian Science: Ancient and Medieval' on November 24, 2017



Lecture delivered by Prof. V. Shinde on 'Science and Technology of Indus Valley Civilizations'



Lecture delivered by Prof. J.V. Narlikar 'Ancient Indian Science in a Historical Context'

Lecture delivered by Prof. P. Divakaran on 'The Mathematics of India: From Counting to Calculus'

Lecture delivered by Swami Atmapriyananda on 'Jagadish Chandra Bose's Scientific Philosophy and their Roots in Ancient Indian Spiritual wisdom'

IV. Molecular Medicine

Participation of Institutional Programme - IV

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 a 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 showed a 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 suggest that GM2 mediated epithelial-mesenchymal transition (EMT) involves the Hippo signaling pathway in tumorigenesis. Initial findings clearly indicate a critical role of the Hippo signaling component, YAP to be involved in GM2 mediated transcription of an array of genes that regulated EMT.

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. Our data indicates 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. The loss in Sp1 binding to the GM2-synthase promoter is facilitated both by proteasomal degaradation as well as by enhanced acetylation of Sp1 protein, leading to de-repression of GM2-synthase gene.

On a different note, we have very recently undertaken a collaborative study (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. We have already identified a plant derived flavonoid, eriodictyol which shows significant anti-proliferative and pro-apoptotic effects on both human as well as mouse tumor cell lines. The ability of eriodictyol to block tumor cell proliferation and induce apoptosis lies in its ability to modulate critical signaling pathways regulating key cellular processes like proliferation and apoptosis. The mechanistic details underlying eriodictyol's mode of action is currently under investigation.

Publication

1. Basu A, Das A S, Sharma M, Pathak M P, Chattopadhyay P, Biswas K and Mukhopadhyay R (2017) STAT3 and NF-kB are common targets for kaemferol-mediated attenuation of COX-2 expression in IL-6-induced macrophages and carrageenan-induced mouse paw edema. *Biochem. Biophys. Rep.,* 12, 54-61.

Dr. Tanya Das

Professor

Scientific Reports

A. Contribution of cancer stem cells in immunosuppressive T-regulatory cell generation: An approach towards making cancer immunotherapy effective

Increasing evidence suggests that cancer development is due to a rare population of cells, termed cancer stem cells (CSCs) that uniquely initiates and sustains disease. Despite CSCs are considered as a promising source of cells to modulate immune systems in favour of tumor, the detail mechanisms underlying their immunosuppressive effects remain restricted. Recent reports have clarified that CSCs release nano-vesicles, known as exosomes, which may serve as mediators of cell-to-cell communication and may potentially reprogram neighboring non-CSC recipient cells, including immune cells. Our results identified a small population of chemo-resistant breast cancer cells that not only displayed self-renewal, tumorigenic and differentiation properties, but also exhibited 'stemness signature' as well as ability to promote metastasis and neo-angiogenesis, thereby confirming their identity as CSCs. It was observed that culturing naive T-cells with either non-stem cancer cell spent media or exosome- depleted spent media of CSCs required at least 24 hours to generate significant amounts of FOXP3-positive $CD4^+$ T-regulatory (Treg) cells. However, exosomes, derived from these CSCs, induced $FOXP3^+CD4^+$ Treg cell generation much early, indicating the contribution of CSC-shed exosomes in $FOXP3^+CD4^+$Treg generation even at early time points. A search for the underlying mechanism revealed the presence of both FOXP3 mRNA and protein in CSC-shed exosomes. That exosomes from FOXP3-ablated CSCs failed to augment immuno-suppressive $FOXP3^+CD4^+$ Treg cell generation indicated the requirement of CSC-gifted FOXP3, mRNA and/or protein, in $FOXP3^+CD4^+$ Treg generation. Interestingly, perturbation of transcription or translation in T cells significantly decreased exosome-augmented FOXP3 level in these cells suggesting the involvement of both transcriptional as well as translational machineries of T cells in CSC-exosome-induced $FOXP3^+CD4^+$ Treg cell generation. These results raise the possibility that CSCs provide the initial trigger for immunosuppressive Treg cell generation and thus breaching the deadly-liaison between them might be a promising strategy in breast cancer therapy.

B. A non-metabolic role of Hexokinase2 in regulating pluripotency and drug-resistance of breast cancer stem cells

Recent advances in breast cancer research have attributed the relapse of the disease post chemotherapy to the tumor-initiating Cancer Stem Cells (CSCs), a very small subpopulation of the tumor microenvironment consisting of only 1-3% of the total tumor population. CSCs are capable of self-renewal and maintenance of pluripotency and are responsible for imparting resistance to the conventional chemotherapy thereby leading to the relapse of the disease. The metabolic switch of these CSCs to aerobic glycolysis or the 'Warburg Effect', for which Hexokinase2 (HK2 is the first rate limiting enzyme, from the conventional oxidative phosphorylation is recently being appreciated as a crucial mechanism underneath drug resistance. Interestingly, inhibiting catalytic activity of HK2 translocated it into the nucleus although its role within the nucleus is still the *Cinderella of investigation*. Our aim of understanding as to whether this metabolic enzyme can also function as a transcriptional regulator and/or as a transcriptional mediator of genes associated with pluripotency and drug-resistance revealed nuclear translocation of HK2 under stresses like hypoxia and chemotherapy. Under such conditions, HK2, in association the locus-specific transcription factor Oct4, promotes the transcription of SOX2, which is involved in regulating several pluripotency and drug-resistance genes. These findings not only exposed a non-metabolic role of HK2 but also unraveled an intertwined metabolism-pluripotency-chemoresistance axis in breast CSCs that can be targeted for overcoming drug-resistance of CSCs and thus sensitizing them towards the conventional chemotherapy.

C. Do cancer stem cells modulate their division pattern as an efficient strategy to survive various stress signals?

Over the last 100 years, many studies have been performed to determine the origin of neoplasms. At the end of the last century, the leading paradigm considered the origin of neoplasms to be set of genetic and/or epigenetic mutations. However, in the last 20 years a new potential 'epistemological' paradigm is represented by cancer stem cell (CSC) theory that reflects the stem origin of the neoplastic cells. It was observed that the breast CSCs exhibit 'stemness signature' and display self-renewal and multi-lineage differentiation properties. Like the normal stem cells, CSCs are also privileged with the efficient strategy to undergo asymmetric cell division **(ACD**) since this dynamic phenomenon ameliorate their ability to maintain the pool of CSCs while producing differentiated non-stem cancer cells (NSCCs) in a single division within the heterogeneous tumor cell population. Existence of a multitude of cell fate determinants like Prospero, Miranda, Par3, Par6, aPKC, Numb, Trim32, Brat, Inscuteable, Notch1 etc., have been reported, which acts as a controlling device in regulating whether a stem cell will undergo self-renewal or give rise to a lineage specific progenitor for future differentiation. Our results showed that breast CSCs can efficiently manipulate their division pattern in response to various stress signals in its tumor microenvironment. We observed a reduced expression of progenitor markers like Numb and Trim32 in $CD44^{+}/CD24^{-}$ breast CSCs than in their NSCC counterparts, i.e., $CD44^{+}/CD24^{+}$ and $CD44^{-}/CD24^{+}$ subpopulations, when analysed both from mammospheres and clinical samples of human breast tumor tissues. Further studies showed that in response to hypoxia or genotoxic drug-induced stress that kills NSCCs, pre-existing CSCs discontinue ACD while encouraging symmetric division to produce two daughter CSCs, thereby restricting number of vulnerable NSCCs and escaping the stress-induced death. This might, therefore, be a smart survival strategy which is adopted by the CSCs in the

presence of any kind of stress condition, which further boosts their resistance towards conventional cancer therapeutics. Work is in progress to map the detail molecular mechanisms.

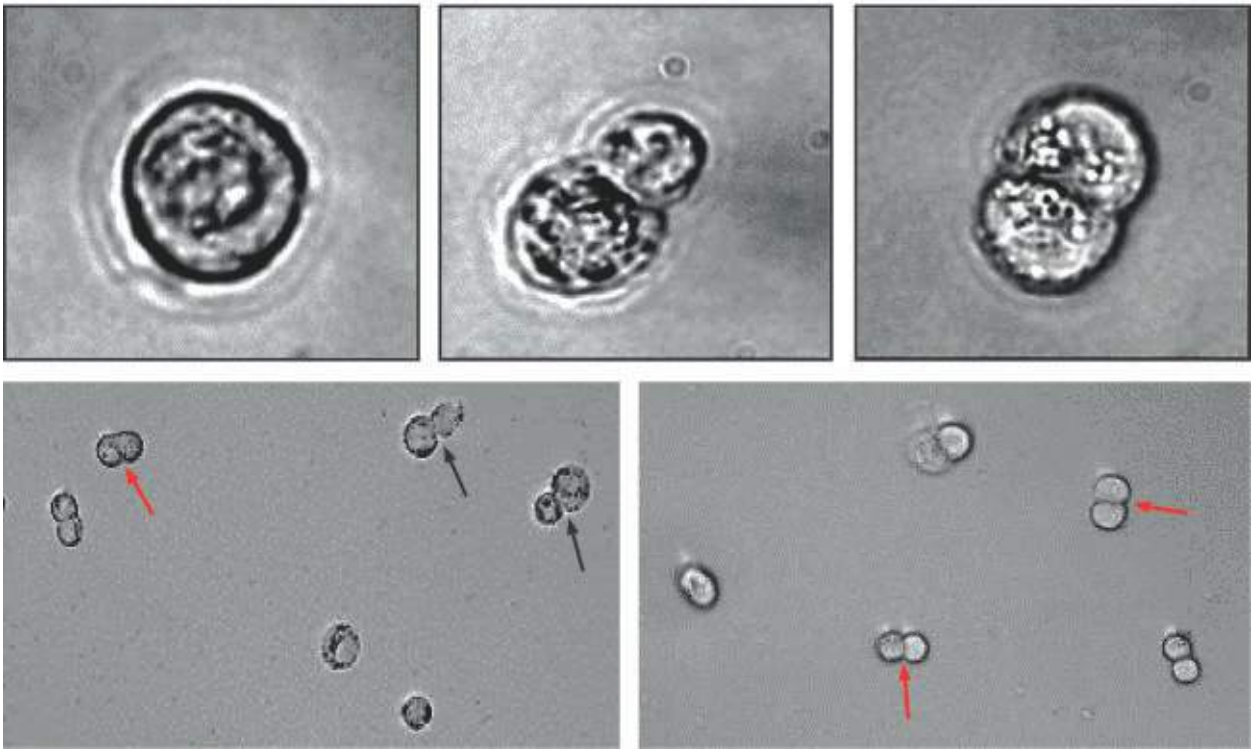


Figure-1. Effect of stress on breast cancer stem cell division.

Upper row- Left panel: undivided CSC; middle panel: asymmetric division of CSC; right panel: symmetric division of CSC.

Lower row- Left panel: asymmetric (←) and symmetric (←) divisions of untreated CSCs; Right panel: symmetric division (←) of chemo-treated CSCs.

D. Cancer stem cells and M1 macrophages: Friends or foes??

Macrophages in a tumor microenvironment have been characterized as M1- and M2-polarized subtypes. Numerous reports suggest that the different macrophages impact differently on cancer cells. While M2 subset promotes cancer progression and metastasis, M1 subset imposes anti-tumorigenic effect. Moreover, M1/M2 gene signatures have been documented to be significantly correlated with the extended overall survival of cancer patients thus indicating that M1/M2 polarization may be a target of investigation of immune-modulating therapies for cancer in the future. Hence, a number of studies aim at M2 to M1 switching over for better prognosis of the disease. Recently, contribution of self-renewing and drug-resistant cancer stem cells (CSCs) in all the Hallmarks of cancer has been well recognized. Therefore, it becomes imperative to understand the interaction between CSCs and the above-mentioned subtypes of tumor associated macrophages. Our recent findings suggest that while M1 macrophages induce an apoptotic effect on non-stem cancer cells (NSCCs), they fail to do so in breast CSCs. In contrast, this pro-inflammatory subtype induces NSCC to CSC conversion via paracrine signaling by shedding soluble bio-modulators. In future, we aim at delineating the detail mechanism underneath this ''unexpected'' M1/CSC cross-talk with the final aim of targeting such ''deadly liaison'' between these two cells.

E. A hitherto unknown role of the mammalian base excision repair protein, NEIL2, as a transcription factor in breast cancer stem cells

Chemotherapy, the principal mode of cancer treatment, is rendered ineffective due to the emergence of drug resistance. Recent reports suggest the contribution of a small subset of highly resistant tumor cells, called cancer stem cells (CSCs), in drug-resistance and cancer relapse. These CSCs, that give rise to the heterogeneous population of tumor cells, have stem cell-like characteristics, e.g., self-renewal and differentiation. Sensitizing CSCs by manipulating reactive oxygen species (ROS) has, therefore, been the aim of cancer research in recent years. Our previous work demonstrated an inverse relationship between ROS and NEIL2, a mammalian base excision repair (BER) protein that repairs DNA by assisting the excision of oxidized DNA lesions from bubble or single-stranded structures, in breast CSCs wherein the crosstalk can be targeted for CSC sensitization. Here we report a hitherto unidentified function of NEIL2 in CSCs, i.e., its ability to bind to the promoter regions of Oct4 and Sox2 thereby upregulating their expressions as well as stemness. Interestingly, Pyridoxine (VitB6), a commonly used vitamin, inhibited NEIL2 activity thereby sensitizing otherwise resistant CSCs towards Doxorubicin. Studies are in progress to delineate the detail mechanisms underlying this newly identified role of NEIL2. Thus, for the first time we report here that apart from its known function as a DNA repair enzyme and redox modulator, NEIL2 regulates transcription of stemness factors in breast CSCs and inactivation of NEIL2 function by an affordable, non-toxic, regularly used vitamin (VitB6) sensitizes these highly resistant cells towards commonly used chemotherapeutic drug Doxorubicin. Knowledge gathered from this study may pave way for the development of efficient therapeutics against breast cancer by targeting NEIL2.

F. Delineating the role of SMAR1 as a 'master regulator' in cancer stem cells

Recent researches have indicated the presence of a distinct subset of stem-like cells, designated as cancer stem cells (CSCs), within the tumor mass, adorned with the potential of self-renewal and multi-lineage differentiation and are thought to be the major cause behind tumor initiation, progression, angiogenesis, drug resistance, metastasis and relapse. A cancer stem cell-targeted approach is therefore, of utmost necessity in order to conquest the vicious battle against cancer. SMAR1, a scaffold/matrix attachment region-binding protein, is involved in chromatin-mediated gene regulation via chromatin remodelling through the recruitment of histone deacetylases (HDACs) and de-acetylation of histones. Tumnor suppressor protein p53 positively regulates SMAR1, and the latter in turn stabilizes p53 by inhibiting its mdm2-mediated proteasomal degradation. SMAR1 has been reported to inhibit EMT and suppresses tumor progression by repressing expression of Cyclin D1, Slug, snail etc. Our data showed significantly lower SMAR1 expression in breast CSCs derived from established breast cancer cell lines and primary tumor tissues, than their non-stem counterparts. Promoter analysis of SMAR1 predicted a joint Oct4-Sox2 binding domain just downstream to its TATA box. Further results indicated that while Oct4 and Sox2 jointly represses SMAR1 expression in CSCs, over-expression of SMAR1 decreases pluripotency markers, e.g., Oct4, and drug resistance proteins, e.g., ABCG2. Bioinfomatic analysis using S/MAR detection software predicted that the promoter region of these genes harbours S/MAR-binding domain. This prediction was validated by chip assay thus confirming SMAR1 as a ''master regulator'' of pluripotency. Interestingly, SMAR1-over-expressed CSCs underwent apoptosis by a

low dose of Doxorubicin, thereby indicating that upregulating SMAR1 in CSCs can be a possible solution of sensitizing these highly drug-resistant cells towards chemotherapy thereby halting chemo-resistance and related relapse of breast cancer.

Publications

1. Khan P, Bhattacharya A, Banerjee S, Dutta Choudhury D, Dutta A and Das T (2017) Proteolytic networks at the cross roads of cancer cell life and death: cancer stem cell deciding cell fate. In *Pathophysiological Aspects of Proteases* (Ed: Dhalla NS and Chakrabarti S) Springer Publishing Company, NY, USA, 237-264.
2. Mazumdar D, Banerjee S, Bhattacharya A and Das T (2017) Repurposing of Aspirin to Regress Tumor from its 'Root'- The Cancer Stem Cells. *Austin J Pharmacol Ther*, 5(2): 1096.

Grants-in-Aid Schemes

Title of the scheme	Project funded by
Role of cancer stem cells in tumor neo-angiogenesuis: A mechanistic study (PI)	DST
miR 325: a Distinct miRNA that controls T regulatory cell development and function (Co-PI)	DST
Multi-dimensional research to enable systems medicine: Acceleration using a cluster approach (Director is the Co-ordinator)	DBT

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

i) Delivered invited lecture in 2nd International Conference and Exhibition on Marine Drugs and Natural Products, held during June 15-17, 2017, in London, United Kingdom.

ii) Delivered an invited lecture at the International conference on Translational Research in September, 2017, at Amity University.

iii) Invited to deliver talks at the Regional Science Congress, in Kalyani University, in December, 2017, and at the 18th International Symposium of All India Congress of Cytology and Genetics on "Translating Genes and Genomes" at CSIR-Indian Institute of Chemical Biology in January, 2018.

iv) Delivered a special lecture at the One Day Symposium in Women's Commission, West Bengal. She also delivered an invited lecture at the National Symposium of NSCWSI-2018 on "Women in Science" in March, 2018.

***Seminars / Symposia organized at Bose Institute*:**

Acted as the secretary of the organizing committee of 37th IACR Convention, held in Bose Institute, during February 23-25, 2018, and chaired a scientific session in the same.

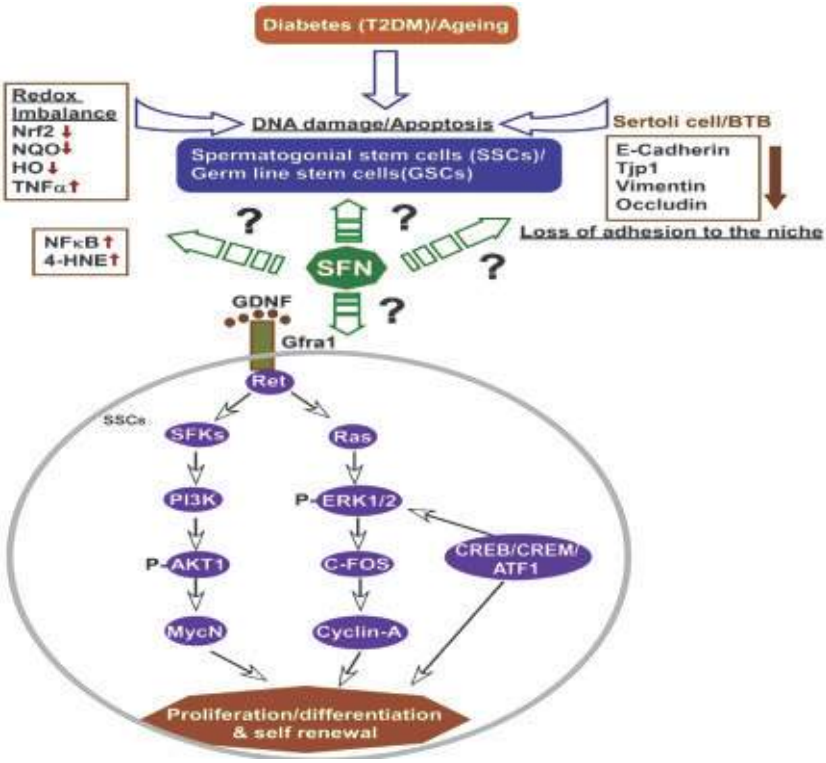
Dr. Kuladip Jana

Senior Scientist

Scientific Reports

(A) Insulin defective stage of Type 2 Diabetes (IDS-T2DM) induced testicular Germ cell death/apoptosis in association with the up-regulation of Nrf2 expression: Ameliorative potential of sulforaphane (SFN) and resveratrol (RES).

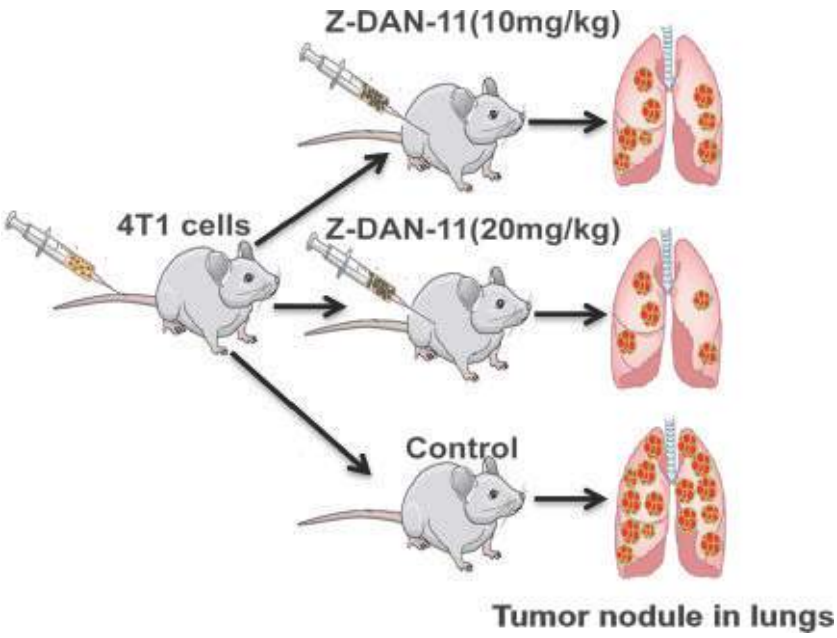
Diabetes-induced testicular cell death is due predominantly to oxidative stress. Nuclear factor (erythroid- derived 2)-like 2 (Nrf2) is an important transcription factor in controlling the anti-oxidative system and is inducible by sulforaphane (SFN) and resveratrol (RES). To test whether SFN/RES prevents diabetes-induced testicular germ cell death/apoptosis, an insulin-defective stage of type 2 diabetes (IDS-T2DM) was induced in mice. This was accomplished by feeding them a high-fat diet (HFD) for 3 months to induce insulin resistance and then giving one intraperitoneal injection of streptozotocin to induce hyperglycemia while age-matched control mice were fed a normal diet (ND). IDS-T2DM and ND-fed control mice were then further subdivided into those with or without 3-months SFN/RES treatment. IDS-T2DM induced significant increases in testicular germ cell death/apoptosis presumably through receptor and mitochondrial pathways, shown by increased ratio of Bax/Bcl2 expression and cleavage of caspase-3 and caspase-8 without significant change of endoplasmic reticulum stress (GRP78/CHOP). Diabetes also significantly increased testicular oxidative damage and inflammation (TNFα and



SCIENTIFIC REPORT

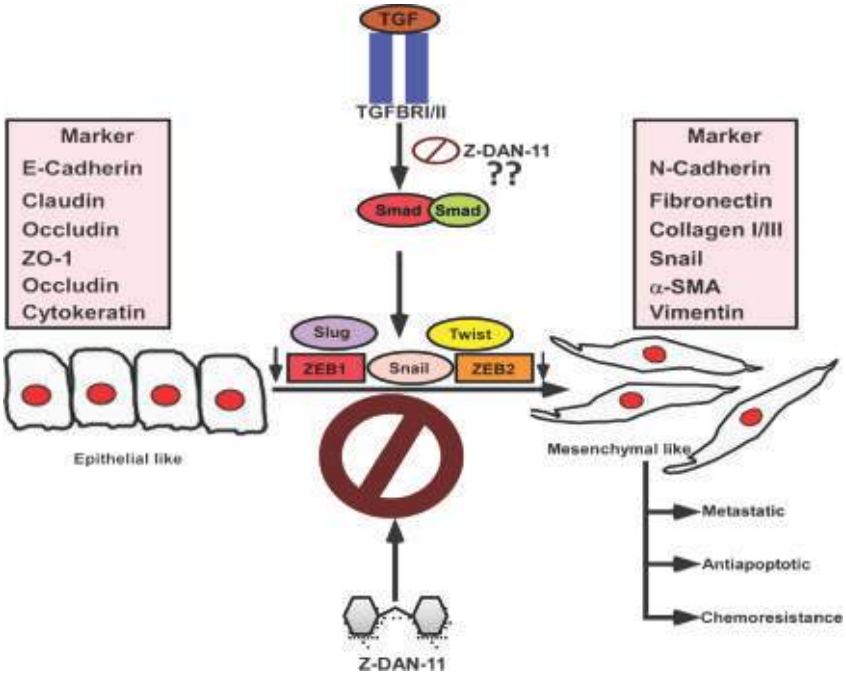
NFκB). All of these diabetic effects were significantly prevented by SFN/RES treatment with up-regulated Nrf2 expression. These results suggest that IDS-T2DM induces testicular germ cell death/apoptosis presumably through caspase-8 activation and mitochondria-mediated cell death pathways and also by significantly down-regulating testicular Nrf2 expression and function. SFN/RES up-regulates testicular Nrf2 expression and its target antioxidant expression, which was associated with significant protection of the testis from IDS-T2DM-induced germ cell death.

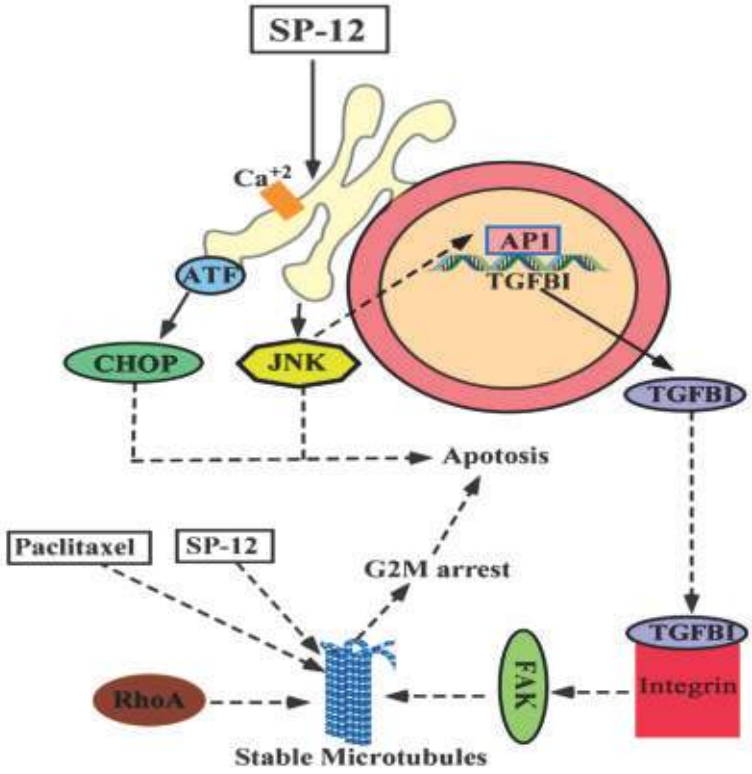
(B) A microtubular dynamics interfering trans-stilbene derivative compound Z-DAN-II drives G2/M arrest, apoptosis and impedes cancer progression: *In Collaboration with Prof. Anup K. Misra & Dr. Kaushik Biswas, Division of Molecular Medicine, Bose Institute, Kolkata*



Resveratrol, a *trans* –stilbene polyphenolic compound and its synthetic derivatives have been widely used bioactive molecules due to their remarkable chemopreventive potential. Here, we have identified a novel resveratrol analogue, compound Z-DAN II ((Z)-3-(3, 4-dimethoxyphenyl)-2-(3, 4, 5-trimethoxyphenyl) acrylonitrile which inhibits proliferation of several cancer cell lines *in vitro* through microtubule depolymerization that induced G2M arrest and consequently leads to apoptotic cell death. Importantly, compound Z-DAN shows limited cytotoxicity to normal cells as compared to cancer cells. Moreover, insight into the molecular and mechanistic detailed studies we reasoned that compound Z-DAN induces increase in the expression of pro-apoptotic proteins and decrease in the expression anti-apoptotic proteins that decisively helps the activation of caspase 8, caspase 9, caspase 3, leading to PARP-1 and cell death via intrinsic and extrinsic pathways of apoptosis. More importantly, we also have established the crucial contribution of tumor suppressor protein p53 in compound Z-DAN mediated apoptosis. Interestingly, the compound Z-DAN also imparts its anti tumorigenic effect by inhibiting clonogenic property and anchorage independent growth potential of cancer cells. Finally, *in vivo* study with immune-competent syngeneic mice tumor model shows that administration of compound Z-DAN is able to impede tumor progression without any side effects. So, our presently studied novel *trans*-stilbene derivative compound Z-DAN has tremendous anti-tumorigenic potential and can be added to the current regimes of chemotherapy. At present we are studying the anti-metastatic potential of this compound and its molecular signalling.

(C) A novel sulforaphane derivative SP12 induces apoptosis and prevails paclitaxel resistance through over expression of TGFBI protein.



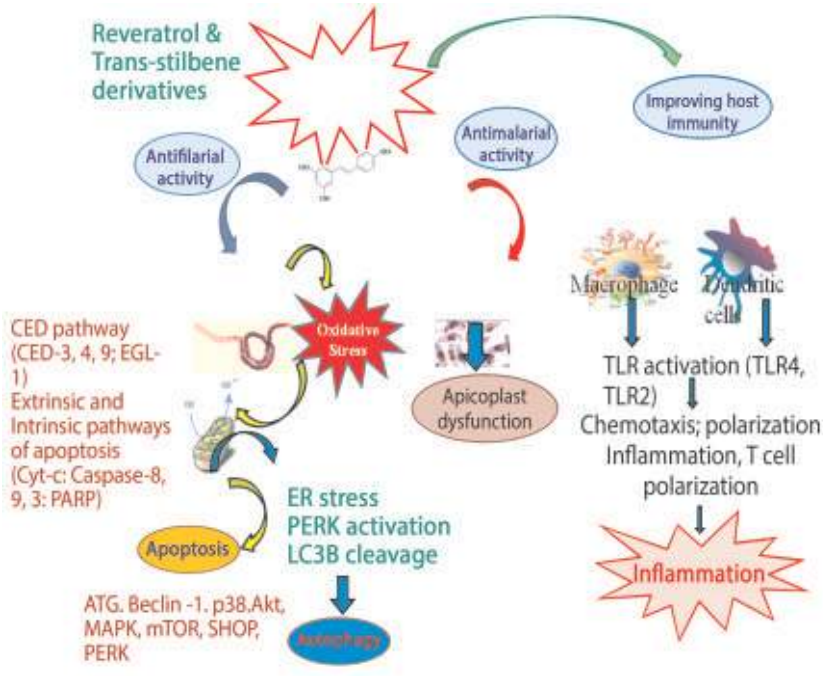


Extracellular matrix (ECM) proteins including ECM receptors and their counterpart binding proteins have been largely associated with tumor cell progression and metastasis. Transforming growth factor-b-induced (TGFBI or keratoepithelin or βIg-h3), one of the ECM protein, which has been implicated in a number of cellular disease processes including, angiogenesis, tumor progression and metastasis. 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 down-regulated various human cancers including Ovarian cancer, lung cancer and breast cancer where it acts a tumor suppressor. Interestingly, we have identified a novel sulforaphane derivative **SP12** which induces the over expression of TGFBI in paclitaxel resistant SKOV-3 (ovarian cancer), MCF-7/P (breast cancer) and A549/P (lung cancer) cell lines. As reports suggests that JNK

signaling pathway activates during TGFBI over-expression. Treatment of **SP-12** showed significant increase in the expression of TGFBI along with c-Jun in above cell lines. On the other hand Malt inspector analysis also revealed probable binding site for c-Jun transcription factor in TGFBI promoter region. So, our first objective is to validate the role of c-Jun transcription factor and JNK/SAPK pathway in **SP-12** mediated over expression of TGFBI.Microtubule dynamic interfering agents such as paclitaxel (taxol), docetaxel (taxotere), vinblastine, vincristine 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. Preliminary experiment with SP12, demonstrated higher expression level of an important ER stress biomarker CHOP/DDIT3/GADD153. Again, ER stress has been reported to be linked with activation of JNK/SAPK pathway. Thus, SP12 mediated activation of JNK/SAPK pathway may have a critical role in ER stress. So, our second objective is to deduce the role of **SP12** mediated activation of JNK/SAPK in ER stress dependent apoptosis. A recent report suggests TGFBI over expression sensitizes ovarian cancers to paclitaxel via FAK- and Rho-dependent stabilization of microtubules by binding to integrin-αvβ3. So our third objective is to check the function of **SP-12** mediated over expression of TGFBI in paclitaxel sensitivity in paclitaxel resistant cells using paclitaxel and **SP-12** in combination.

(D) Oxidative stress plays major role in mediating apoptosis in filarial nematode Setariacervi in the presence of trans-stilbene derivatives: *In collaboration with Prof. A. K. Misra & Prof. S Sinhababu, VisvaBharati, Shantiniketan.*

Lymphatic filariasis, affecting around 120 million people in 80 countries worldwide, is an extremely painful disease and caused permanent and long term disability. Owing to its alarming prevalence there is immediate need for development of new therapeutics. A series of *trans*-stilbene derivatives were synthesized using aqueous reaction condition showing potential as antifilarial agents demonstrated in vitro. MTT reduction assay and dye exclusion test were performed to evaluate the micro and macrofilaricidal potential of these compounds. Amid twenty *trans*-stilbene derivatives together with Resveratrol (RSV), a multifunctional natural product was screened; nine compounds have showed promising micro and macrofilaricidal activities and four of them showed better effectiveness than RSV. In the treated parasites apoptosis was established by DNA laddering, in situ DNA fragmentation and FACS analysis. The generation of ROS in the treated parasites was indicated by the depletion in the level of GSH,GR and GST



SCIENTIFIC REPORT

activity and elevation of SOD, catalase, GPx activity and superoxide anion and H_2O_2 level. Along with the ROS generation and oxidative stress, the decreased expression of anti-apoptotic ced-9 gene and increased expression of nematode specific pro-apoptotic genes, egl-1, ced-4 and ced-3 at the level of transcription and translation level; the up-regulation of caspase-3 activity and involvement of caspase-8,9,3, cytochrome-c and PARP were also observed and which denotes the probable existence of both extrinsic and intrinsic pathways apoptosis in parasitic nematodes. This observation is reported first time and thus it confirms the mode of action and effectiveness of the *trans*-stilbene compounds.

Publications:

1. Datta C, Subuddhi A, Kumar M, Lepcha TT, Chakraborty S, Jana K, Ghosh Z, Mukhopadhyay AK, Basu J, Kundu M (2018) Genome-wide mRNA-miRNA profiling uncovers a role of the microRNA miR-29b-1-5p/PHLPP1 signalling pathway in Helicobacter pylori-driven matrix metalloproteinase production in gastric epithelial cells. *Cell Microbiol*. e12859.
2. Dutta A, Dhara D, Parida PK, Si A, Yesuvadian, R, Jana K* & Misra AK* (2017) C-Glycosylated cinnamoylfuran derivatives as novel anticancer agents. *RSC Advances* 7: 28853-28864.
3. Ghosh R, Banerjee B, Das T, Jana K, Choudhury SM (2018) Antigonadal and endocrine-disrupting activities of lambda cyhalothrin in female rats and its attenuation by taurine. *Toxicol Ind Health*. 34(3):146-157.
4. Gucchait A, Joardar N, Parida PK, Yesuvadian R, Sinha Babu SP, Jana K*, Misra AK* (2018) Development of novel anti-filarial agents using carbamo(dithioperoxo)thioate derivatives. *European Journal of Medicinal Chemistry*;143:598-610.
5. Parida PK, Raha S Misra AK, Biswas K*, Jana K* (2018) Inhibition of cancer progression by a novel trans-stilbene derivative of Resveratrol by interfering with microtubule dynamics, driving G2/M arrest and p53-dependent apoptosis. *Cell Death & Disease* 9(5): 448.
6. Roy A, Ahir M, Bhattacharya S, Parida PK, Adhikary A, Jana K*, Ray M* (2017) Induction of Mitochondrial Apoptotic Pathway in Triple Negative Breast Carcinoma Cells by Methylglyoxal via Generation of Reactive Oxygen Species. Molecular Carcinogenesis ; 56(9):2086-2103.
7. Sahu SK, Kumar M, Banerjee S, Kumar R, Gupta P, Jana K, Gupta UD, Ghosh Z,Kundu M, Basu J (2017) "miR-26a-KLF4 and CREB-C/EBP beta regulate innate immune signalling, the polarization of macrophages and the trafficking of Mycobacterium tuberculosis to lysosomes during infection. *PLoS Pathogen* ;13: e1006410.
8. Sarkar P, Jana K, Sikdar SR (2017) Overexpression of biologically safe Rorippaindicadefensin enhances aphid tolerance in *Brassica juncea*. *Planta*; 246(5):1029-1044.

Participation in Conferences/ Symposia/ Workshops & Invited Talks delivered at various organisations:

1. International Conference on "Reproductive Biology & Comparative Endocrinology (ICRBCE)" from 9-11 February, 2017 organized by Department of Life Sciences, University of Hyderabad, Hyderabad, India (Invited Talk)

2. PHYSIOCON, 2017, International Conference of Physiological Society of India & VII Congress of Federation of Indian Physiological Societies (FIPS), Organized by Defense Institute of Physiology & Allied Sciences, DRDO, Delhi, India from 5th - 7th November 2017 (Invited Talk)
3. International Conference "Reproductive Biology & Comparative Endocrinology (ICRBCE)" from January 20-22, 2018 at BITS PILLANI at Goa Campus (Invited Talk).

Awards/Honors Received:

1. Bharat Bikas Award, 2017 for outstanding contribution in Molecular Medicine.
2. Rastriya Gourav Award, 2018

Joined as Editorial Board Member (2018):

Journal of Cancer Research and Molecular Medicine, Annals of Translational Medicine & Epidemiology, Frontiers in Endocrinology, International Journal of Clinical Endocrinology and Metabolism, International Journal of Obstetrics and Gynecology, Advances in Applied Physiology, Austin Endocrinology & Diabetes Case Reports, & Archives of Endocrinology.

Dr. Subrata Majumdar

Professor

Scientific Reports

The antiproliferative effect of C2-ceramide leads to ceramide mediated up regulation of PKCζ in B16F10 melanoma cell: *in collaboration with Sweta Ghosh and Sweta Ghosh*

Our study explores the anti-proliferative effect of C2 ceramide in the treatment of melanoma. We found C2 ceramide can induce apoptosis in B16F10 cells, where PKCζ plays a major role. Treatment with exogenous C2 ceramide at a noncytotoxic dose of 20μM concentration for 24 hrs was found to be suitable for induction of apoptosis, which also induces pro inflammatory cytokines release like TNFα, IFNγ, and IL12. After screening all PKCs we found that increased level of PKCζ is responsible for C2 ceramide mediates apoptosis which acts as an upstream regulator of Akt and decreases the Akt level. We are further interested in analyzing the role of C2 ceramide *in* regulation of T cell functions in melanoma *cells*.

Immunomodulator- mediated regulation of transcription factors in melanoma cancer: Involvement of immune functions: *in collaboration with* Subir Juin

In the present study, we have evaluated the cytotoxicity of Glycyrrhyzic acid (GA), a potential immunomodulator, on melanoma cancer cell lines and control melanocytes. 50 μg/ml dose of GA have been selected for the experiment as this dose showed distinct cytotoxicity against B16F10 compared to control melanocytes. Moreover, GA- treatment also showed anti-proliferative effect on B16F10 cells in a dose dependent manner. The pro- and anti- inflammatory cytokines level was

measured from the B16F10 cells followed by GA-treatment *in vitro*. It has been observed that mRNA expression of pro-inflammatory cytokines become increased and anti-inflammatory cytokines become decreased after the treatment of GA. This finding was further confirmed by measuring the cytokine levels by ELISA. Currently, we are aiming to investigate the GA- mediated changes in $FOXP3^+$ T-regulatory cell function in melanoma tumor microenvironment along with modulation in Th1 and Th2 cytokine bias.

Comparative analyses of antigen presenting ability of dendritic cell and macrophages and the specific role of PKCs: *in collaboration with Junaid Jibran Jawed*

In our study we have isolated bone marrow derived dendritic cells and infected it with *Leishmania donovani* promastigotes. We analysed the ability of the DC in terms of antigen presentation, cytokines response, reactive molecules generation and its ability to polarize T cell generation and the modulation of DC based PKC in these functions then compared its efficacies with infected macrophages. We found that In comparison to macrophages, DC were more potent antigen presenting cells and successfully able to drive T cell polarization. Our data shows specific PKC regulation in DC during infection. We are further interested in analysing the ability of nfected DC and its PKCs in the polarization of Th-17 and Treg cell generation.

Regulation of MTMR6 phosphatase and BTK by Arabinosylated lipoarabinomannan, an immunomodulator during visceral leishmaniasis: *in collaboration with Shabina Parveen*

During *L. donovani* infection, the parasite affects host macrophage signaling through different tyrosine kinases and phosphatases to devise its survival strategy. Ara-LAM which is an established anti-leishmanial molecule against visceral leishmaniasis acts through TLR2 receptor. Therefore, we tested the efficacy of Ara-LAM in modulation of MTMR6 and BTK. Ara-LAM facilitates TLR2 signaling events to induce pro-inflammatory cytokines and reverses the compromised signaling intermediates of innate immune defense system in mice during Visceral Leishmaniasis (VL). Interestingly, Ara-LAM treatment resulted in restoration of the impaired signaling intermediates required for the pathogen clearance through reducing MTMR6 and inducing BTK expression. Therefore, we can suggest Ara-LAM as an effective immunomodulator, which provides protection against VL through regulating MTMR6 and BTK expression.

Asmase mediated ceramide generation during early *Leishmania donovani* infection in mouse macrophages is dependent on PKC- ζ and - δ and Toll-like receptor 2: *in collaboration with Suchandra Majumdar*

Leishmania donovani promastigotes, the causative agent of visceral leishmaniasis utilize the lipid raft microdomains as a portal of entry in the host macrophages to circumvent phagocytosis. We have observed that silencing of Acid Sphingomyelinase (Asmase),Toll like receptor 2 (TLR2), Protein kinase C-ζ and -δ downregulate *L. donovani* parasite burden in mouse macrophages. TLR2, PKC delta and PKC zeta silencing significantly downregulate Asmase expression as well as ceramide generation in macrophages during early surface interaction with infective *L.donovani* promastigotes indicating their regulatory role in asmase-mediated ceramide generation. Our study also showed that initial interaction of parasite with the host macrophages resulted in significant increase in the expression of TLR2 and integrin receptor CD11b but silencing ASMase, PKCζ and TLR2 showed reduced expression of these

receptors indicating their positive regulatory role in the parasite entry. However, there was no significant decrease in the expression of TLR2 when Asmase and PKCζ were silenced indicating that these signalling molecules are located downstream of the TLR2 signalling pathway. Due to Asmase activity at early hour of infection, ceramide is synthesized and accumulate in the lipid raft microdomain to form a signaling platform helping the parasite to enter into the host macrophage escaping phagolysosomal activity and plays a great role in signal transduction.

Grants-in-Aid Schemes

Title of Scheme	Scheme funded by
Crucial role of transcription factor-EB (TFEB) in regulating differential antigen presentation and cross presentation during *Leishmania donovani* infection	CSIR

Organised seminar/symposium

Organized Centenary Celebration of Bose Institute during 24-30 November, 2017 as a Convener.

Visits Abroad

Inaugurated the 9th Immunology Congress Meeting at London and also given the Key Note Address during March 8-9, 2018.

Dr. Atin Kumar Mandal

Associate Professor

Scientific Reports

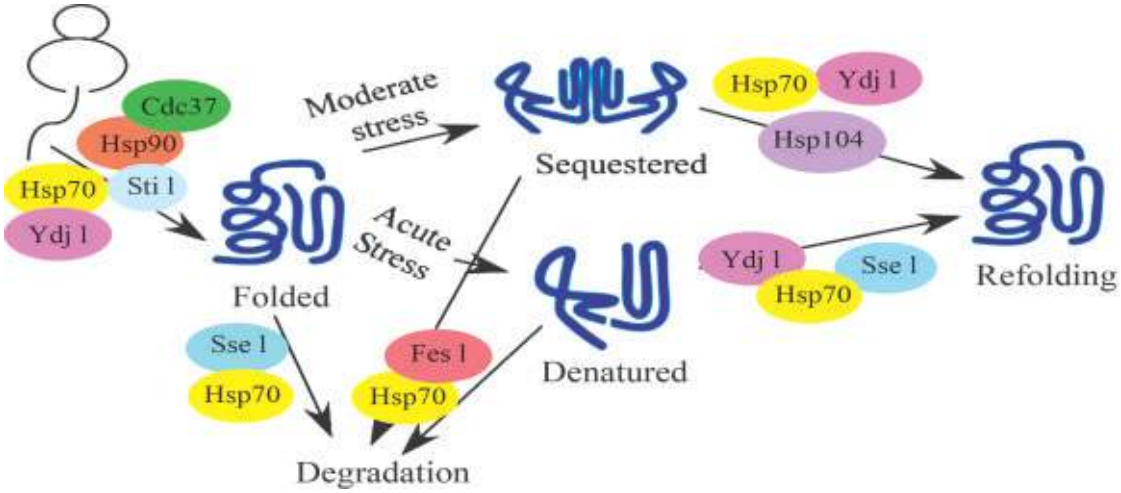
Role of Hsp90 co-chaperones in regulation of CRAF kinase activity

Mammalian CRAF requires continuous chaperoning by Heat shock protein 90 (Hsp90) for its stability and activity. Previously we showed that chaperones Hsp90 and Cdc37 facilitate phosphorylation of CRAF at S621 position necessary for its stability and activity. Screening of other chaperones in yeast identified essential role of Hsp90 co-chaperones, HOP (Hsp70/Hsp90 organizing protein) and Aha1. However, in contrast to Hsp90, HOP/Aha1 does not affect S621 phosphorylation of CRAF and hence its stability, but is required for CRAF activity. Deletion of Sti1 (homologue of HOP)/Aha1 in yeast abolishes CRAF kinase activity. Similarly, silencing of HOP in mammalian cell reduces CRAF basal kinase activity and MAPK signaling. On contrary, overexpression of HOP enhances MAPK signaling and increases CRAF activity. HOP overexpression enhances Hsp90 recruitment to CRAF and consequently increases CRAF membrane translocation.

Molecular Chaperones in determining the fate of cytosolic misfolded proteins

Cellular protein quality control machinery maintains protein homeostasis by refolding/degrading the damaged proteins or sequestered into specified compartments. Hsp70 chaperone plays a critical role

in deciding the fate of the damaged proteins. In yeast we found that heat denatured kinases (incubated at 42ºC) are refolded back to its native state when placed at physiological temperature (30ºC), but form IPOD inclusion when placed at non-permissive temperature (37ºC). In contrast, moderate stress (incubated at 37ºC) generates stress foci. In both conditions the refolding of kinase requires Hsp70's ATPase activity. Hsp70/Ydj1/Sse1 chaperone complex is essential for refolding of heat inactivated kinases (at 42ºC) upon withdrawal of heat stress. In contrast, Hsp70/Ydj1/Hsp104 assist refolding of kinase inclusions accumulated as stress foci at 37ºC. Nucleotide exchange factors (NEFs) have differential behaviours. Sse1 assists Hsp70 in degradation of kinase at physiological condition or Hsp90 inhibition, but Fes1 works during heat stress. Thus, co-chaperones of Hsp70 play a decisive role in determining the fate of misfolded protein whether to fold, hold or degrade.



SCIENTIFIC REPORT

Students Awarded Ph.D.

Name of Student (University/ Year)	Title of Thesis
Dr. Joydeep Roy (C.U., 2017)	'Functional role of molecular chaperone Hsp70 in quality control of protein kinases'
Dr. Sahana Mitra (C.U.,2017)	Characterization of the function of chaperone network in quality control of Raf1 kinase'

Grant-in-Aid Schemes

Title of the Scheme	Project funded by
Role of co-chaperones in triage decision of Hsp70	DST-SERB

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

i) Delivered talk at the 'International Congress of Cell Biology-2018' conference held at Hyderabad during 27-31 January, 2018.

Group Members:

i) Nilanjan Gayen gave a talk at the 'International Congress of Cell Biology-2018' conference held at Hyderabad during 27-31 January, 2018.

ii) Baijayanti Ghosh presented a poster at the 'International Congress of Cell Biology-2018' conference held at Hyderabad during 27-31 January, 2018.

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

Characterisation of disease resistant/ susceptible DNA markers in marine giant black tiger shrimp, *Penaeus monodon*

Giant black tiger shrimp, *Penaeus monodon* (Fabricius) is one of the valuable captured and cultured marine shrimp species has relentlessly affected due to several viral pathogen related diseases across the world. Among these viral pathogens, white spot syndrome virus (WSSV) causative agent of white spot disease (WSD) is the most lethal one and creates severe epizootics in shrimp production. Various efforts against WSD have already been taken but the problem still remains and no fruitful remedy was found; therefore, development of disease-resistant DNA marker is an alternative and cost-effective strategy to identify the disease-resistant broodstocks for disease free shrimp aquaculture industry.

We have developed so far eight (8) DNA markers (442 bp, 236 bp, 71 bp, 457 bp, 848 bp, 773 bp, 299 bp and 262 bp) to identify disease resistant population of *P. monodon*. In the present investigation, putative ORF region within the earlier developed 457 bp, 779 bp, 299 bp, 262 bp and 848 bp microsatellite DNA marker have been searched through the ORF Finder to predict the molecular information about the DNA marker. Two putative ORF's have been found in the 457 bp sequence. Although, these predicted amino acid sequences did not showed any significant similarity with known proteins. Four putative ORF's have been found in the 773 bp sequence. The predicted amino acid sequence from the +2 and -2 reading frame showed similarity with known database. Eight putative ORF's have been found in the 848 bp sequence. The predicted amino acid sequence from +1, +2, -2, +3 and -3 reading frame showed similarity with known database.

The inverse PCR result showed that Hind III digested PCR produced one fragment (524 bp) and Sau3A digested PCR produced two fragments (195bp and 510bp) has similarity with some known data base. The homology searching result depicted that these sequences have similarity with 2 types of protein i.e. i) membrane bound protein ii) proteins related to metabolic pathway. Based on these homology new primers have designed. It is under investigation that whether these sequences belong to bacteria or *P. monodon* and if these sequences belong to shrimp whether they play a role in establishment of white spot syndrome disease or not.

The anchored PCR result showed that among the PCR products only 152 bp fragment got 78% identity with Mus musculus BAC clone RP23-109J14 from 1, complete sequence (54% query coverage) . Rest fragments had no significant similarity with known database.

The results from RACE showed that the sequence of 190 bp has maximum homology with the *Litopenaeus vannamei* arginine kinase mRNA, complete cds. Arginine kinase mainly participates in energy metabolism in invertebrates. Arginine kinase is functionally analogous to creatine kinase, phosphoarginine and arginine kinase are the most commonly found phosphagen and phosphagen kinase in invertebrates, such as arthropods, marine invertebrates etc. Since, the following gene is suspected to be present in the 3' region of 71 bp microsatellite DNA marker and its major functioning is in energy metabolism therefore dysfunctioning of this gene may leads to host susceptibility.

Achievements from Medical Biotechnology research

Development of ecofriendly natural/synthetic medicine against non-communicable diseases

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 studied on the anti-proliferative efficacies of BODIPY based organometallic fluorescent compounds.

We have developed some orally administrable medicine from natural resources for amelioration against iron-induced toxicity by chelating iron or by trapping free radicals (antioxidant). In addition to endogenous antioxidant systems, consumption of natural supplements rich in antioxidants alter the redox environment thereby lowering risk of many oxidative stress-related diseases. Up till last year, an Indian Desert Shrub 'Hiran Chabba', *Farsetia Hamiltonii* Royle, few lichens, *Everniastrum cirrhatum* (Fr.) Hale ex. Sipman, *Acroscyphus sphaerophoroides* and *Dirinaria consimilis* found to be a promising source of natural antioxidant and iron-chelating drugs. Recently we have investigated the activity of tannic acid, isolated from *Drosera burmannii Vahl.* for possible activities of ameliorating iron-overloaded toxicity in mice liver.

Cancer is one of the dreaded diseases in the present global scenario with millions of incidences of affected patients and associated deaths. Apart from natural products, organometallic supramolecules also 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. Constructing these synthetic metallarectangles give us the liberty to tailor them in a way that favors selective killing of cancer cells. Moreover, upon incorporating BODIPY ligands in their structure, the resultant metallarectangles displayed fluorescence due to the co-

existence of monomeric and aggregated compounds. Previously, we have investigated certain Ru (II),Ir (III) and Pd-based supramolecules for their antiproliferative activities against cancers of different origins. This year we have explored a series of novel BODIPY-based Ir (III) rectangles containing bis-benzimidazole ligands and Ru(II) rectangles containing thiophene ligands supramolecules and have found that they showed selective killing against brain carcinoma (U87), breast carcinoma (MCF-7) and cervical cancer (HeLa) cells.The characteristic green fluorescence of BODIPY ligands in the complexes was used as a tracking tool under a confocal microscope to investigate the intracellular regions where the compounds were localized. All compounds showed anticancer activities comparable to the standard drug cisplatin. Presently we are actively working on many other series of compounds for our search of better and safer drugs to combat cancer.

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

Publications

Published in Peer-Reviewed Journal

1. Basu T, Panja S, Shendge A K, Das A and Mandal N (2018) A natural antioxidant, tannic acid mitigates iron-overload induced hepatotoxicity in Swiss albino mice through ROS regulation. 33:603–618. DOI: 10.1002/tox.22549. *Environmental Toxicology (Impact factor: 2.937)*
2. Debnath RP, Mandal N and Rout J (2018) Phytochemical screening of macrolichens*Acroscyphussphaerophoroides* and *Dirinariaconsimilis* from North East India for antioxidant and antibacterial activities. E-ISSN: 2456-0251, 190-196. *Cryptogam Biodiversity and Assessment*.
3. Gupta G, Das A, Lee J, Mandal N and Lee C Y (2018) Self-Assembled BODIPY-Based Iridium Metallarectangles: Cytotoxicity and Propensity to Bind Biomolecules. 83: 339–347. DOI: 10.1002/cplu.201800035. *ChemPlusChem* (Impact factor: 2.797).
4. Gupta G, Das A, Panja S, Ryu JY, Lee J, Mandal N and Lee C Y (2017) Self-assembly of novel thiophene-based BODIPY Ru(II) rectangles: Potential antiproliferative agents selective against cancer cells. 23:17199–17203.DOI: 10.1002/chem.201704368 *Chemistry A European Journal* (Impact factor: 5.317).
5. Shendge A K, Basu T, Sinha GP and Mandal N (2017) Assessment of the antioxidant activity and phytochemical analysis of a lichen, *Everniastrumcirrhatum* (Fr.) Hale ex. Sipman. *World Journal of Pharmacy and Pharmaceutical Sciences* 6: 1440-1464 DOI: 10.20959/wjpps20179-10056 (Impact factor: 6.647).

Published as a Book Chapter

1. Das A, Chaudhuri D, Sarkar R, Ghate N B, Panja S, and Mandal N (2018) Plants of Indian Traditional Medicine with Antioxidant Activity: In *Nutritional Antioxidant Therapies: Treatments and Perspectives*, (Edited by Kaïs Hussain Al-Gubory and Ismail Laher). Springer Nature, Springer International Publishing AG, Gewerbestrasse 11, 6330 Cham, Switzerland, pp 27-64. DOI: 10.1007/978-3-319-67625-8.

Grants-in-aid Schemes

Tiltle of the Scheme	Project Funded by
Molecular characterization of developed DNA markers linked to disease resistance/ susceptibilityin giant black tiger shrimp, *Penaeus monodon*	DST-SERB
Identification and characterization of micro RNAs (miRNAs) in *Penaeus monodon*	DBT

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

1. Attended the National Conference on "Current Developments and Next Generation Lichenology" held on January 27 – 28, 2018 at NBRI, Lucknow, India organized by Indian Lichenological Society (ILS) NBRI, Lucknow.
2. Attended the "3rd International Conference and Expo on Herbal and Alternative Medicine" held on September 01-02, 2017 at Park Inn by Radisson, London, UK Organized by Allied Academies

Talks delivered by BI faculty at other Institutions

1. Delivered an invited lecture on "Importance of Lichen to control non-communicable diseases" at the National Conference on "Current Developments and Next Generation Lichenology" held on January 27 – 28, 2018 at NBRI, Lucknow, India organized by Indian Lichenological Society (ILS) NBRI, Lucknow.
2. Delivered an invited Key note lecture on "Drug development from natural resources: An insectivorous plant, Drosera burmannii, is a source of better medicine to combat breast cancer by altering tumor – microenvironment" at the "3rd International Conference and Expo on Herbal and Alternative Medicine" held on September 01-02, 2017 at Park Inn by Radisson, London, UK Organized by Allied Academies.

Social relevance of research performed at Bose Institute

Prof. Mandal's 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.

Developing effective strategies to combat various non-communicable diseases resulting from failure of anti-oxidant defense in humans has become an immediate need for the society. Diseases like anemia, heart failure, liver cirrhosis, fibrosis, diabetes, arthritis, depression, impotency, infertility and even cancer are caused by oxidative stress due to failure of anti-oxidant systems, rise in percentage of ROS and RNS and iron overload in human. There is always a constant need of developing cheaper medicines which not only treat the affected tissues, or kill the cancer cells, but also are non-toxic to associated normal healthy cells.

Prof. Mandal's **Medical Biotechnology** research program is in constant search of prospective sources of orally administrable drugs against iron-overload-induced hepatotoxicity as well as cancer. His laboratory successfully isolated tannic acid from *Drosera burmannii Vahl*. and found them to be promising candidates for the development of drugs against iron-overload-induced hepatotoxicity. Moreover, active fractions isolated from two plants and an algae that were previously found sources of anticancer drugs, were found to be actively involved in projecting anti-proliferative activities. Additionally, Prof. Mandal's group is also looking for answers for tackling cancer, in synthetic supramolecules, and very recently have found a series of fluorescent BODIPY based Irridium and Ruthenium complexes to selectively kill brain, breast and cervical cancer cells in a way similar or better than cisplatin. Prof. Mandal's socially beneficial research would lead to the development of safer, cheaper and effective drugs against the deadly non-communicable diseases, which would be easily available for common people.

Awards/Honours received by the members of BI

1. Delivered invited lecture, felicitated and presided over as Chairperson of a technical session in the National conference on "Current Developments and Next Generation Lichenology" held on January 27 – 28, 2018 at NBRI, Lucknow, India .
2. Delivered invited Key note lecture, felicitated and presided over as Chairperson of a technical session in the "3rd International Conference and Expo on Herbal and Alternative Medicine" held on September 01-02, 2017 at Park Inn by Radisson, London, UK.

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. Gucchait A, Joardar N, Kumar P P, Roy P, Mukherjee N, Dutta A, Yesuvadian R, S P. Sinha Babu, Jana K, Misra A K (2017) Development of novel anti-filarial agents using carbamo(dithioperoxo) thioate derivatives. *European Journal of Medicinal Chemistry 143,* 598-610.
2. Si A, Misra AK (2017) Concise Synthesis of the Phosphoglycerylated Tetrasaccharide Repeating Unit of the Capsular Polysaccharide of Streptococcus pneumoniae Serotype 11 A. *Chemistry Select 2,* 11771-74.
3. Si A, Misra A K (2017) Concise synthesis of the pyruvic acid acetal containing pentasaccharide repeating unit of the cell wall O-antigen of Escherichia coli O156. *RSC Advances, 7*, 49903-09.
4. Bhaumik I, A K Misra (2017) Rapid Transformation of Alkyl Halides into Symmetrical Disulfides Using Sodium Sulfide and Carbon Disulfide. *SynOpen, 1*, 117-120.
5. Dutta A, Dhara D , Parida P K, Si A, Yesuvadian R, Jana K, Misra AK (2017) C-Glycosylated cinnamoylfuran derivatives as novel anti-cancer agents. *RSC Advances*, *7*, 28853-64.
6. Gucchait A, Jana K, Misra A K (2017) Convenient preparation of thioglycomimetics: S-glycosyl sulfenamides, sulfinamides and sulphonamides. *RSC Advances,* **(2017)** *7*, 32478-87.
7. Harale KR, Rout JK, Chhikara M K, Gill D S, Misra A K (2017) Synthesis and immunochemical evaluation of a novel Neisseria meningitidis serogroup A tetrasaccharide and its conjugate. *Organic Chemistry Frontiers, 4*, 2348-57.
8. Si A, Misra AK (2017) Concise synthesis of the pyruvic acid acetal containing pentasaccharide repeating unit of the cell wall O-antigen of *Escherichia coli* O156. *RSC Advances, 7*, 49903-09.

Students awarded with Ph.D. degree

Name of the student (University/Year)	Title of the thesis	Supervisor
Anshupriya Si (C.U., 2018)	Synthetic studies on polysaccharide fragments of microbial origin	Dr. Anup Kumar Misra

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 andtheir use in the preparation of glycoconjugate derivatives",	CSIR

Dr. Mahadeb Pal

Professor

Scientific Reports

Identification and purification of modulators of heat shock factor 1 (HSF1) from medicinal plant extracts and study their mode of actions

Plant extract containing various medicinal values have been known and methodically in use in various branches of traditional medicine in India. We have been carrying out a project to screen plant extracts for small molecule modulators of heat shock factor 1 (HSF1), a central regulator of cellular proteotoxic stress response. Deregulation of HSF1 activity has been implicated in various human diseases such as in cancer and various neurodegenerative diseases. By using cell based HSF1 sensitive reporter assay we have isolated azadiradione, a triterpenoid from methanolic extracts of neem seed that activates HSF1 by direct physical interaction with high spcificity. This compound ameliorates polyQ disease associated toxicity fruit fly. Currently, we are investigating other molecules present in neem seeds and other the plant extracts that activate HSF1 by similar or different mechanism. An important objective include isolation of compounds that will activate HSF1 with minimal toxicity to the normal cell at the effective dose and. Analysis of the structures of these compounds may also provide clue on the pharmacophore in the molecule responsible for the HSF1 activating function.

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 or prostate cancer. The project is progressing towards identifying mode of action which include targeting signalling network that is specifically modulated isolation of activities and by the activity only in the cancer cells but not in the normal cells. We are also close to purification of an activity that sensitises colon cancer cells ~10 fold more than its normal counterpart. Our results suggest that activation of cellular MAO-A is responsible for the most the observed function.

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

Inducible form of heat shock (HS) proteins such as HSP70A1A and HSP70A1B play important role in maintaining cellular protein homeostasis. Altered expression of these proteins has been correlated with different human pathologies such as inflammation, cancer and cardiovascular diseases. Relatively more is known on the association of these proteins with different diseases than mechanisms that control it transcription. A project in the lab is being carried out to unravel mechanism of over expression of these proteins such as Hsp70A1A under HS. To this end we found that NFκB cooperates with HSF1 in inducing its expression under HS. Our studies have revealed that NFκB (p50/p65) upon enagement at a κB site located on HSP70A1A promoter brings DNA break repair complex consisting of DNA-PK, PARP1 and TopoIIβ that help facilitating upregulation of this protein under HS. Experiments are continuing to obtain a deeper insight into the process. We are relying on the mass spec based approaches to this end.

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 the pol II can proceed to elongation mode soon after an activation signal is encountered without much delay. 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 need to be entitled to this unique mechanism. We are addressing as well if this mechanism varies with activators.

Understanding molecular mechanism of cross talk between cellular heat shock and inflammatory responses

For a healthy cell heat shock response (HSR) is a protection mechanism and is upregulated as required basis to challenge an unfavourable extra and intra cellular stressful environments. The HSR brought back to the 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 have identified a cellular pathway that directly link HSF1 with a key pro-inflammatory mediator. Our results for the first time suggest that a proinflammatory mediator induced through direct transcriptional activity of HSF1 activates NFkB via interacting with a extracellular receptor. These results in addition gave new insights on transcriptional machinery HSF1 engages upon heat shock treatment.

Understanding control of Heat shock factor 1 (HSF1) gene under an oxidative stress

Many types of cancer cells have been observed to carry elevated levels of HSF1 protein. In fact in certain cancer types elevated HSF1 gene expression has been correlated with poor prognosis although the underlying mechanisms remain not well understood. Our ongoing study in the lab has unravelled a mechanism that guides this upregulatory mechanism including the transcription activator and chromatin modifying activity involved in the process. Results obtained in the lab suggest that HSF1 gene is upregulated by NRF2, a central player in cellular antioxidant stress response. These results revealed for the first time a direct link between these two cytoprotective pathways.

Grant-in-Aid Scheme

Title of the Scheme	Schemes funded by
1. Understand molecular mechanism of action of a protein chaperone inducer azadiradione and its therapeutic development for Parkinson's disease treatment	DBT
2. Understand regulation of heat shock factor 1 activity in human cells	SERB

Participation in conferences

Delivered an invited talk at International 35th IAN Conference on 'Translational Neuroscience and its Application in Mental Health' Held in Ravensaw University, Cuttack October 29 - 31, 2017.

Publications

1. Hazra J, Mukherjee P, Ali A, and Pal M (2017) Engagement of Components of DNA-Break Repair Complex and NFκB in Hsp70A1A Transcription Upregulation by Heat Shock. *PLOS ONE* Jan 18;12(1):e0168165
2. Pemmaraju D, Appidi T, Minhas G, Singh SP, Khan N, Pal M, Srivastava R, Rengan AK (2017) Chlorophyll rich biomolecular fraction of *A. cadamba* loaded into polymeric nanosystem coupled with Photothermal Therapy: A synergistic approach for cancer theranostics. *Int J Biol Macromol* S0141-8130(17)33018-0.
3. Safina A, Cheney P, Pal M, Brodsky L, Ivanov A, Kirsanov K, Lesovaya E, Naberezhnov D, Nesher E, Koman I, Wang D, Wang J, Yakubovskaya M, Winkler D, Gurova K (2017) FACT is a sensor of DNA torsional stress in eukaryotic cells, *Nucleic Acid Research*, Jan 12, 2017
4. Sarwar S, Ali A, Pal M Chakrabarti P (2017) Zinc oxide nanoparticles provide anti-cholera activity by disrupting the interaction of cholera toxin with the human GM1 receptor, *J Biol Chem* 2017 Nov 3;292(44):18303-18311.
5. Singh B, Vatsa N, Nelson V, Kumar V, Kumar S, Mandal S, Pal M and Jana N (2018) Azadiradione Restores Protein Quality Control and Ameliorates the Disease Pathogenesis in a Mouse Model of Huntington's Disease, *Mol Neurobiol*. 2018 Jan 2. doi: 10.1007/s12035-017-0853-3.

Dr. Gaurisankar Sa

Professor

Scientific Reports

Repurposing of Andrographolide as a VEGFR2 inhibitor to impede T-regulatory cell-mediated tumor-angiogenesis

New blood vessels formation or neo-angiogenesis is major perpetrator behind the establishment of tumor in the host. As the tumor grows beyond diameter of 1-2mm, a hypoxic condition arises in the inner core of tumor triggering the release of pro-angiogenic factors and chemokines in the tumor microenvironment. The chemokines attract T-regulatory (Treg) cells in the tumor site. Here we report that with the advancement of the disease, a significant number of Treg cells infiltrate in tumor-site and secrete high-amount of VEGFA to trigger neo-angiogenesis. An in-depth analysis revealed that FOXP3, a Treg-specific transcription factor, in association with STAT3 binds to *VEGFA* promoter to induce its transcription. The Treg-shed VEGFA activates VEGFR2 in endothelial cells of

the existing blood vessels and induces neo-angiogenic-signals. To inhibit tumor-angiogenesis, a small molecule inhibitor was screened which can potentially interact with the VEGFR2 kinase domain and inhibit its activity. Molecular docking module was used to identify the specific inhibitor of VEGFR2, and andrographolide was found to be one of the best docking molecules. Andrographolide binds to the same amino acids responsible for binding of ATP present in the kinase pocket of VEGFR2, prevents ATP binding to the receptor, and specifically inhibits its kinase activity. Thus, for a more radical approach towards safe VEGFR2 inhibitor we validate the potential of non-toxic andrographolide with greater bioavailability; in repealing tumor-angiogenesis and diminish tumor burden in the host.

Providence of $CD25^{+}KIR^{+}CD127^{-}FOXP3^{-}CD8^{+}$ T cell subset determines the dynamics of tumor immune surveillance

$Cd8^{+}$ T-regulatory cells are progressively emerging as crucial components of immune system. The previous report suggests the presence of FOXP3-positive $CD8^{+}$ Treg cells, similar to $CD4^{+}$ Tregs, in cancer patients which produce high levels of IL10 and TGF for its immunosuppressive activities. At an early stage of tumor development, we have identified a subset of FOXP3-negative $CD8^{+}CD25^{+}KIR^{+}CD127^{-}$ a Treg-like subset which is essentially IFN-positive. However, this early induced $CD8^{+}CD25^{+}CD127^{-}$ T cell subset certainly distinct from the $IFN^{+}CD8^{+}$ T-effecter cells. This $CD8^{+}CD25^{+}CD127^{-}$ T cells are equipped with other $FOXP3^{-}CD8^{+}$ Treg cell signature markers and can selectively suppress HLA-E-positive T_{FH} cells in autoimmune condition as well as tumor-induced $CD4^{+}$ Treg cells. Contrasting to FOXP3-positive $CD8^{+}$ Tregs, this subset does not inhibit effector T cell proliferation or their functions as they are HLA-E-negative. Adoptive transfer of this early-$CD8^{+}$ Treg-like subset detained tumor growth and inhibited $CD4^{+}$ Treg generation that obstacles the immune surveillance and impairs cancer immunotherapy. At the late stage of tumor development, when $CD4^{+}$ Treg cells dominate tumor-microenvironment, $CD4^{+}$ Tregs mediate the clonal deletion of this tumor-suppressive $FOXP3^{-}IFN^{+}CD8^{+}CD25^{+}CD127^{-}$ T cells and ensures tumor immune evasion. Our findings suggest that at an early stage of the tumor, this tumor-induced IFN-producing FOXP3-negative $CD8^{+}CD25^{+}CD127^{-}$ T cell subset can potentiate immune surveillance by targeting HLA-E-restricted $CD4^{+}$ Treg cells whereas leaving the effector T cell population unaffected, and hence maneuvering their profile can open up a new avenue in cancer immunotherapy.

Integrin-EGFR interaction regulates anoikis resistance in colon cancer cells

Anoikis resistance is an essential property of cancer cells that allow the extra-cellular matrix-detached cells to survive in suspended state in body fluid in order to metastasize and invade to distant organs. It is known that integrins play an important role in anoikis resistance but detailed mechanisms are not well understood. Here we report that highly metastatic colon cancer cells showed higher degree of anoikis resistance than the normal epithelial cells. These anoikis-resistant cancer cells express high-levels of integrin-α2, β1 and EGFR in anchorage-independent state than anchorage-dependent state. In contrast, normal epithelial cells failed to elevate these proteins. Interestingly, a higher co-association of EGFR with integrin-α2 and -β1 was observed on the surface of detached-cancer cells whereas integrin-α5 was associated with EGFR in adherent condition. Thus in absence of extra-cellular matrix, integrin-α2β1 in association with EGFR activates downstream

effectors ERK and AKT to support the survival of cells as was confirmed from the gene-ablation studies. Interestingly, these anoikis-resistant cancer cells express high-level of cancer stem cell signatures (CD24, CD44, CD133, EpCAM) and pluripotent stem cell markers (OCT-4, SOX-2, Nanog) as well as drug-resistant pumps (ABCG2, MDR1, MRP1). Altogether, our findings unravel the interplay between integrin-α2β1 and EGFR in anoikis-resistance and suggest that the resistant cells are cancer initiating or cancer stem cells, which may serve as a promising target to combat metastasis of cancer

Publications

1. Chakraborty S, Bhattacharya P, Panda AK, Kajal K and Sa, G (2018) Clonal deletion of anti-tumorogenic $IFN^{hi}FOXP3^{-}CD8^{+}$ Treg cells confine tumor immunosurvillance. ***Immunology Cell Biology.*** doi: 10.1111/imcb.12166.
2. Chakraborty S, Panda AK, Bose S, Roy D, Kajal K, Guha D and Sa G (2017) Transcriptional regulation of FOXP3 requires integrated activation of both promoter and CNS regions in tumor-induced $CD8^{+}$Treg cells. *Scientific Reports* **7**: 1628.
3. Panda, AK, Chakraborty, D, Sarkar, I, Khan, T and Sa, G (2017) New insights into therapeutic activity and anticancer properties of curcumin. *J. Experimental Pharmacology*, 9, 31-45.
4. Panda AK, Chakraborty S, Kajal K, Roy D, Sarkar T and Sa G (2017) Role of proteases in tumor immune evasion. In: *Pathophysiological aspects of proteases.* (Eds: Dhalla NS & Chakraborti, S). Springer Publishing Company, New York, USA. 237-264, 2017
5. Panda AK, Bose S, Sarkar T, Roy D, Chakraborty D, Chakraborty, S, Sarkar I and **Sa G (2017)** Cancer-immune therapy: restoration of immune response in cancer by immune cell modulation. *The Nucleus*, DOI 10.1007/s132-37-017-0194-7.
6. Saha T and Sa G (2017) Constraint-driven docking: a logistic docking approach for deriving protein-protein complex structure. *Protocol Exchange* doi:10.1038/protex.2017.011.

Students Awarded Ph. D

Name of the student (University/ Year)	Title of the Thesis
Dr. Debliona Guha (C.U., 2018)	Deciphering Anoikis: An Approach to Overpower Detachment-Induced Apoptosis Resistance in Invasive Cance
Sreeparna Chakravarty (C.U., 2018)	Unravelling the Role of CD8+ T-regulatory Cells in Cancer

Grants-in-aid Schemes

Title of the scheme	Project funded by
(As Co-PI) Role of cancer stem cells in tumor neo-angiogenesuis: A mechanistic study	DST
(As PI) miR-325: a Distinct miRNA that controls T-regulatory cell development and function	DST
(As Co-PI) Multi-dimensional research to enable systems medicine: Acceleration using a cluster approach	DBT

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

i) Delivered a key-note lecture in 2nd International Conference and Exhibition on Marine Drugs and Natural Products, held in June, 2017, in London, UK.'

ii) Delivered an invited lecture at the International conference on Translational Research in September, 2017, at Amity University, Kolkata.

iii) Invited to deliver plenary talks at the national Conference on Recent Advances in Applied Biological Sciences, in Kalyani University, in December, 2017.

iv) Delivered key-note lecture at the 86th Conference of Society of Biological Chemists in November, at JNU, New Delhi, a plenary talk at the Immunocon-2017 at Nirma University, Ahmedabad.

v) Delivered an invited talk at the an Indo-US conference on Transcription, Chromatin Structure, DNA Repair and Genomic Instability at Indian Institute of Science, Bangalone in March 2018.

vi) Delivered an Invited talk at the 37th Indian Association of Cancer Research convention in February, 2018, at Bose Institute, Kolkata and at the 18th International Symposium of All India Congress of Cytology and Genetics at CSIR-Indian Institute of Chemical Biology in January, 2018.

vii) Delivered a plenary lecture at the Annual convention of Indian Doctor's Association at Kolkata in February, 2018.

Seminars / Symposia organized at Bose Institute:

Organized International conference on Translational Research in September, 2017, INDO-JAPAN Conference on Epigenetics, Human Microbiomes and Disease, in February, 2018, and 37th Indian Association of Cancer Research convention in February, 2018. .

Awards / Honors received by the members of BI:

Elected as the member of Nanyang Academy of Science (NAS), Singapore in 2018.

Dr. Parames C Sil

Professor and Coordinator

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

Main objectives

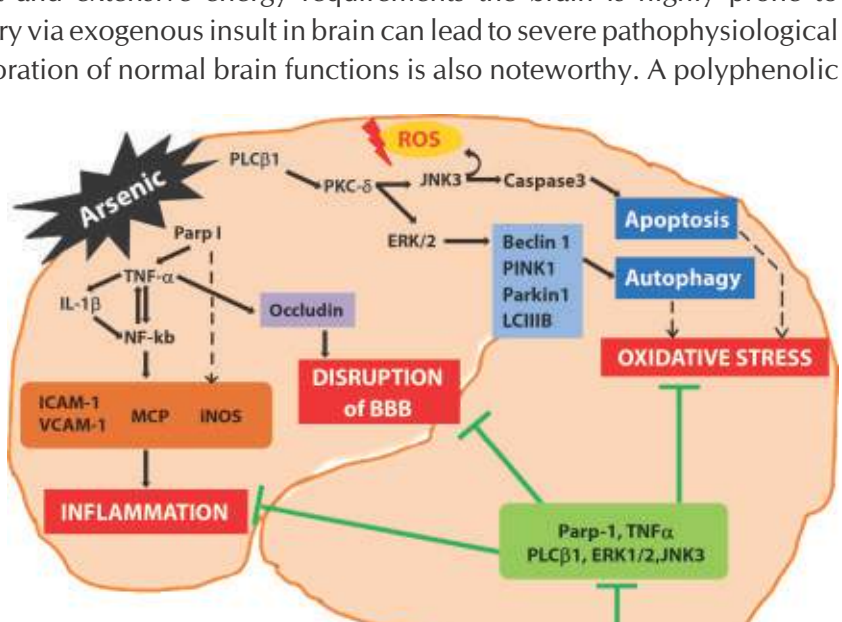
Research in our laboratory encompasses several major areas of organ pathophysiology (hepatotoxicity, gastropathy, neurotoxicity, and nephrotoxicity), diabetes, cancer and its protection via bio-active molecules.

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.

Ameliorative role of genistein against age dependent chronic arsenic toxicity in murine brains via the regulation of oxidative stress and inflammatory signaling cascades

Owing to its huge lipid content and extensive energy requirements the brain is highly prone to oxidative damage. Oxidative injury via exogenous insult in brain can lead to severe pathophysiological situations. Age dependent deterioration of normal brain functions is also noteworthy. A polyphenolic isoflavonoid, genistein, obtained mainly from the soy plant, is well known to protect against several diseased conditions. Here, in this study chronic brain toxicity model was developed using oral administration of arsenic in adult and aged murines. We observed that intraperitoneal administration of genistein improved the arsenic induced behavioral abnormalities in the rats. It was also evident from the histopathological studies that the extent of tissue damage due to arsenic exposure was more in aged rats compared to the



SCIENTIFIC REPORT

adults. Evaluation of different stress markers, intracellular ROS level and mitochondrial membrane potential revealed the involvement of oxidative stress and mitochondrial dysfunction in inducing brain damage in arsenic exposed murines. It was observed that genistein can significantly ameliorate the stressed condition in both the animal groups but the protective effect of genistein was more significant in the adult animals. The underlying signalling mechanism behind the cytotoxicity of arsenic was investigated and revealed that genistein exhibited neuroprotection significantly by modulating the JNK3 mediated apoptosis, ERK1/2 mediated autophagy and TNF associated inflammatory pathways. Overall study infers that genistein has significant ameliorative effect of against age dependent neurotoxicity of arsenic in murines.

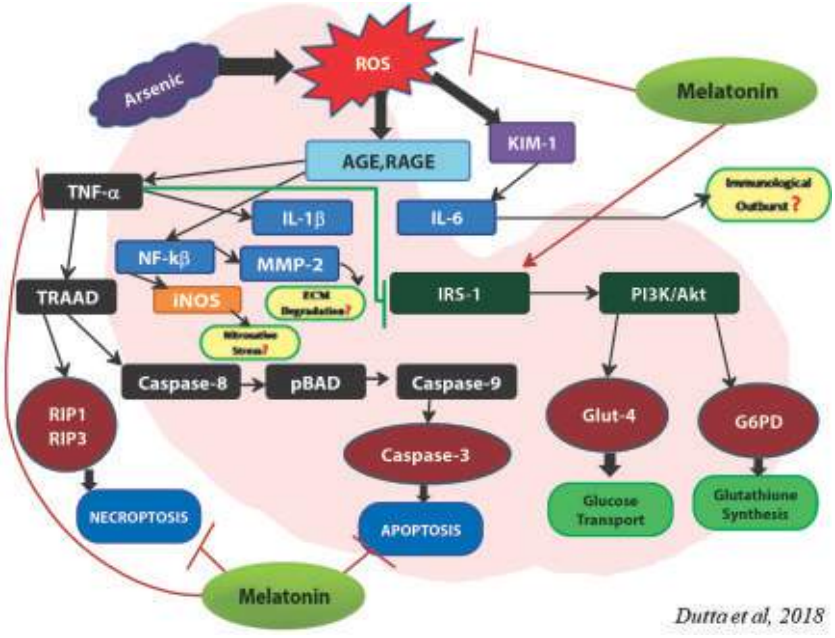
Melatonin attenuates arsenic induced nephropathy via the regulation of oxidative stress and inflammatory signaling cascades in mice

Arsenic (As) is a natural element widely present in our drinking water, food and soil. The major reason of As toxicity in human is due to its contamination through drinking As polluted water where the concentration varies in between 0.01–3.7 mg/l (1.3–49 μM). In human body and environment, As is present in both organic and inorganic forms, the later being more toxic. Again inorganic As is present in either arsenite [As(III)] or arsenate [As(V)] depending on its valence state. Due to its colourless and odourless nature, As detection in contaminated food or drinking water is very tough and thus initially it leads to serious health hazards silently. Further, it can also be absorbed through skin. As toxicity affects nearly all major organs but kidney being the organ responsible for excretion and osmoregulation, is mostly affected. It is already reported that bio-methylated As compounds (monomethyl arsinic and dimethyl arsinic acids) are excreted by the kidney through urine but still the mechanism of As induced renal toxicity lacks understanding. During metabolic activation of As compounds, reactive oxygen species (ROS) are generated which in turn increase oxidative stress in As induced nephrotoxicity . Several epidemiological studies from As polluted areas and occupational populations indicated about the correlation between high As level in drinking water and chronic kidney diseases**.** It promotes deleterious phenomenon like oxidative stress, inflammation, cell death and altered glucose uptake leading to distorted kidney homeostasis that end up in chronic kidney disease. This study investigated the possible protective role of melatonin; a natural antioxidant produced by the pineal gland, against arsenic induced nephrotoxicity. Melatonin (N-acetyl-5-methoxytryptamine) is a hormone, synthesised in pineal gland and released into the blood and the cerebrospinal fluid. Melatonin acts as an antioxidant and free radical scavenger. Melatonin and its metabolites play important protective role in different pathophysiological conditions by mitigating oxidative stress and inflammation. It also increases the activity of antioxidant enzymes and inhibits pro-oxidative enzymes. Melatonin successfully ameliorated arsenic induced renal toxicity both in *in vitro* and *in vivo* models. Elevated BUN, creatinine, urine glucose and protein levels and altered renal histopathological conditions were observed in arsenic intoxicated mice. Significant oxidative stress induced damage of biomolecules along with downregulation in antioxidant enzymes and thiols were also detected in the kidney tissues of arsenic-intoxicated mice. These alterations along with mitochondrial dysfunction ultimately triggered TNFα mediated inflammatory and cell death cascades. Interestingly arsenic also led to disruption of glucose uptake in the kidney. Melatonin, by activating IRS1 facilitated glucose metabolism and simultaneously inhibiting arsenic triggered TNFα mediated inflammation, apoptosis and necroptosis, exhibits ameliorative role against arsenic induced renal toxicity. As melatonin is a

natural antioxidant molecule, detailed pharmacokinetic and pharmacodynamic studies are expected to establish it as an effective nephro-protective agent in future.

Hyaluronic acid modified mesoporous silica nanoparticle increases the bioavailability of curcumin and enhances its target specific mortality in breast cancer cell

Mesoporous silica nanoparticles (MSNs) have been reported to be promising vehicles for drug delivery. Curcumin © a natural antioxidant, has many beneficial effects. However, poor bioavailability due to their less water solubility renders it unsuitable as an anti-cancer drug. In this study, we have synthesized hyaluronic acid (HA) modified mesoporous silica nanoparticles (MSN-HA-C) loaded with curcumin and then characterized it by DLS, TEM, SEM, XRD and FTIR. MTT, flow cytometry, scratch assay and immunoblotting were employed to assess the cell viability, cellular uptake, cell cycle arrest, apoptosis and wound healing etc. The expression levels of different signalling molecules in breast cancer cells were also explored. The result of this study indicates that MSN-HA-Q facilitates higher cellular uptake of C and increases its bioavailability to the breast cancer cells. The targeting capacity of the MSNs due to HA tagging was also employed using over-expressed HA receptors on MDA MB 231 cells. Our experimental results also suggest that the newly synthesized MSN-HA-Q showed cell cycle arrest and apoptosis in breast cancer cells by the modulation of apoptotic signalling pathways. In conclusion we hope that this novel delivery system based on mesoporous silica nanoparticle may provide a targeted delivery with enhanced bioavailability for the molecules like curcumin.

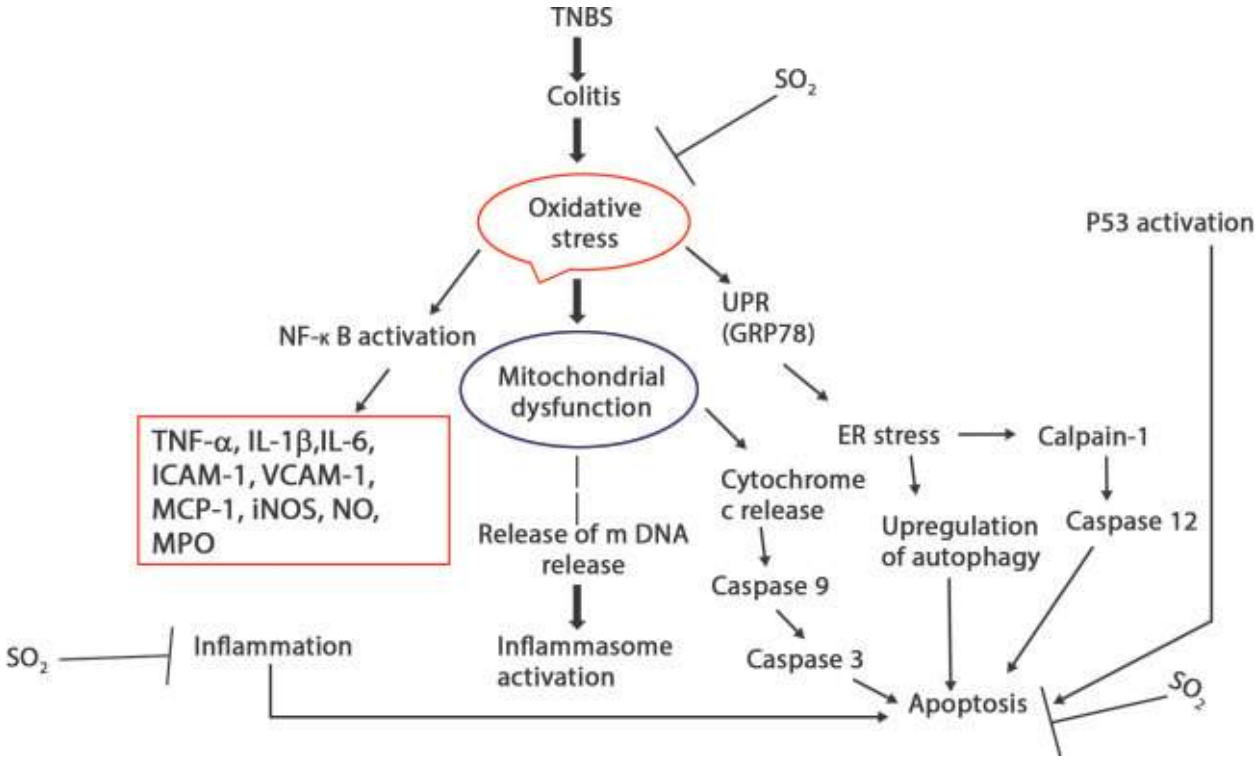


Sulphur dioxide ameliorates colitis induced inflammation

Colitis is an inflammatory disease of the gastrointestinal tract. Inflammation, oxidative stress and cell death constitute the backbone of colitis. microbial dysbiosis of gut microbiota and over activation of mucosal immune system play a pivotal role in this disease. Colonic macrophages release cytokines like interleukin 1β (IL-1β), tumor necrosis factor α (TNF-α), interleukin 6 (IL-6) and reactive species metabolites which in turn aggravates severity of colitis by recruiting more inflammatory cells and increasing oxidative stress Most of the drugs prescribed for inflammatory bowel disease (IBD) have various side effects. In this scenario, we would like to determine the therapeutic role sulphur dioxide, a gaso-transmitter produced through the metabolism of cysteine in

colitis. Sulphur dioxide has also been classified as a gasotransmitter like the others discussed above. Recent investigation suggest that sulpher dioxide is endogeneously produced in pulmonary vessels and regulates vascular activities. SO_2 is endogeneously produced through metabolism of sulphur containing amino acids. L-cysteine is first converted to L-cysteinesulfinate by cysteine dioxygenase. This L-cysteinesulfinate can also be produced through transamination with the help of glutamate-oxaloacetate transaminase (GOT). This enzyme converts L-cysteine into b-sulfinylpyruvate, which decomposes spontaneously to pyruvate and SO_2. This SO_2 is metabolized further to form sulphite in vivo and is oxidized into sulfate by sulfite oxidase and is excreted in urine. This L-cysteinesulfinate can also get decarboxylated by cysteinesulfinate decarboxylase to produce CO_2 and hypotaurine. The hypotaurine produced is oxidized to taurine. TNBS administration resulted in increased oxidative stress, NF-κ B and inflammasome activation, ER stress and autophagy. Moreover, TNBS administration also resulted in activation of p53 and apoptosis. SO_2 reversed all these alterations and ameliorated colitis in rats. Administration of an inhibitor of endogenous SO_2 production along with TNBS exacerbated colitis. Results suggest that down-regulation of SO_2 / glutamate oxaloacetate transaminase pathway is involved in IBD.

The protective role of SO_2 in colitis is attributed to its anti-inflammatory and anti-oxidant nature. Down-regulation of SO_2/glutamate oxaloacetate transaminase pathway is involved in IBD. Since SO_2 is not toxic at low concentration and endogenously produced, it may be used with prescribed drugs for synergistic effect after intensive research. Our result demonstrated the therapeutic role of SO_2 in colitis for the first time.



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

Under pathophysiological conditions, the cells or the tissues have two options of 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 in-vitro (normal lung cell line) and in-vivo 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 in–vitro system and proceed with the treatment of the most effective one, in in-vivo 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 in-vivo will be monitored. Finally, histological sections will be analyzed to study the effective protection provided by the selected bioactive molecule.

Studying the molecular mechanisms of NSAIDs induced gastropathy

Nonsteroidal anti-inflammatory drugs (NSAIDs) provide analgesic and antipyretic effects by inhibiting the activity of cyclooxygenase-1 (COX-1) and cyclooxygenase-2 (COX-2), and thereby the synthesis of prostaglandins and thromboxanes. indomethacin, a widely used NSAID induces gastric mucosal ulceration by stimulating nuclear translocation of NF-κB as well as the expression of cell adhesion molecules e.g., ICAM-1, VCAM-1, etc. and proinflammatory molecules e.g., IL-1β, TNF-α, MCP-1, etc. Reactive oxygen species (ROS) generation is a key regulator in gastric injury. Mitochondrial oxidative stress (MOS) is an important prostaglandin-independent pathway of the induction of gastric mucosal injury.

Gastric mucosal injury is auto repaired by body's own healing mechanism. Autophagy and mitophagy play important roles in this case. HO-1, a cytoprotective enzyme associated with tissue repair mechanisms is stimulated in response to oxidative stress.

Following these studies, we intend to investigate the pathophysiological manifestations and signaling pathways associated with indomethacin induced gastropathy and its healing mechanism both in vivo and in vitro. We want to find out the crosstalk among the roles of apoptosis, necrosis, necroptosis and autophagy involved in indomethacin induced gastropathy.

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.

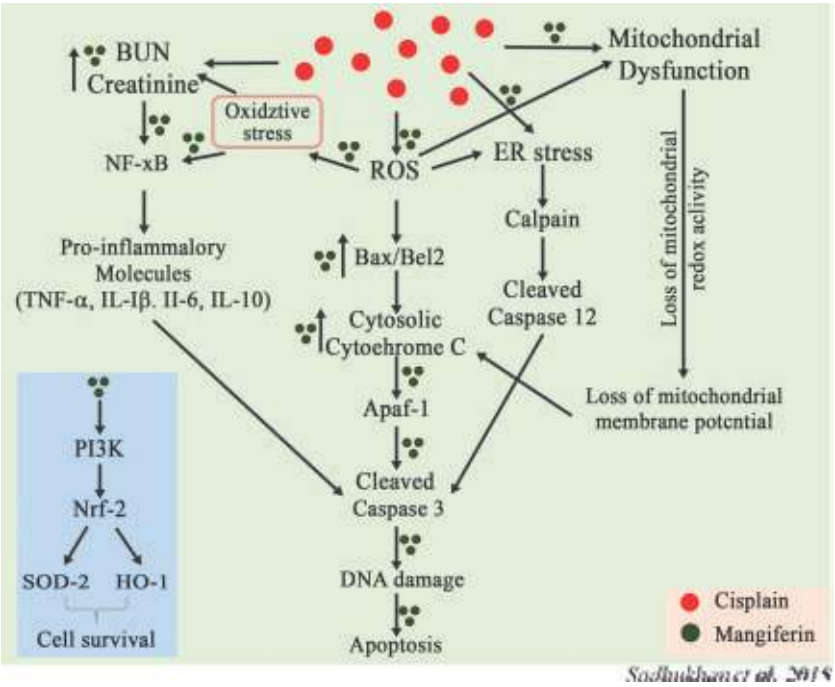
Selective anticancer activity of naturally occurring polyphenolic compounds and synthetic derivatives mediating oxidative stress

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.

Prophylactic activity of mangiferin cisplatin induced acute kidney injury

Occurrence of oxidative stress is the principal cause of acute kidney injury induced by cisplatin. Mangiferin, a naturally occurring antioxidant molecule, is found to ameliorate several oxidative stress mediated pathophysiological conditions including cancer. Cisplatin induced cytotoxicity was measured in NKE cells by MTT assay and microscopic analysis. Induction of oxidative stress and regulation of proapoptotic molecules were subsequently investigated by using different spectrophotometric analyses, FACS and immunocytochemistry. Induction of nephrotoxicity was determined by analyzing different serum biomarkers and histological parameters in vivo using swiss albino mice. Activation of NF-κB mediated pro-inflammatory and caspase dependent signaling cascades were investigated by semi-quantitative RT-PCR and immunoblotting. Mangiferin was



found to ameliorate cisplatin induced nephrotoxicity in vitro and in vivo by attenuating the induction of oxidative stress and upregulating Nrf-2 mediated pro-survival signaling cascades via the activation of PI3K. Additionally, mangiferin showed synergistic anticancer activity with cisplatin in cancer cell lines (MCF-7 and SKRC-45) and EAC cell induced solid tumor bearing experimental mice. The ameliorative effect of mangiferin is primarily attributed to its anti-oxidant and anti-inflammatory properties. It acts differentially in normal tissue cells and tumor cells by modulating different cell survival regulatory signaling molecules. For the first time, the study reveals a mechanistic basis of mangiferin action against cisplatin induced nephrotoxicity. Since Mangiferin shows synergistic anticancer activity with cisplatin, it can be considered as a promising drug candidate, to be used in combination with cisplatin.

SCIENTIFIC REPORT

Publications

1. Banerjee S, Sinha K, Chowdhury S, Sil PC (2018) Unfolding the mechanism of cisplatin induced pathophysiology in spleen and its amelioration by carnosine. *Chemico-Biological Interactions*, 279, 159-170.
2. Basak P, Sadhukhan P, Sarkar P, Sil PC (2018) Perspectives of the Nrf-2 signaling pathway in cancer progression and therapy. *Toxicology Reports*, 4, 306-318.
3. Dihingia A, Ozah D, Ghosh S, Sarkar A, Baruah PK, Sil PC & Manna P (2018) Vitamin K1 inversely correlates with glycemia and insulin resistance in patients with type 2 diabetes (T2D) and positively regulates SIRT1/AMPK pathway of glucose metabolism in liver of T2D mice and hepatocytes cultured in high glucose. *The Journal of Nutritional Biochemistry,* 52, 103-114.
4. Dutta S, Saha S, Mahalanobish S, Sadhukhan P, Sil PC (2018) Melatonin attenuates arsenic induced nephropathy via the regulation of oxidative stress and inflammatory signaling cascades in mice. *Food and Chemical Toxicology*, 118, 303-316.
5. Ghosh S, Chowdhury S, Sarkar P, Sil PC (2018) Ameliorative role of ferulic acid against diabetes associated oxidative stress induced spleen damage. *Food and Chemical Toxicology,* 118, 272-286.

6. Rashid K, Chowdhury S, Ghosh S, Sil PC (2017) Curcumin attenuates oxidative stress induced NFκB mediated inflammation and endoplasmic reticulum dependent apoptosis of splenocytes in diabetes. *Biochemical Pharmacology*, 143, 140-155.

7. Sadhukhan P, Saha S, Dutta S, Sil PC (2018) Mangiferin ameliorates cisplatin induced acute kidney injury by upregulating Nrf-2 via the activation of PI3K and exhibits synergistic anticancer activity with cisplatin. *Frontiers in Pharmacology*, 9, 638.

8. Sadhukhan P, Saha S, Dutta S, Mahalanobish S, Sil PC (2018) Nutraceuticals: An emerging therapeutic approach against the pathogenesis of Alzheimer's disease. *Pharmacological Research*, 129, 100-114.

9. Saha S, Sadhukhan P, Mahalanobish S, Dutta S, Sil PC (2018) Ameliorative role of genistein against age-dependent chronic arsenic toxicity in murine brains via the regulation of oxidative stress and inflammatory signaling cascades. *The Journal of Nutritional Biochemistry*, 55, 26-40.

10. Sarkar P, Basak P, Ghosh S, Kundu M, Sil PC (2017) Prophylactic role of taurine and its derivatives against diabetes mellitus and its related complications. *Food and Chemical Toxicology*, 110, 109-121.

Centenary Celebration Lecture on 'History of Indian Science: Modern Contribution' on November 25, 2017

Lecture delivered by Prof. Amitava Ghosh on 'Scientific aspects of Indian Engineering and Architecture'

Lecture delivered by Prof. Sibaji Raha on the work of 'Sir J. C. Bose and Dr. D. M. Bose'

Lecture delivered by Prof. Partha P Majumder on the works of 'Dr. Mahalanobis'

Lecture delivered by Prof. Partha Ghosh on the works of 'Dr. M. N. Saha and Dr. S. N. Bose'

Lecture delivered by Prof. Syamal Roy on the 'Discovery of U. N. Brahmachari on Kala-Azar'.

Lecture delivered by Dr. Amit Ghosh on the works of Dr. Shambhunath De, 'Discovery of Cholera Toxin'.

Lecture delivered by Dr. B. N. Chakraborty on the works of 'Dr. Subhas Mukherjee'

V. Basic and Applied Microbiology

Participation of Institutional Programme - V

Dr. Sujoy K. Das Gupta (Co-ordinator), Dr. Joyoti Basu, Dr. Manikuntala Kundu, Dr. Tapan Datta, Dr. Subrata Sau, Dr. Srimonti Sarkar, Dr. Wriddhiman Ghosh. Dr. Abhrajyoti Ghosh.

Introduction

The overall aim of this program is to investigate microbes from various perspectives, such as the role they play in causing human mortality and morbidity, the mechanism by which they survive under extreme conditions, their ability to perform beneficial acts, for example, degradation of environmental pollutants and finally how they evolve. In the area of infectious diseases the focus is on three human pathogens: *Mycobacterium tuberculosis*, the TB pathogen, *Helicobacter pylori*, the causative agent of gastritis and the unicellular protist *Giardia lamblia*, which causes the enteric disease, giardiasis. The scope of the environmental microbiology research component within program V encompasses exploration of microbial biodiversity of extreme environments, for instance, hot springs of Ladakh and the saline waters of the Sunderbans, and understanding the molecular biology of microbes that degrade complex environmental pollutants. Apart from the microbes themselves, their viruses and plasmids are also studied to understand their propagation mechanisms.

Dr. Joyoti Basu

Professor

Scientific Reports

The role of the transcription factor, ATF3 in the regulation of the survival of *Mycobacterium tuberculosis* in macrophages: *in collaboration with Manikuntala Kundu, Zhumur Ghosh and Kuladeep Jana*

Murine macrophages infected with *Mycobacterium tuberculosis (Mtb)* at a multiplicity of infection (MOI) of 10. Transcriptional profiling showed that ATF3 one of the highly up-regulated members of the CREB/ATF family. We pursued our investigations on the role of ATF3 during infection, in the light of reports of the role of ATF3 in tuning down transcriptional activation pathways regulating the inflammatory response. In order to understand the role of ATF3 upregulation during *Mtb* infection, *atf3* was silenced by transfection with siRNA. Survival of *Mtb* was augmented after silencing of ATF3 in RAW264.7 and bone marrow-derived macrophages (BMDMs) at different time points of infection. It is known that foamy macrophages (FMs) serve as nutrient rich reservoirs for *Mtb*. We identified the role of

Mtb induced transcription factor ATF3 in lipid body (LB) formation and FM generation. We show for the first time that ATF3 regulates *Mtb* induced FM formation. The upregulation of ATF3 in *Mtb* infected macrophages downregulates FM generation and thereby represses lipid body accumulation. This likely tilts the balance in the host-pathogen interplay in favour of the host.Furtherdelineation of the role of ATF3in infection is under way.

Publications

1. Sharma A, Mahatha A K, Banerjee AC, Kumar SK, M., Saha, S, Basu, J and Kundu, M (2017) Global mapping of MtrA-binding sites links MtrA to regulation of its targets in *Mycobacterium tuberculosis*. 164, 99-110.
2. Sahu SK, Kumar M, Chakraborty S, Banerjee S, Kumar R, Jana K, Gupta UD, Ghosh, Z Kundu, M and Basu J (2017) MicroRNA 26a (miR-26a)/KLF4 and CREB-C/EBPβ regulate innate immune signaling, the polarization of macrophages and the trafficking of Mycobacterium tuberculosis to lysosomes during infection. *PLoSPathog*. 13, e1006410.

SCIENTIFIC REPORT

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

i) Delivered a lecture at the *"EMBO Conference on Hijacking Host Signaling and Epigenetic Mimicry During Infections" being organized by* European Molecular Biology Organization (EMBO) and Institut Pasteur *held in Paris, France,from June 13-16, 2017*.

ii) Delivered a lecture in the meeting entitled "Inhaled Therapies for Tuberculosis and Other Infectious Disease" *being organized by*Rany Condos, MD, Associate Professor of Medicine, NYU School of Medicine, USA *held in*Durham, North Carolina on 16-17 October, 2017.

iii) Delivered a lecture in the Congress of the International Cell Biology held in Hyderabad from January 20 to February 1, 2018

Group Members

i) Arijita Subuddhi, Institute Fellow presented a poster in the "Development ofTissue and Pathogen-specific Cellular Innate Immunity" held at Freiburg, Germany on 27th to 29st September 2017

Grants-In-Aid Schemes

Title of the scheme	Scheme funded by
1. With Prof. M. Kundu and Dr. J. Mukhopadhyay as Co-PI Evaluating the sensor kinase MtrB of *Mycobacterium tuberculosis* as a regulator of bacterial physiological responses, and as a potential target for therapy	DST-SERB
2. J. C. Bose Fellowship	DST-SERB

Dr. Sujoy K Das Gupta

Professor and Coordinator

Scientific Reports

Did replication and transcription have a common origin. An evolutionary insight using a mycobacterial plasmid replication system.

In case of replication as well as transcription, DNA is copied by nucleotidyl polymerases giving rise to new strands of nucleic acids which could be either DNA (replication) or RNA(transcription). Although, the two processes are very similar, they are catalyzed by different enzymes, which do not appear to be evolutionarily related. However, in the evolutionary past, the situation could have been different. Plasmids and viruses are believed to be 'relics of the past' and therefore these could be used to study the relationship between transcription and replication processes that existed in the distant past.

The model system that we use is a mycobacterial plasmid named pAL5000, which, has been widely used for the genetic engineering of mycobacteria. The replication region of this plasmid is 1.8 kb in size and it spans a segment comprising a cis acting replication origin, and two open reading frames encoding the replication proteins RepA and RepB respectively. RepB was earlier characterized to be a plasmid origin binding protein, which is distantly related to sigma factors. The fact that a replication protein could be homologous to a sigma factor was an interesting observation, and so we saught to investigate the functional implication of such a relationship.

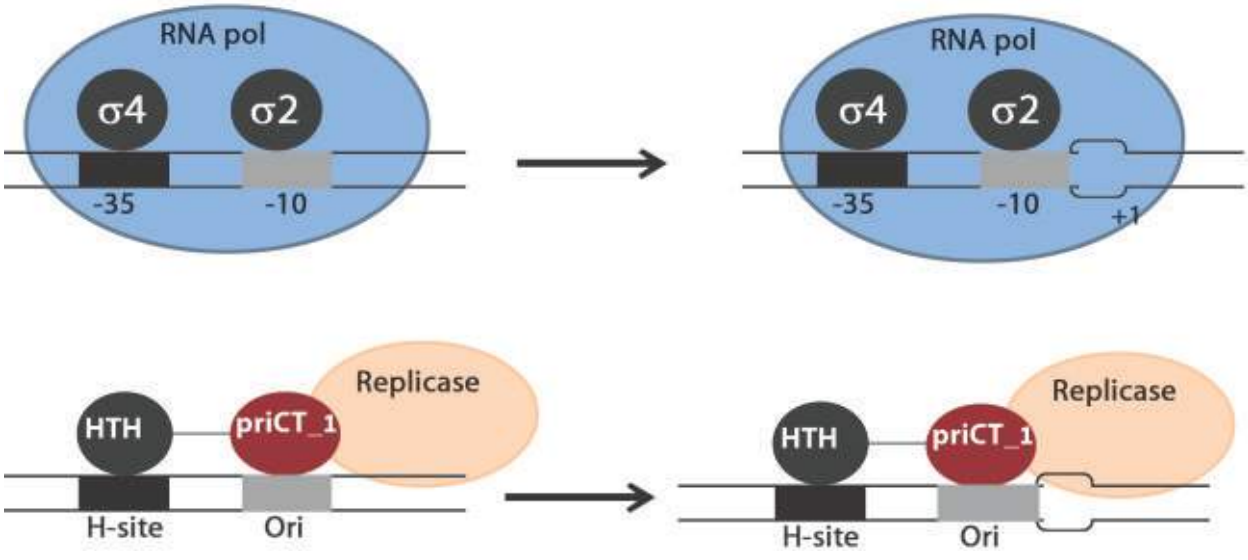


Figure. A model comparing the mechanism of action of RepB with that of sigma factors. In the schema, the C-terminal HTH domain of RepB and the PriCT_1 of RepA are considered to be the functional equivalents of regions 4 and 2 of sigma factors, respectively. Interaction of RepB and sigma factors with their cognate elements in the DNA allows the recruitment of the corresponding nucleotide polymerizing enzymes, RepA (a DNA replicase) and RNA polymerase (RNA pol), respectively, to their sites of action. In both cases, one of the consequences of the recruitment is the opening up of the DNA at specific sites, as shown.

In silico studies as well as *invitro* experiments revealed that RepA is evolutionarily related to a family of ancient replicases known a primase-polymerases that are found in plasmids present in a wide variety of bacteria, including archaebacteria. In this study we also show that RepA and RepB interact with each other thereby forming a complex. The interaction involves the C-terminal domain of RepA and N-terminal one of RepB. A fusion protein in which the C-terminal domain of RepA is linked in frame to the N-terminal one of RepB was found to be capable of not only binding the origin, as RepB does on its own, but in addition it could bend and deform the origin in a site-specific manner. Based on the results obtained a model has been proposed about how RepA and RepB act together. According to this model RepB interacts with RepA, thereby recruiting it to the origin. We have pointed out further the intriguing similarity between how RepB recruits RepA to the origin and how sigma factors recruit RNA polymerase to the promoter. Thus apart from unravelling for the first time how RepA functions, this study highlights the inherent relatedness between DNA replication and transcription processes as given in the model below.

Publication

1. Chatterjee S, Patra M M, Samaddar S, Basu A & Gupta S K D (2017) Mutual interaction enables the mycobacterial plasmid pAL5000 origin binding protein RepB to recruit RepA, the plasmid replicase, to the origin. *Microbiology*. 2017;163:595–610

Students awarded Ph.D.

Name of Student	Title of the Thesis
Soniya Chatterjee (CU, 2017)	"Functional and evolutionary insight into the mode of action of Rep A-Replication protein of the pAL5000 family of actinobacterial plasmid."

Grants-in-Aid Schemes

Title of the Scheme	Funded by
Phage inspired antibiotic for Mycobacteria.	DST, SERB

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

1. Delivered a seminar talk at the International Conference on Anti-Microbial Resistance held on February 16-17, 2018 at the ICMR-National Institute of Cholera and Enteric Diseases, Kolkata entitled "Mycobacteriophage based platform to discover drug targets for Mycobacteria"

Symposium organised by the Plan Project

International Symposium was organised by the Plan Project V entitled, "Microbiology in the New Millennium: from molecules to Communities." October 27-29, 2017.

Seminars / Symposia organized at Bose Institute:

i) International Symposium was organised by the Plan Project V entitled, "Microbiology in the New Millennium: from molecules to Communities." October 27-29, 2017.

Dr. Tapan K. Dutta

Professor

Scientific Reports

Exploration of catabolic potential of various aromatic compounds degrading bacteria

Based on the sole information of structural genes of the 2-nitrobenzoate (2NBA) utilizing catabolic gene cluster (*onbX1X2FCAR1EHJIGDBX3*), 2NBA-sensing bioreporters were constructed by incorporating *egfp* into the *onb* gene cluster of *Cupriavidus* sp. strain ST-14. Incorporation of reporter gene with the disruption of the gene encoding inducer-metabolizing enzyme was turned out to be advantageous in reporter gene expression at low inducer concentration and could detect the inducer 2NBA at (sub)nanomolar level exhibiting a strict specificity. The present study is a successful demonstration which can be used as a model for the development of bioreporters for other environmental pollutants.

Apart from nitrobenzoates, *Cupriavidus* sp. ST-14 can utilize a wide array of toxic anthropogenic and lignin derived phenylalkanoic acids and their mono-hydroxylated derivatives. The present study illustrates a broad degradative potential of strain ST-14, harbouring diverse metabolic machineries, elucidating couple of pathways, reported for the first time in the assimilation of various substituted aromatics.

In a separate study, the presence of a novel gene cluster termed *nol*, comprised of ten complete ORFs responsible for metabolizing 2-naphthol to gentisate was revealed in *Burkholderia* sp. BC1. Gentisate, in succession, was metabolized via the conventional 3-hydroxybenzoate metabolic pathway encoded in the *mhb* operon. The *nol* operon (*nolRBFAcAdAbAaECD*) was suggested to be evolved by recruiting genes from both Gram positive and Gram negative bacteria. A unique combination of the *nid*/*nar*/*phd*/*pht*-type terminal oxygenase components (*nolAcAd*) with a plant-type ferredoxin (*nolAb*) and a GR-type reductase (*nolAa*) suggests the evolution of a novel type of bacterial ring-hydroxylating oxygenase (RHO).

In addition, *Burkholderia* sp. strain BC1 is being investigated for its degrading potential of various cyanophenolic compound like 2-, 3-, and 4-hydroxybenzonitrile. Biochemical characterization on degradation of these compounds has already been elucidated. Recently, we are focusing on the identification of the gene clusters involved in the conversion of the above compounds into their respective amides and acids. Also, attemts are made to evaluate the existence of possible crosstalk between the metabolic pathways of these cyano compounds. In addition, since Burkholderiales are reported to be versatile biodegraders, the degradation capability of BC1 towards nitrophenolic compounds like 2-nitrophenol and 4-nitrophenol while nitroarene compounds like nitrobenzene,

2- and 3-nitrotoluenes, 2,3-, 2,4- and 2,6-dinitrotoluenes, and 2-, 3- and 4-chlorobenzoic acids are being tested.

In another study, a Rieske non-heme iron ring-hydroxylating oxygenase (RHO) from *Sphingobium* sp. PNB involved in the initial oxidation of a wide range of low and high molecular weight polycyclic aromatic hydrocarbons (PAHs) was investigated. *In silico* structural analysis of catalytic subunit revealed a very large substrate-binding pocket, satisfying the spatial requirements to accommodate high molecular weight substrates. Guided by molecular docking studies, dioxygenation of several PAHs as well as alkyl- and aryl benzenes was examined with the recombinant RHO expressed in *Escherichia coli*, demonstrating metabolic robustness of strain PNB.

Worldwide consumption of plastics ramped from 1.5 million tons in 1950 to 322 million tons in 2016. Importantly, plastics contain small molecular weight compounds which are used as additives to enhance flexibility, extensibility and workability called Plasticizers. Phthalic acid esters (PAEs) are the most commonly used plasticizers which are also known as Endocrine Disruptors. The mounted concerns with PAEs are because of their tendency to leach out from the plastic surface due to its non-covalent association and accumulation in the plastic-contaminated environment and eventually enter the food chain thereby affecting human health. Among various PAEs, di-2-ethylhexyl phthalate (DEHP) (Fig. 1) has been listed as a priority pollutant by the leading Environmental Protection Agencies around the world. Although microbial degradation is considered as primary effective approach to reduce pollution, the microbial degradation of DEHP is an onerous process since it is strongly hydrophobic in nature and has a complex structure, a diester formed from branched long side-chain alcohol, 2-ethylhexanol and phthalic acid. In this context, a bacterial strain was isolated, capable of utilizing DEHP as sole carbon source for its growth. Apart from DEHP, the strain can also utilize a couple of possible metabolic pathway intermediates. A combination of chromatographic and spectrometric analyses together with oxygen uptake and enzyme activity studies is in progress to evaluate the metabolic pathway of the degradation of DEHP in the isolated halophile.

A continued efforts on bacterial metabolism of estrogenic phthalates and development of bacterial biosensors in this laboratory was rewarded by a recent sanction of a DST (Technology Mission Division) **sponsored** Indo-UK project entitled "**The development and implementation of sensors and treatment technologies for freshwater systems in India**" focusing development of various bacterial biosensor strains and biosensor-biodegrader strains capable of monitoring diverse endocrine disrupting chemicals (EDCs) and bioreactor-based remediation of EDC-contaminated industrial wastewater, respectively.

Evaluation of bacterial regulatory modules for biotechnological application

Recent studies in molecular biology demand proper and rapid expression of proteins of interest upon its cloning into suitable expression vectors. However, in few cases, protein expression faces few drawbacks like poor expression which can be the result of non-recognition of existing promoters present in the vector or even poor strength of the promoters causing less efficient transcription and thus poor translation of target proteins. The widely used expression vectors like pET28 series carries Lac promoters (from *Escherichia coli*) which often does not work properly in wild type environmental bacterial isolates belonging to the genera such as *Burkholderia*,

Cupriavidus, *Sphingobium* etc. Attempts have been made to identify a versatile promoter system that can well-function in both *E. coli* as well as in other soil isolates in order to prepare a biotechnologically important novel protein expression system.

A dual promoter region has been identified in the naphthalene degrading *nag* operon of *Burkholderia* sp. strain BC1. This promoter contains both, a constitutive as well as a salicylate inducible promoter activity and was found to be recognized by *E. coli*. Moreover, tuning of the promoter sequence like addition of multiple promoter fragments in tandem and construction of deletion mutants enabled us to increase promoter activity with an optimum length of the DNA fragment. Further tuning will be performed by base alteration using site directed mutagenesis in order to study the effect (positive or negative) of such changes on promoter activity. Observations from this study will be finally accumulated to construct a shuttle vector used for controlled protein expression in the various Gram negative bacteria.

Metagenomic analysis of Hilsa and sludge microbiome

Apart from above, this laboratory is involved in metagenomic analyses of gut and sludge microbiomes for functional identification of biotechnologically important enzymes. To explore the gut microbiome of Hilsa (***Tenualosailisha)*** fish, both culture-dependent and independent (metagenomic) approaches have been made. Attempts are also being made to study the bacterial population present in the gill and mucosa of this fish. Apart from microbial diversity analysis, attempts are being made to understand functional roles of fish microbiota in host physiology using individual gut, gill and mucosa isolates and that of gut metagenomic DNA.

In addition, metagenomic approaches are also implied for identification of potential carbon monoxide dehydrogenase (CODH) and sulfate reductase (SR) enzymes from the anaerobic bacterial community present in the anaerobic granular sludge samples based on PCR based cloning and analysis of total metagenome sequence data. The same sludge samples are now being evaluated to study the diversity that may reveal the taxonomy of bacterial OTUs that may possess CODH and SR genes.

Identification of novel antimicrobial compounds

In the present time, one of the greatest challenge of medical biology is emergence of multidrug resistant bacteria that are nearly impossible to be killed by existing chemotherapeutics such as antibiotics. A promising alternative to the classical treatments with antibiotics are antimicrobial peptides (AMPs) which are host defense molecules produced by a wide range of organisms including bacteria, protozoa as well as by animals. In our lab, quite a number of bacterial strains have been isolated till date that showed antagonistic properties against a number of pathogen. Attempts are now being made to isolate the responsible peptide molecule (if any) by proteomic approaches. Efforts have also been made to characterize broad spectrum antimicrobials from bacterial and plant origin, collected from unexplored niches.

Publications

1. Deb S, Basu S, Singha A, Dutta TK (2018) Development of a 2-nitrobenzoate-sensing bioreporter based on an inducible gene cluster. *Frontiers in Microbiology* 9:254. doi: 10.3389/fmicb.2018.00254.

2. Khara P, Roy, Chakraborty J, Dutta, A, Dutta, TK (2017) Characterization of a topologically unique oxygenase from *Sphingobium* sp. PNB capable of catalyzing a broad spectrum of aromatics. *Enzyme Microb. Technol.* 111, 74-80.

Students awarded Ph.D.

Name of the Student (University, Year)	Title of Thesis
Soumik Basu	Molecular Insight into Bacterial Catabolism of Aromatic Compounds

Grants-in-Aid Schemes

Title of the Scheme	Schemes funded by
1. The development and implementation of sensors and treatment technologies for freshwater systems in India (DST Technology Mission Division sponsored Indo-UK project).	DST
2. Hydrogenogenic carbon monoxide conversion under mesophilic condition using anaerobic granular sludge for biodesulphurization.	DBT

Dr. Abhrajyoti Ghosh

Assistant Professor

Scientific Reports

Archaeal stress response

Study of archaea, the third domain of life, can provide interesting insights into the evolutionary history of different cellular machineries and mechanisms across all life forms. One such mechanism of our concern is that of protein translocation across biological membranes in archaea. Our present focus is on the structural and functional analyses of molecules that are central to the archaeal secretion process under different limiting conditions. Since archaea can sustain such extreme limiting conditions, withstanding different kinds of stresses, we also aim to get a thorough idea about the effect of different types of stressors on archaeal cells at the transcriptomic and proteomic level. We want to study the fate of stress-related proteins under conditions of stress, which includes identification, characterization, and analysis of the mode of regulation of stress-related proteins and their targets. Therefore, the current research in our lab is concerned with understanding the effect of heat stress on archaea with regard to different molecular chaperones.

In a recent study, we investigated structural and functional properties of Hsp20, asHsp from *Sulfolobus acidocaldarius*, a thermoacidophilic crenarchaeon. To provide a framework for investigating structure-

function relationship of Hsp20 and understanding its dynamic nature, we employed several biophysical and biochemical techniques. Our data suggested the existence of a ~24-mer structure of Hsp20 at room temperature and a higher oligomeric form at the native environmental conditions, of pH 3.5 and 76°C. To our surprise, we identified a dimeric form of protein as the functional conformation in presence of aggregating substrate proteins. The oligomeric plasticity of Hsp20 is mainly regulated by the hydrophobic microenvironment and it plays a key role in protection of stress-induced protein aggregation. In *Sulfolobus* sp., Hsp20, despite being a non-secreted protein, has been reported to be present in secretory vesicles and it is still unclear whether it stabilizes substrate proteins or membrane lipids within the secreted vesicles. To address such an issue, we tested the ability of Hsp20 to interact with membrane lipids along with its ability to modulate membrane fluidity. Our data revealed that Hsp20 interacts with membrane lipids via a hydrophobic interaction and it lowers the propensity of *in vitro* phase transition of bacterial and archaeal lipids. To summarize, we have demonstrated interrelation between the oligomeric plasticity of *S. acidocaldarius* Hsp20 and its contribution on *in vitro* protein protection and lipid stabilization for the first time. Moreover, these observations allowed us to propose for the first time a low-resolution model describing spatial ensembles comprising "storage oligomer", "inactive oligomer" and "active oligomer" of Hsp20 (Figure 1).

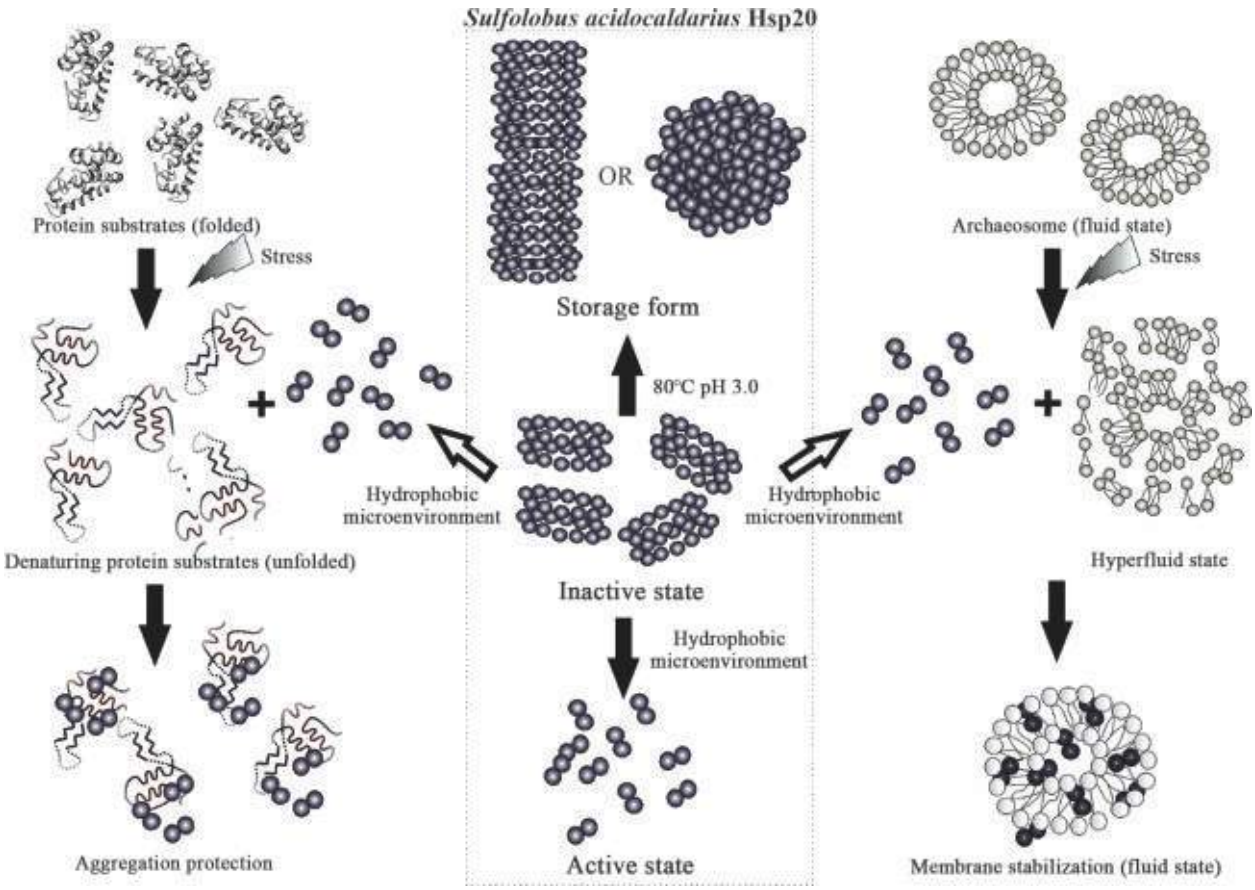


Figure 1. Schematic diagram showing the mechanism of action of *S. acidocaldarius* Hsp20.

Structural and functional genomics of microorganisms

We study the phylogenetic diversity, metabolic capabilities, and ecological role of microbes 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 microbial species is adopted. Our studies on the diversity and distribution of bacteria and archaea in Sundarbans sediment revealed distinct anthropogenic interventions 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.

In parallel to this, our group is also involved in studying plant-microbe interactions at the genomic and functional levels.In the coastal region of Bengal deltaic plain of Eastern India, As-contaminated groundwater is frequently used for irrigation purposes resulting in an elevated level of soil As in agricultural lands. The health hazards associated with As necessitates development of cost-effective remediation strategies to reclaim contaminated agricultural lands. Among the available technologies developed in recent times, bioremediation using bacteria has been found to be the most propitious. In this study, two As-resistant halophilic plant growth-promoting bacterial strains *Kocuria flava* AB402 and *Bacillus vietnamensis* AB403 were isolated, identified and characterized from mangrove rhizosphere of Sundarban. The isolates, AB402 and AB403, could tolerate 35mM and 20mM of arsenite, respectively. The effect of As on the exopolysaccharide (EPS) synthesis, biofilm formation, and root association was evaluated for both the bacterial strains. Arsenic adsorption on the cell surfaces and intracellular accumulation in both the bacterial strains were promising under culture conditions (Figure 2). Moreover, both the strains when used as inoculum, not only promoted the growth of rice seedlings but also decreased As uptake and accumulation in plants(Figure 2).

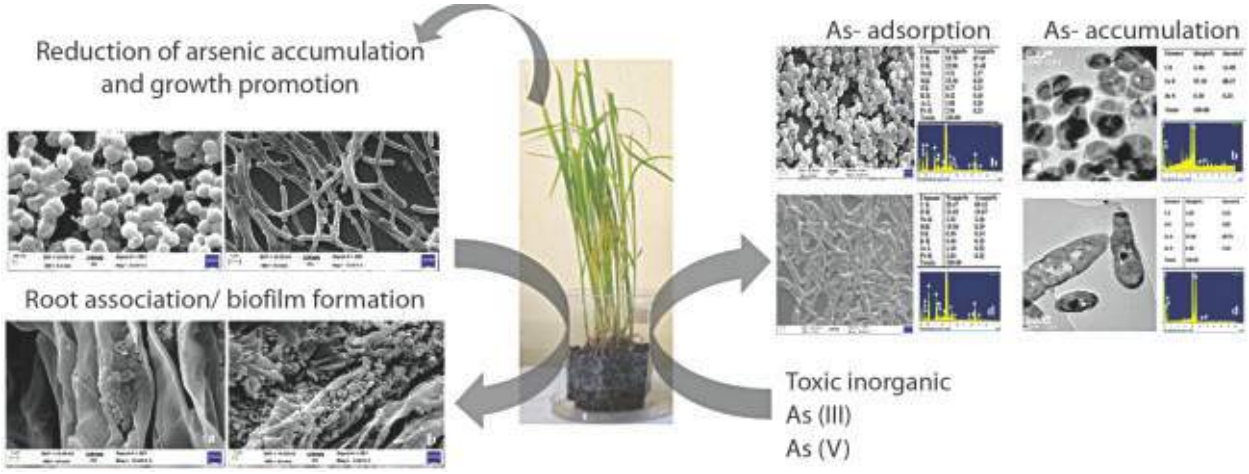


Figure 2. Schematic diagram showing microbe-assisted remediation of arsenic by plant growth-promoting bacterial strains

Functional and structural studies on archaeal Actin-like protein: *in collaboration with Prof. 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. Mahato M, Mukherji S, Van Hecke, K Harms K, Ghosh A, Nayek, HP. (2017) Mononuclear homoleptic organotin(IV) dithiocarbamates: Syntheses, structures and antimicrobial activities. *Journal of Organometallic Chemistry*, 853:27-34.
2. Mallick I, Bhattacharyya C, Mukherji S, De, D, Sarkar SC, Mukhopadhyay UK, Ghosh A. (2018) Effective rhizoinoculation and biofilm formation by arsenic immobilizing halophilic plant growth promoting bacteria (PGPB) isolated from mangrove rhizosphere: A step towards arsenic rhizoremediation. *Sci Total Environ*. 610-611:1239-1250.

Grants-in-Aid Schemes

Title of the Scheme	Scheme Funded by
1. Understanding protein translocation under extreme conditions	DST-Ramanujan Fellowship research grant, SERB, DST, Govt. of India
2. Investigation of the archaeal diversity and activity in Sundarbans mangrove sediment, India	CSIR, Govt. of India
3. 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 Conference/ Symposia/ Workshops & Invited Talks Delivered at Various Institutes

1. Participated in the 23rd INPEC meeting: Protein structure, function and engineering at Unified Campus of Bose Institute, Saltlake, Kolkata, West Bengal India during 9th November-11th November 2017.

Seminar/ Symposia Organized at Bose Institute

1. Organized an International conference to commemorate 100 years of Bose Institute titled "Microbiology in the New Millennium: from Molecules to Communities" between October 27-October 29, 2017 at Bose institute, Unified Campus, Saltlake, Kolkata, West Bengal, India.
2. Participated as a Resource person of Microbiology in "Hands onTraining" on Basic and Applied Biological Sciences for the High School Students held at Bose Institute, Madhyamgram campus of Bose Institute between 11th-13thDecember 2017; 3.
3. Participated as a Resource person in DST-sponsored North-East Students' Summer Training on Basic Sciences (NESST-BASE 2017)held at Bose Institute, Darjeeling campus between 29th-31stMay'2017.

Dr. Wriddhiman Ghosh

Assistant Professor

SCIENTIFIC REPORT

Scientific Reports

Carbon-sulfur cycling/sequestration in the sediments of the Arabian Sea oxygen minimum zone

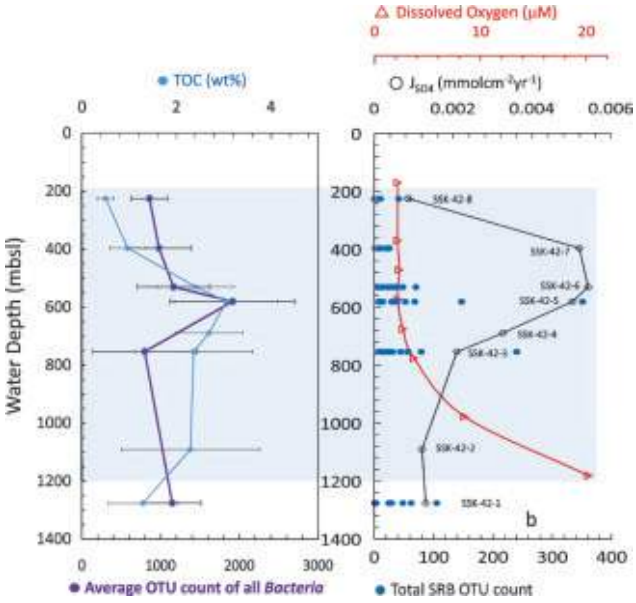


Fig. 1 Trends of water-depth dependent variation of key geochemical and microbiological parameters of the Arabian Sea OMZ sediments. A, Variations in the average TOC content of the studied sediment cores (light blue curve), and the average OTU-count of all *Bacteria* (purple curve) in the sediment cores. The error bars in the average TOC plot indicate standard deviation. B, Variations in the bottom-water oxygen concentration (red triangle), sulfate flux J_{SO4} (black circles), and total SRB-OTU-count (blue dots) in the studied sediment cores. The light blue shaded region represents the thickness of oxygen minimum zone.

Sediments of marine oxygen minimum zones (OMZs) are hot-spots of carbon-sulfur cycling/sequestration in the global ocean and so can have crucial bearings on benthic biota. The water-mass spanning 100-1200 mbsl of Arabian Sea (AS) is the thickest and most-hypoxic of all perennial OMZs; yet, little is known about the microbes of its sedimentary C-S cycle. So my team collaborated with the geological oceanographers of the CSIR-National Institute of Oceanography to couple pore-fluid chemistry and high-throughput microbial-ecological (metaomics) data to reveal the *in situ* C-S cycle across a transect covering the entire thickness of AS OMZ. We discovered that the C-S biogeochemistry of the OMZ sediments is sensitive towards the dissolved O_2 level of the bottom-waters and the lability of available organic matters, which in turn leads to a remarkable heightening in the microbial processes of the sedimentary C-S cycle in the center of the OMZ (Fig. 1).

In another microbiological study of the AS OMZ sediments my team analyzed the population dynamics of sulfate-reducers, methanogens, anaerobic methanotrophs and acetogens, along two sediment horizons of the OMZ center (530 and 580 mbsl water-depths), and compared the ecology with those of the sediments underlying the two flanks of the OMZ (31 and 1275 mbsl). This revealed the ecological signatures of the sediments underlying the heart of the OMZ, including peculiarities such as a cryptic methanogenesis/ methanotrophy cycle in the sulfate-rich upper (0-15 cmbsf) layers, and coexistance and covariance of methanogens, methanotrophs, sulfate-reducers and acetogens throughout the sediment-horizons explored (Fig. 2). When considered in the context of comparator environments from other geological settings, sedimentary ecology of the acutely hypoxic marine zones appear bioenergetically similar to other O_2-deficient ecosystems having high C- and H_2–supply, including those potentially located in the ancient Earth or in extra-terrestrial locations.

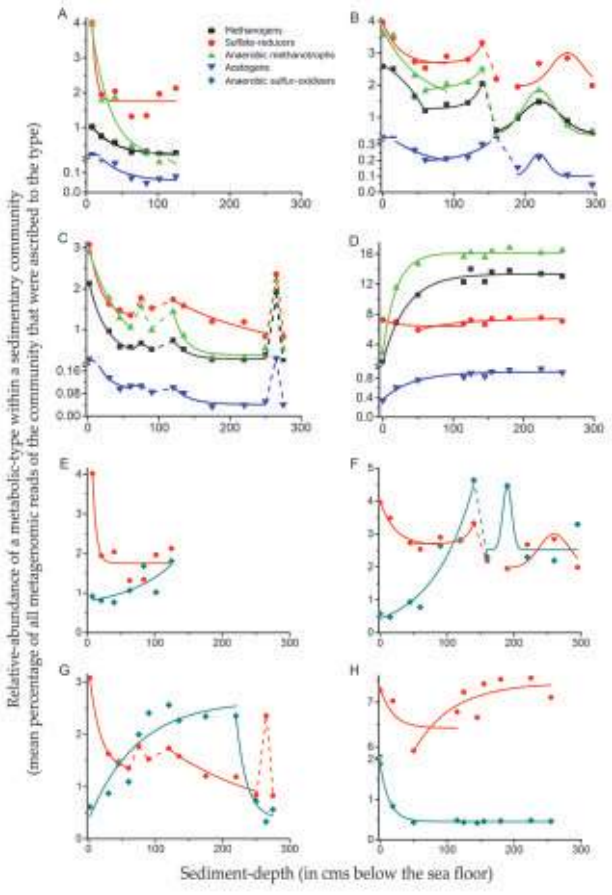


Fig. 2 Prevalence (expressed as mean percentage of all metagenomic reads) of sulfur-reducers, methanogens, anaerobic methanotrophs, and acetogens, along the sediment-depths of coring-stations located at (**A**) 1275, (**B**) 580, (**C**) 530 and (**D**) 31 mbsl water-depths; Prevalence of anaerobic sulfur-oxidizers (in relation to that of sulfur-reducers) along the sediment-depths of the above coring-station are shown in **E** through **H**, in the aforesaid order of water-depth. The solid lines represent the different zones of mathematically-defined distributions and the dashed lines represent the zones of undefined distribution.

Publication

1. Pyne P, Alam M and Ghosh (2017). A novel soxO gene, encoding a glutathione disulfide reductase, is essential for tetrathionate oxidation in Advenella kashmirensis. *Microbiological Research* ***205***: 1-7.

Students awarded Ph.D.

Name of the Student (University, Year)	Title of Thesis
Chayan Roy (C.U., 2018)	Molecular Insight into Bacterial Catabolism of Aromatic Compounds

Grants-in-Aid Schemes

Title of the Scheme	Schemes funded by
Quest for the biophysical basis of habitability of hydrothermal vent ecosystems	SERB

Dr. Manikuntala Kundu

Professor

Scientific Reports

Regulation of stress responsive genes by the transcription factor, MtrA of *Mycobacterium tuberculosis:* *In collaboration with Joyoti Basu and Sudipto Saha*

Mycobacterium tuberculosis employs two component systems (TCSs) for survival within its host. MtrAB TCS comprises of sensor kinase MtrB and the response regulator MtrA. Genome-wide ChIP-sequencing using MtrA antibody suggests that MtrA binds upstream of at least 45 genes of *Mtb* including those involved in cell wall remodelling, stress responses, persistence and regulation of transcription. It binds to the promoter region of *whiB4*, a critical regulator of the oxidative stress response, and *relF*, one-half of the toxin-antitoxin locus *relFG*. We have identified a new consensus 9 bp loose motif for MtrA binding. We observed that overexpression of a gain-of-function mutant, MtrAY102C, enhanced expression of the aforesaid genes in *Mtb*isolated from macrophages, whereas expression of each of these targets was lower in *Mtb*overexpressing a phosphorylation defective mutant, MtrAD56N. This result suggests that phosphorylated MtrA (MtrA-P) is required for the expression of its targets in macrophages. Our data uncover new MtrA targets which suggest that MtrA is required for a transcriptional response which likely enables *Mtb*to persist within its host.

SCIENTIFIC REPORT

Publications:

1. Chatterjee A, Sharma AK, Mahatha AC, Banerjee SK, Kumar M, Saha S, Basu J and Kundu M (2017) Global mapping of MtrA-binding sites links MtrA to regulation of its targets in *Mycobacterium tuberculosis.*, *M.Microbiol.* 164, 99-110.
2. Sahu SK, Kumar M, Chakraborty S, Banerjee SK, Kumar R, Gupta P, Jana K, Gupta UD, Ghosh Z, Kundu M and Basu J. (2017) MicroRNA 26a (miR-26a)/KLF4 and CREB-C/EBPβ regulate innate immune signaling, the polarization of macrophages and the trafficking of Mycobacterium tuberculosis to lysosomes during infection. *PLoSPathog.* (2017) 13, e1006410.

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

1. Presented her work in the Gordon Research Conference on Tuberculosis Drug Development held in Renaissance Tuscany Il Ciocco, Lucca (Barga), Italy, from June 25-30, 2017.

Students Awarded Ph.D.

Name of student (University/Year)	Title of Thesis
Arun Kumar Sharma (C.U., 2018)	Understanding the role of two component signal transduction system in *Mycobacterium tuberculosis* cell physiology

Grants-In-Aid Schemes

Sl. No	Title of the Scheme	Scheme funded by
1.	*(With Prof. J. Basu as Co-PI)* Regulation of the mycobacterial stress response by the two component system SenX3-RegX3 in *M. tuberculosis*.	DST-SERB
2.	*(With* Dr. Z. Ghosh *as Co-PI)* Transcriptional regulator RegX3-dependent modulation of the macrophage immune response by *Mycobacterium tuberculosis*.	DBT

Dr. Srimonti Sarkar

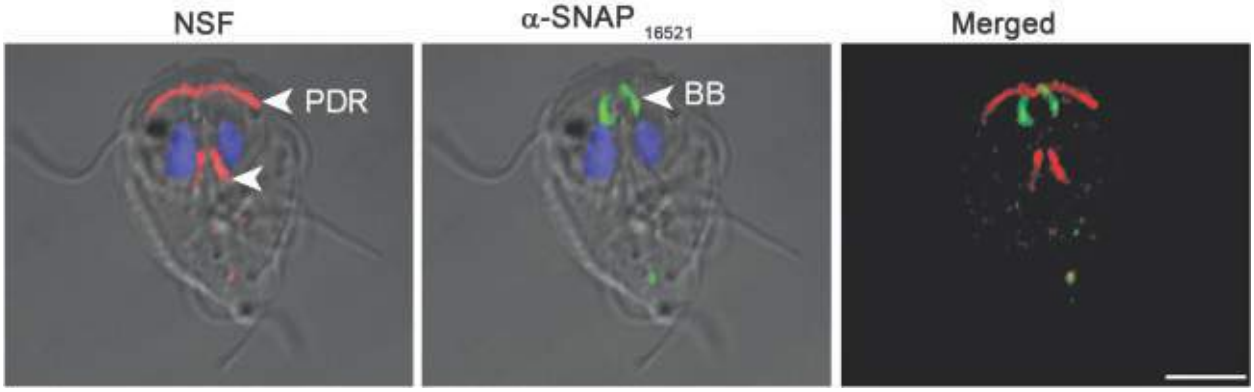
Professor

Scientific Reports

Functional divergence of paralogous proteins of *Giardia lamblia*

Giardia lamblia is a human gut pathogen that causes the diarrheal disease giardiasis. The biology of this unicellular protist is also intriguing as multiple cellular processes are known to be discharged with machinery composed of fewer number of components compared to that present in most eukaryotes. Curiously, our studies indicate exceptions to this rule wherein multiple paralogues are present for certain proteinsfor which most eukaryotes encode only one copy.

We have uncovered three such families of paralogues, members of which are components of the machinery supporting the endomembrane system of *Giardia*. The first family includes three paralogues of α-soluble NSF-attachment protein (α-SNAP), which is known to play an important role in ensuring the fidelity of the vesicle-mediated trafficking process. The second family comprises of the two Vps46 paralogues and the third includes the three Vps4 paralogues; homologues of the last two are known components of the ESCRT pathway, which is responsible for inducing negative curvature of various cellular membranes. The paralogues of all the three families are expressed in all the morphological stages, trophozoites, encysting trophozoites and cysts, indicating that all of these are required throughout the parasite's life-cycle. Two of the three α-SNAPs exhibit changes in mutually-exclusive subcellular distribution pattern during encystation and also upon exposure to oxidative stress; however, the distribution of the third member remains unchanged. This indicates that two paralogues may have acquired novel functions during to course of evolution. Studies of the other two families also indicate similar functional divergence, with the two paralogues of Vps46 exhibiting difference in interaction with known Vps46 interactors and the three paralogues of Vps4 having significant divergence in key residues of important domains. Thus, our studies have revealed an interesting conundrum: while giardial cellular processes are accomplished using fewer components, yet some of these components have multiple paralogues.



Localization of NSF (green) at the brush border (BB) and α-SNAP$_{16521}$ (red) atthe paraflagellar dense rods (PDRs)

Publications

1. Jana A, Sinha A, and Sarkar S (2017) Phosphoinositide binding profiles of the PX domains of *Giardia lamblia*. *Parasitology International* Volume 66: 606-14. doi: 10.1016/j.parint.2017.04.008
2. Saha N, Dutta S, Datta SP and Sarkar S (2018) The minimal ESCRT machinery of *Giardia lamblia* has altered inter-subunit interactions within the ESCRT-II and ESCRT-III complexes. *Eur. J. Cell Biol*. Volume 97: 44-62. doi: 10.1016/j.ejcb.2017.11.004

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

i) Delivered the following invited talks:

ii) (a) Visiting Professor under UGC-CAS Phase VII, Dept. of Botany, Calcutta University; (b) Refresher Course in Biotechnology, HRDC-ASC, Calcutta University; (c) Science Orientation Workshop, Jagadish Bose National Talent Search; (d) Annual Summer School in Basic Sciences organized by Indian Association for Cultivation of Science, Kolkata

Seminars / Symposia organized at Bose Institute

Member of the Organizing Committee Microbiology in the New Millennium: From Molecules to Communities (2017).

Dr. Subrata Sau

Professor

Scientific Reports

Studies on some staphylococcal proteins involved in gene regulation and pathogenesis

Staphylococcus aureus, a Gram-positive bacterium, encodes many virulence factors for successfully causing infections in human and other animals. Expression of virulence factors is coordinately

regulated by many virulence regulators in *S. aureus*. One of the widely-studied virulence regulators is SarA, a winged-helix DNA binding protein. The putative DNA binding region of SarA is composed of forty-five amino acid residues. To clearly demonstrate the roles of the DNA binding residues, we have constructed nine mutants of SarA by replacing the amino acid residues at the DNA binding region with an alanine residue. Our gel shift assay reveals that seven out of nine mutants possess 2-4 fold less DNA binding activity than SarA. The DNA binding affinity of no mutant also has matched to others.

Many low GC Gram-positive bacteria synthesize RsbW, an anti-sigma factor. RsbW blocks the transcription initiation activity of SigB, an alternative sigma factors. In *S. aureus* and other Gram-positive bacteria, SigB controls the expression of many virulence factors along with managing the general stress response. To study the structure, function, and stability of RsbW in details, we have purified a recombinant *S. aureus* RsbW (rRsbW) to homogeneity. To obtain clues about the domain structure of RsbW, we have performed limited proteolysis of rRsbW using several proteolytic enzymes. The N-terminal end residues of some major proteolytic fragments are determined using standard methods. Analysis of the sequence data indicates that RsbW is a single-domain protein.

Phage ϕ11 encodes repressors CI and Cro for controlling its lytic-lysogenic growth in *S.aureus*. Previously, we identified three homologous operators *O1*, *O2*, and *O3* in between its two repressor-encoding genes and demonstrated that CI binds to *O1* and *O2*, whereas Cro interacts only with *O3*. To find out additional CI binding operators in ϕ11, we have searched the genome sequence of ϕ11 using the *O1*/*O2* sequence as a bait. The data reveal that ϕ11 carries a putative CI binding operator (*O4*) at the 3' end of its *cro*. We have noticed that *O4* differs from *O2* and *O1* by one base and five bases, respectively. *O4* also shows binding to rCI, a recombinant CI. However, *O4* shows no binding to a chimeric Cro under the conditions of the study. Additional investigations suggest that six guanine bases, located in and around *O4*, interact with rCI. We have also found out that the rCI binding affinity of *O4* or *O1* is about fifteen times higher than that of *O2*. A comparative study suggests that some bases and structural alteration, unique to *O1* and *O4*, may be responsible for their increased rCI binding affinity. In sum, the study has extended the gene regulatory circuit of *ϕ11*.

Publication

1. Biswas A, Mandal S, Sau S (2017) Identification and characterization of a CI binding operator at a distant location in the temperate staphylococcal phage ϕ11. *FEMS Microbiol Lett*. 364(20). IF: 1.765

Students Awarded with Ph.D degree

Name of the Student (University /Year)	Title of thesis
Mr. Anindya Biswas (C.U., 2017)	Studies on the DNA-binding domain of the immunity repressor of a staphylococcal phage ϕ11.

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

Group Members

Mr. Sukhendu Mandal presented a poster in the conference entitled "Microbiology in the New Millennium, From Molecules to Communities" held at Bose Institute, Kolkata from 27 to 29 October, 2017.

Mr. Debabrata Sinha presented a poster in the conference entitled "Microbiology in the New Millennium, From Molecules to Communities" held at Bose Institute, Kolkata from 27 to 29 October, 2017.

Mr. Soham Seal presented a poster in the conference entitled "Microbiology in the New Millennium, From Molecules to Communities" held at Bose Institute, Kolkata from 27 to 29 October, 2017.

Mr. Soham Seal presented a poster in the Bose Institute Centenary Celebration held at Bose Institute, Kolkata from 24 to 30 November, 2017.

VI. Systems Biology

Participation of Institutional Programme - VI

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

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

Role of cross-talk and fluctuations in MAPK pathways

Biochemical networks having similar functional pathways are often correlated due to cross-talk among the homologous proteins in the different networks. Using a stochastic framework, we address the functional significance of the cross-talk between two pathways. A theoretical analysis on generic MAPK pathways reveals cross-talk is responsible for developing coordinated fluctuations between the pathways. The extent of correlation evaluated in terms of the information theoretic measure provides directionality to net information propagation. Stochastic time series suggest that the cross-talk generates synchronisation in a cell. In addition, the cross-interaction develops correlation between two different phosphorylated kinases expressed in each of the cells in a population of genetically identical cells. Depending on the number of inputs and outputs, we identify signal integration and signal bifurcation motif that arise due to inter-pathway connectivity in the composite network. Analysis using partial information decomposition, an extended formalism of multivariate information calculation, also quantifies the net synergy in the information propagation through the branched pathways. Under this formalism, signature of synergy or redundancy is observed due to the architectural difference in the branched pathways.

Publication

1. Maity A K, Chaudhury P and Banik S K (2017) Information-theoretical study of cross-talk mediated signal transduction in MAPK pathways, *Entropy* 19, 469

Students awarded Ph.D.

Name of Student (University,Year)	Title of Thesis
Prasun Sarkar (IIEST - 2017)	Theoretical Study of Noise-driven Nonlinear Dynamical Systems

Symposia organized at Bose Institute

SSC 2017: International Symposium on Systems, Synthetic & Chemical Biology

Dr. Joyoti Basu

Professor

Scientific Reports

Role of epigenetic modifications and the long non-coding RNA HOTAIR in the establishment of infection by *Mycobacterium tuberculosis:* *in collaboration with Maniuntala Kundu and Zhumur Ghosh*

Epigenetic modifications in host cells play a role in governing the innate immune response to infection. We observed genome-wide changes in H3K4me3 occupancy as a result of *M. tuberculosis (Mtb)* infection of macrophages, compared to uninfected macrophages. We identified a set of loci that is differentially modified in terms of H3K4me3 occupancy, between macrophages infected with *Mtb*H37Rv or H37Ra. We validated that macrophages infected with *Mtb* H37Rv show higher H3K4me3 association at the *SATB1* and *DUSP4*loci as well as higher levels of expression of both genes, compared to cells infected with the avirulent*Mtb*H37Ra. We also demonstrated (a) co-occurrence of bivalent marks H3K4me3 and H3K27me3 at the *SATB1* and *DUSP4* loci, and (b) that knock down of EZH2 the catalytic subunit of the polycomb repressive complex responsible for deposition H3K27me3 marks, augmented expression of SATB1 and DUSP4. In addition to the role of histone modifications, the lncRNA HOTAIR also regulates the expression of *DUSP4* and *SATB1*. We confirmed the association of lncRNA HOTAIR with EZH2 during *Mtb* infection of macrophages and showed that overexpression of HOTAIR augments the association of repressive H3K27me3 marks at the *SATB1* and *DUSP4*loci thereby downregulating their expression. Our studies suggest that

identification of epigenetic targets could broaden the ambit of host-directed approaches for chemotherapeutic intervention in TB.

Publications

1. Chatterjee A, Sharma A K, Mahatha A C, Banerjee S K, Kumar M, Saha S, Basu J and Kundu M (2017) Global mapping of MtrA-binding sites links MtrA to regulation of its targets in *Mycobacterium tuberculosis*. *Microbiol*. 164, 99-110.
2. Sahu S K, Kumar M, Chakraborty S, Banerjee S K, Kumar R, Gupta P, Jana K, Gupta U D, Ghosh Z, Kundu M and Basu J (2017) MicroRNA 26a (miR-26a)/KLF4 and CREB-C/EBPβ regulate innate immune signaling, the polarization of macrophages and the trafficking of *Mycobacterium tuberculosis* to lysosomes during infection. *PLoSPathog*.13, e1006410.

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

1. Delivered a lecture at the *"EMBO Conference on Hijacking Host Signaling and Epigenetic Mimicry During Infections" being organized by* European Molecular Biology Organization (EMBO) and Institut Pasteur *held in Paris, France, from June 13-16, 2017*.
2. Delivered a lecture in the meeting entitled "Inhaled Therapies for Tuberculosis and Other Infectious Disease" *being organized by* Rany Condos, MD, Associate Professor of Medicine, NYU School of Medicine, USA *held in* Durham, North Carolina on 16-17 October, 2017.
3. Delivered a lecture in the Congress of the International Cell Biology held in Hyderabad from January 20 to February 1, 2018.

Group Members

1. Arijita Subuddhi, Institute Fellow presented a poster in the "Development of Tissue and Pathogen-specific Cellular Innate Immunity" held at Freiburg, Germany on 27th to 29st September 2017.

Grants-In-Aid Schemes

Title of the Scheme	Scheme funded by
I. *With Prof. M. Kundu (Co-PI) and Dr. J. Mukhopadhya(Co-PI)* Evaluating the sensor kinase MtrB of *Mycobacterium tuberculosis* as a regulator of bacterial physiological responses, and as a potential target for therapy.	DST-SERB
II. *With Prof. J. Basu as PI* J. C. Bose Fellowship	DST-SERB

Dr. Zhumur Ghosh

Assistant Professor

Scientific Reports

A. Role of Regulatory RNAs in Mammalian Development

Mammalian development is a very complex sequence of events which starts immediately after fertilization. It is maintained by a complex interaction of different molecules. Non coding RNAs (ncRNAs) constitute one such group of molecules which play important regulatory roles in mammalian development. These RNAs regulate cell fate in various ways and can be broadly classified in two groups; long ncRNAs (length ≥ 200 nucleotides) and small ncRNAs (length ≤ 36 nucleotide). Apart from the regulatory RNAs, transcription factors (TFs) play a key role towards regulating as well as maintaining every cellular state. Hence to elucidate the true dynamic nature of a cell during early stages of murine development, it is essential to explore the complex interaction between different TFs and regulatory ncRNAs(rncRNAs).

a) **Studying the role of transcription factors as modulators of murine embryonic development**.

Transcription factors (TFs) play a key role towards maintaining pluripotency and cellular reprogramming. We have tried to investigate the TF expression dynamics and regulatory mechanisms within the naïve and the primed pluripotent states of murine development. We have screened 4TFs essential for maintenance, self-renewal and differentiation and can act as novel markers distinguishing these two states.

b) **Studying the role of rncRNAs as regulators during fertilization and early stages of murine development.**

During the process of fertilization both sperm and oocyte delivers fistful number of small ncRNAs (22-30 nt long microRNA and endo-siRNA). These parental ncRNAs play critical role in fertilization and preimplantation development. We are investigating the precise interaction of these regulatory molecules with mRNAs and associated epigenetic mechanisms in stringent regulation of gene expression during fertilization and in zygote. Also we are investigating the role of the small ncRNAs in the decision making event during selection of the sperm during fertilization. The specific pool of small ncRNAs in the sperm and the ovum bears the clue behind such selection. This eventually leads to a crosstalk among themselves which facilitates the handshaking mechanism between the two and eventually leads to fertilization and subsequently formation of zygote.

B. **Studying the role of the microRNA miR-29b-1-5p/PHLPP1 signalling pathway in Helicobacter pylori-driven matrix metalloproteinase production in gastric epithelial cells.** [*in collaboration with Dr. Manikuntala Kundu*]

In this work we have analysed the transcriptomes and miRnomes of human gastric epithelial cell line-AGS infected with *H. pylori*. Bioinformatic analysis of miRNA-mRNA interactions suggested miR-29b-1-5p to be a likely regulator of pathways associated with gastric epithelial cell pathology. PH domain leucine rich phosphatase 1 (PHLPP1) which is a negative regulator of the Akt signaling pathway has been detected as the target of miR-29b-1-5p. Overall, this study suggests that targeting

the miR-29b-1-5p/PHLPP1 signalling axis could be a potential host-directed approach for regulating the outcome of *H. pylori* infection.

Publication

1. Deb A, Sarkar A & Ghosh Z (2017) Dissecting the Variation in transcriptional circuits between Naïve and Primed pluripotent states. FEBS Lett. Vol. 591(15):2362–2375.

Grant-in-Aid Schemes

Title of the Scheme	Scheme funded by
Epigenetic Alterations inducing oncogenic transformation in stem cell derivatives	ICMR

Participation in Conferences / Symposia / Workshops & Invited Talks delivered at various organization

Group Members

Dr. Arpana Verma presented her work entitled "*Molecular hallmark of epigenetic control in fertilization and embryonic development: A bird's eye view on role of noncoding RNAs*" in Indo-Japan Conference on epigenetics and human disease, Bose Institute, Kolkata 7-9 February, 2018.

SCIENTIFIC REPORT

Dr. Manikuntala Kundu

Professor

Scientific Reports

Global transcriptional profiling of miRNA and mRNA of epithelial cells infected with *Helicobacter pylori.*: *in collaboration with Joyoti Basu and Zhumur Ghosh*

In order to gain insight into whether microRNAs are differentially regulated during the early hours of infection of gastric epithelial cells with *H. pylori*, and to obtain insight into the likely role of miRNAs in infection, we analyzed the transcriptomes and miRNomes of AGS cells infected with *H. pylori* at an MOI of 100 for 4 h. For the purpose of the present study, we focused on the differentially regulated miRNAs or mRNAs with a fold change 1.5 in infected cells compared to uninfected cells. miRNA-mRNA target pairs were predicted from the list of differentially expressed, inversely correlated miRNAs and mRNAs using miRDB 5.0 (http://www.mirdb.org/download.html). The targets were further analyzed to identify their association with functional pathways probably linked to *H. pylori* infection using the Ingenuity Pathway Analysis tool (IPA, Ingenuity systems, http://www.ingenuity.com). We next generated anmiRNA-mRNA interaction network with the miRNA-mRNA pairs identified in infected AGS cells, focusing on those miRNAs which are upregulated during infection. A total of 10 miRNAs, namely miR-29b-1-5p, miR-671-5p, miR-3646, miR-31-3p, miR-3147, miR-3189-3p, miR-4257, miR4313, miR 629-3p and miR-765 were

identified from this network. We have focused on miR-29b-1-5p considering that it (a) was highly upregulated during the early hours of infection and (b) was associated with a large number of pathways of relevance to gastrointestinal diseases. Mice were infected intragastrically with the mouse-adapted strain of *H. pylori*, SS1. miR-29b-1-5p was upregulated in the pyloric part of the stomach of infected mice, compared to the uninfected mice. Considering that secretory antigens play important roles in regulating pathogen-induced host cell signalling, we tested the possible role of the secreted protein HP0175 in regulating gastric epithelial miRNA and mRNA expression during *H. pylori* infection. Using a knockout strain of *hp0175*, we observed that *H. pylori*-induced upregulationof miR-29b-1-5p was clearly compromised in the absence of *hp0175*. We further tested the role of the virulence factor CagA during infection of AGS cells, by testing the expression of miR-29b-1-5p in a *cagA*-negative strain. miR-29b-1-5pupregulation in AGS cells occurred even in the absence of *cagA*. These results suggested that miR-29b-1-5p upregulation occurs in an HP0175-dependent, CagA-independent manner.

Regulation of genes by transcription factor, RegX3 of *Mycobacterium tuberculosis:* *in collaboration with Sudipto Saha*

Our goal is to identify the targets of RegX3 (the response regulator of the SenX3-RegX3 two component system) in *M. tuberculosis (Mtb)* We knocked out *regX3* in Mtb and made a comparative analysis of the transcriptome of the wild type and RegX3-KO knockout under different conditions, including phosphate starvation. The expression of a selected set of differentially regulated genes was further confirmed by qRT-PCR. Chromatin immunoprecipitation of lysates from *Mtb* grown in the absence or presence phosphate with RegX3 antibody, confirmed increased association of RegX3 with the promoters of selected genes under phosphate depletion. This further confirms the role of RegX3 in modulating genes responsible for the survival of *Mtb* under phosphate stress. *Mtb* is able to survive in granuloma where hypoxic environment prevails. We observed that the survival of RegX3-KO is highly compromised under hypoxia, suggesting a role of RegX3 in the survival of *Mtb* under stress. The signalling pathway linking RegX3 with its survival under hypoxia is in progress.

Publications

1. Chatterjee A, Sharma A K, Mahatha A C, Banerjee S K, Kumar M, Saha S, Basu J and Kundu M (2017) Global mapping of MtrA-binding sites links MtrA to regulation of its targets in *Mycobacterium tuberculosis*. *Microbiol*. 164, 99-110.
2. Sahu S K, Kumar M, Chakraborty S, Banerjee SK, Kumar R, Gupta P, Jana K, Gupta U D, Ghosh Z, Kundu M and Basu J (2017) MicroRNA 26a (miR-26a)/KLF4 and CREB-C/EBPβ regulate innate immune signaling, the polarization of macrophages and the trafficking of *Mycobacterium tuberculosis* to lysosomes during infection. *PLoSPathog*. 13, e1006410.

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

Presented her work in the Gordon Research Conference on Tuberculosis Drug Development held in Renaissance Tuscany Il Ciocco, Lucca (Barga), Italy, from June 25-30, 2017.

Students Awarded Ph.D.

Name of students (University/Year)	*Title of Thesis*
Arun Kumar Sharma (C.U., 2018)	Understanding the role of two component signal transduction system in *Mycobacterium tuberculosis* cell physiology

Grants-In-Aid Scheme

Title of the Scheme	Schemes funded by
With Prof. J. Basu as Co-PI Regulation of the mycobacterial stress response by the two component system SenX3-RegX3 in *M. tuberculosis*.	DST-SERB
With Prof. Z.Ghosh as Co-PI Transcriptional regulator RegX3-dependent modulation of the macrophage immune response by *Mycobacterium tuberculosis*.	DBT

Dr. Jayanta Mukhopadhyay

Associate Professor

Scientific Reports

Direct evidence of robustness in a two-component system: *In collaboration with Dr. Suman Banik*

Two-component systems (TCS) are an integral part of gene regulatory network in almost all species. In the presence of an external stimulus, the sensor kinase gets phosphorylated and concomitantly transfers the phosphate to its cognate response regulator. The phosphorylated regulator subsequently controls various genes as an outcome of the external stimuli. To understand the dependence of output as a function of external stimulus, Uri Alon and co-workers has theoretically shown that if the sensor kinase possesses both kinase and phosphatase activities, the input-output relationship is robust, i.e, the output does not depend on the concentration of the components of TCS or ATP in the cell. To test this theoretical proposition, we have designed a synthetic circuit in *Escherichia coli* using a representative two-component system, MprAB of *Mycobacterium tuberculosis* and monitored the *in vivo* output signal by systematically varying the concentration of either of the components or both. Using in vitro assays, we have further estimated the phosphorylated MprA pool or MprA dependent transcription yield by varying either of the components of TCS. Our results demonstrate the experimental validation of input-output robustness in the TCS signaling pathway.

Publication

1. Mallick Gupta A, Mukherjee S, Dutta A, Mukhopadhyay J, Bhattacharyya D, Mandal S (2017) Identification of a suitable promoter for the sigma factor of Mycobacterium tuberculosis. *Mol Biosyst* 13:2370-2378

***Participation Conferences / Symposia / Workshops*:**

1. Asian Conference on Transcription, Penang, Malaysia, 1-4 Aug, 2017. Novel functions of factor from *Bacillus subtilis* as transcriptional regulator
2. Annual Conference of SBC, JNU, New Delhi, 16-19 Nov, 2019. Novel mechanism of transcriptional regulation in prokaryote
3. GRC, Kumarkom, Kerala December 2-6, 2017 Fundamental Mechanism of Transcription and Gene Regulation

Dr. Sudipto Saha

Assistant Professor & Ramalingaswami Fellow

SCIENTIFIC REPORT

Scientific Reports

Systemic discovery of asthma biomarkers for therapeutics

We investigated the role of ApoE and IL-33 in severe asthma of aged patients using Mass-Spectrometry based Proteomics approach. The clinical data on plasma of asthma patient show that these two proteins are differentially expressed as compared to healthy volunteers. Docking study of small chemicals targeting IL-33-ST2 was performed and a few potential ligands were found. Murine model of chronic asthma was established and now the screening of potential ligands targeting IL-33 is ongoing in the lab.

Fluoroquinolone-Resistance study in Mycobacterium

We investigated the role of mfpA gene (*Mycobacterium tuberculosis*), which has a role in fluoroquinolone resistance in *M. smegmatis*. Initial analyses show that there is 6-fold higher MIC50 to Ciprofloxacin upon mfpA overexpression. The proteome of wild type and mfpA overexpressing M. smegmatis strains were studied using mass-spectrometry to identify the differentially expressed proteins, which could have a role in the resistance mechanism.In addition, Whole Genome Sequencing (WGS) of fluoroquinolone resistance MTB clinical strains data available in public domain were analyzed to identify novel SNPs in genic and intergenic regions.

Publication

1. Subramani C, Nair V P, Anang S, Mandal S D, Pareek M, Kaushik N, Srivastava A, Saha S, Shalimar, Nayak B, Ranjith-Kumar C T, Surjit M (2018) Host-Virus Protein Interaction Network Reveals the Involvement of Multiple Host Processes in the Life Cycle of Hepatitis E Virus. *mSystems*. 23;3(1). pii: e00135-17.

VII. Basic and Applied Problems in Physical and Environmental Sciences

Participation of 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. T. P. Sinha, Dr. S. K. Saha, Dr. Sanjay Kr. Ghosh, Dr. Somsubhro Bandyopadhyay, Dr. Dhruba Gupta, Dr. Rajarshi Ray, Dr. Achintya Singha, Dr. Abhijit Chatterjee, Dr. Supriya Das, Dr. P. S. Joardar, Dr. Soumen Roy, Dr. Probir Roy, Dr. Sidharth Kumar Prasad, Dr. Saikat Biswas and Dr. Sanat Kumar Das.

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

1. Theoretical Research

A. Strong quantum nonlocality without entanglement : ***in collaboration with Saronath Halder, IISER Berhapur, Manik Banik, SNBNCBS Kolkata, Srishti Agarwal, IISER Kolkata***

One of the celebrated manifestations of quantum non-locality is the so called “quantum non-locality without entanglement”. The nonlocality here is conceptually different from what we understand from the violation of Bell inequalities. Quantum nonlocality without entanglement is a consequence of local indistinguishability of product states—that is, we say that set of product states is nonlocal if LOCC cannot distinguish the states as well as global measurements. The nontrivial nature lies in the fact that unlike entangled states which must be prepared jointly, product states admit local preparation and therefore were not expected to possess properties that are accessible only via joint measurements.

The goal of this research program is to study to what extent nonlocal properties of multiparty orthogonal product states are (a) free from local redundancies and (b) robust under partitioning of the subsystems. To this end we have defined strong quantum nonlocality—a set of orthogonal product states are said to be strongly nonlocal if and only if the set is nontrivial in every bipartition. For the first time we have presented a complete orthogonal product basis in a three-qutrit system which is strongly nonlocal. This construction is generalized n higher dimensions involving three parties.

B. Unextendible product bases: ***in collaboration with Saronath Halder, IISER Berhapur, Manik Banik, SNBNCBS Kolkata, Srishti Agarwal, IISER Kolkata***

An unextendible product basis (UPB) is an incomplete product basis spanning a proper subspace whose orthogonal complement contains no product state. We consider the question of extendibility of a multiparty UPB in bipartitions. We show that there exist multiparty UPBs with the property that in every bipartition the parent set can be extended to a UPB by adding more bi-separable states. Our construction is for a three party quantum system where every party holds a three dimensional subsystem. It, however, remains an open question whether every multiparty UPB is always extendible in one or more bipartitions.

C. Bound entangled states: ***in collaboration with Saronath Halder, IISER Berhapur, Manik Banik, SNBNCBS Kolkata, Srishti Agarwal, IISER Kolkata***

A unique feature of UPBs is that they allow systematic construction of bound entangled states—entangled states from which no pure entanglement can be distilled by LOCC. Using our construction of a new class of UPBs we prove that there exist bound entangled states with the property that they are PPT (positive under partial transposition) in one bipartition while being NPT (negative under partial transposition) in other bipartitions. This is the first time such a inhomogeneous property is observed with orthogonal UPBs.

Quantum Optics Laboratory

Like previous years, 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. All the four detectors are now functioning after repair and services.

Publications

1. Bandyopadhyay S, Banik M, Bhattacharya S S, Ghosh S, Kar G, Mukherjee A, RoyA (2017) *Reciprocal ontological models show indeterminism of the order of quantum theory, Foundations of Physics* 47(2), 265-273.
2. Bandyopadhyay S and Singh A I (2017) Polynomial representation of quantum entanglement, Contemporary Mathematics Volume 687, http://dx.doi.org/10.1090/conm/687/13794

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

Delivered Invited talk "*Introduction to Quantum Technologies*", Invited talk at DRDO/JCBCAT-JU one

day workshop on Quantum Technologies at Computer Science Department, Jadavpur University, Kolkata, February 2017.

Grant-in-Aid Schemes

	Title of the scheme	Scheme funded by
1.	Studies on quantum entanglement as a resource in quantum information processing	SERB
2.	Quantum Entanglement and Distributed Quantum Information Processing" (*As Co-PI*)	DST-SERB
3.	Study of Cosmic ray interactions and Cosmic Ray – Aerosol –Cloud connection in the context of regional climate change	IRHPA

Dr. Saikat Biswas

Assistant Professor

Scientific Reports

Characterization of GEM detector for ALICE and CBM experiments: *In collaboration with Mr. R. P. Adak, Ms. S. Roy, Mr. S. Chatterjee, Mr. S. Chakraborty, Dr. S. Das, Prof. S. K. Ghosh, Dr. S. K. Prasad, Prof. S. Raha, Mr. Rajendra Nath Patra, Mr. Rama N. Singaraju, Dr. Zubayer Ahammed, Dr. Tapan K. Nayak, Dr. Yogendra P. Viyogi. (VECC), Mrs. S. Rudra (Seacom Engineering College), Dr. P.K. Sahu, Mr. S. Sahu and Ms. S. Swain (IOP, Bhubaneswar), J. Hehner (GSI).*

We are actively working for the ALICE experiment at CERN, Geneva and CBM experiment of FAIR, Germany. A gas detector laboratory started functioning at CAPSS, Bose Institute. A 10 x 10 cm^2 triple GEM (Gas Electron Multiplier) detector prototype is built and tested with a gas mixture of Argon/CO_2 of 70:30 and 90:10-volume ratio. Tests were conducted using cosmic rays trigger, a ^{106}Ru-Rh β-source and a ^{55}Fe X-rays source. A plateau in the efficiency around 95% has been obtained at different operating voltages for the two Ar/CO_2 gas mixtures. The energy resolution of the detector was measured to be around 20% for FWHM around the plateau region. A time resolution of 10 ns has been achieved with the Ar/CO_2 70:30 gas mixture.

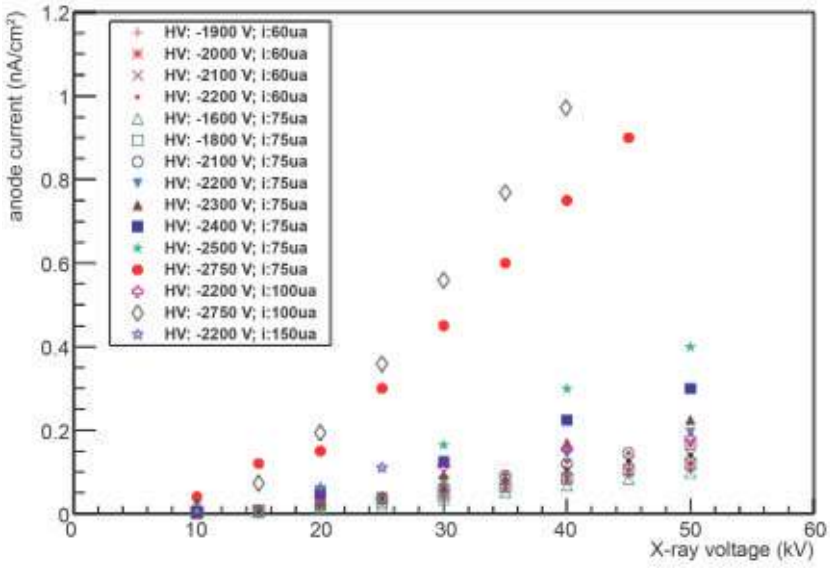
Uniformity in gain and energy resolution of the detector has been studied by dividing the detector in 7x7 zones and observing the response to a ^{55}Fe source for each zone separately. The RMS variations of gain and energy resolution are 8.8% and 6.7%, respectively over the entire area. These gain fluctuations can be used in simulations in order to quantify the overall detector response in experiments.

As a part of ALICE TPC GEM detector R&D quad GEM detector prototype is built and tested with a gas mixture of $Ar + CO_2$ in 70:30 volume ratio with over atmospheric pressure and at a flow rate of 100 ml/min. The gain and energy resolution are measured varying the GEM voltage using Fe^{55} X-ray source. At 1600 V, a typical gain is ~406 and the energy resolution (FWHM) is found to be ~26%. The exponential nature of gas gain with applied voltage is observed.

The anode current is measured for the detector using the Fe^{55} X-ray source and also with X-ray generator. The anode current is increased with applied voltage exponentially as expected. The anode current per unit area of 1 nA/cm^2 is achieved at X-ray generator current of 100 uA and X-ray generator voltage of 40 kV with the GEM HV voltage setting of 2750 V.

The obtained modest resolution (FWHM = 25%) and modest gains (up to 600) are marginal, but the successful operation at anode current density of 1 nA/cm^2 is of importance for the ALICE collaboration for measurements of Pb-Pb collisions after the upgrade during the CERN Long Shut Down (LS2). However, a simple consideration of the anode current leads to electron density in the (GEM) hole, which is considerably below the Raether limit, hence, the achieved anode current density is not surprising.

As a proof of principle, it is seen that with a preamplifier of high intrinsic gain and low noise the GEM detector can be operated at very low gas gain i.e. at very low applied voltage with over atmospheric pressure.



(Left) The experimental set-up with the X-ray generator (at GSI). (Right) Anode current per unit area as a function of X-ray generator voltage.

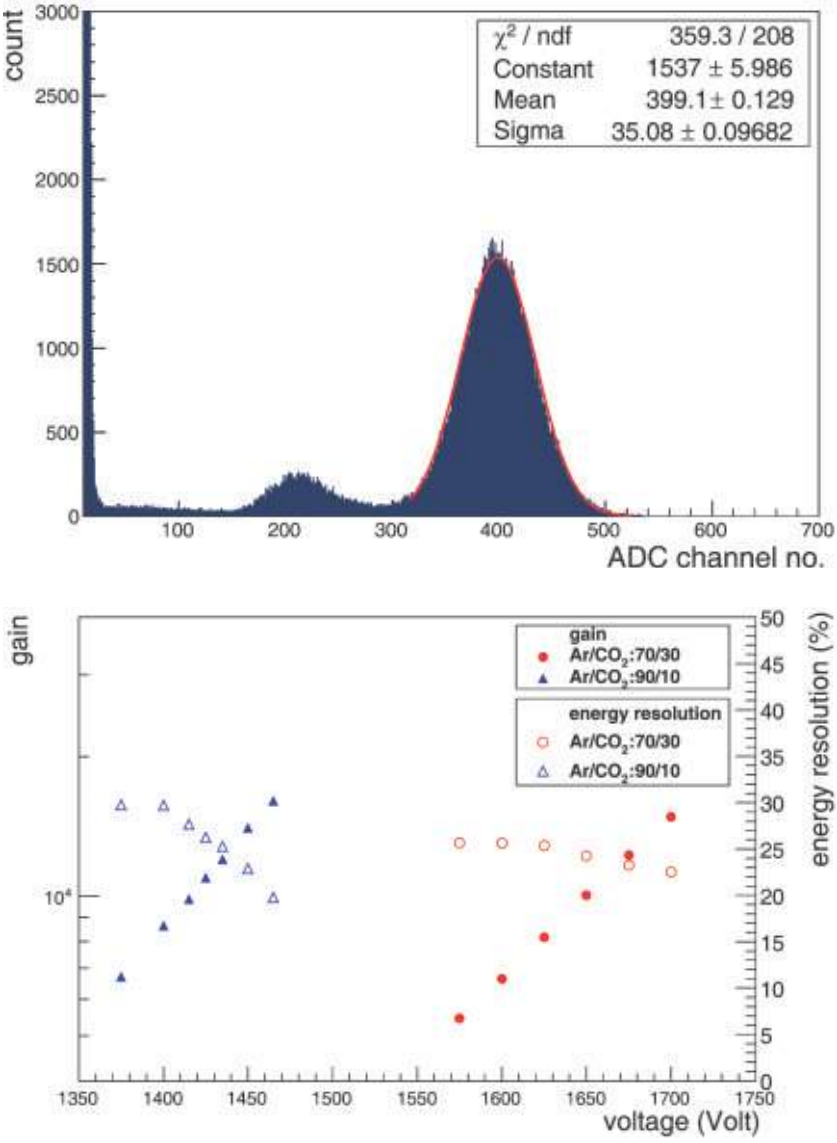
R&D on straw-tube detector for CBM experiment: *In collaboration with Ms. S. Roy, Mr. R. P. Adak, Dr. S. Das, Prof. S. K. Ghosh, Dr. S. K. Prasad, Prof. S. Raha, N. Nandi (University of Calcutta).*

Straw tubes are one of the strong candidates for the 3rd and 4th stations of the CBM Muon Chamber (MUCH). Basic R&D have been carried out with one small straw tube detector prototype with premixed gas of $Ar + CO_2$ in 70:30 and 90:10 ratio using conventional NIM electronics. The variation of gain and energy resolution with rate per unit length is measured.

The count rate for Fe^{55} X-ray source is measured as a function of the applied HV. It is seen that a plateau is obtained from about 1600 V onwards. In the particular study the energy spectrum for the Fe^{55} X-rays is obtained. The absolute gain and energy resolution are measured by obtaining the mean position of 5.9 keV peak with Gaussian fitting, increasing the biasing voltage of the straw tube detector. It is observed that the gain increases exponentially whereas the energy resolution value decreases with the voltage. Possibility to use the straw tube detector in CBM MUCH is under investigation.

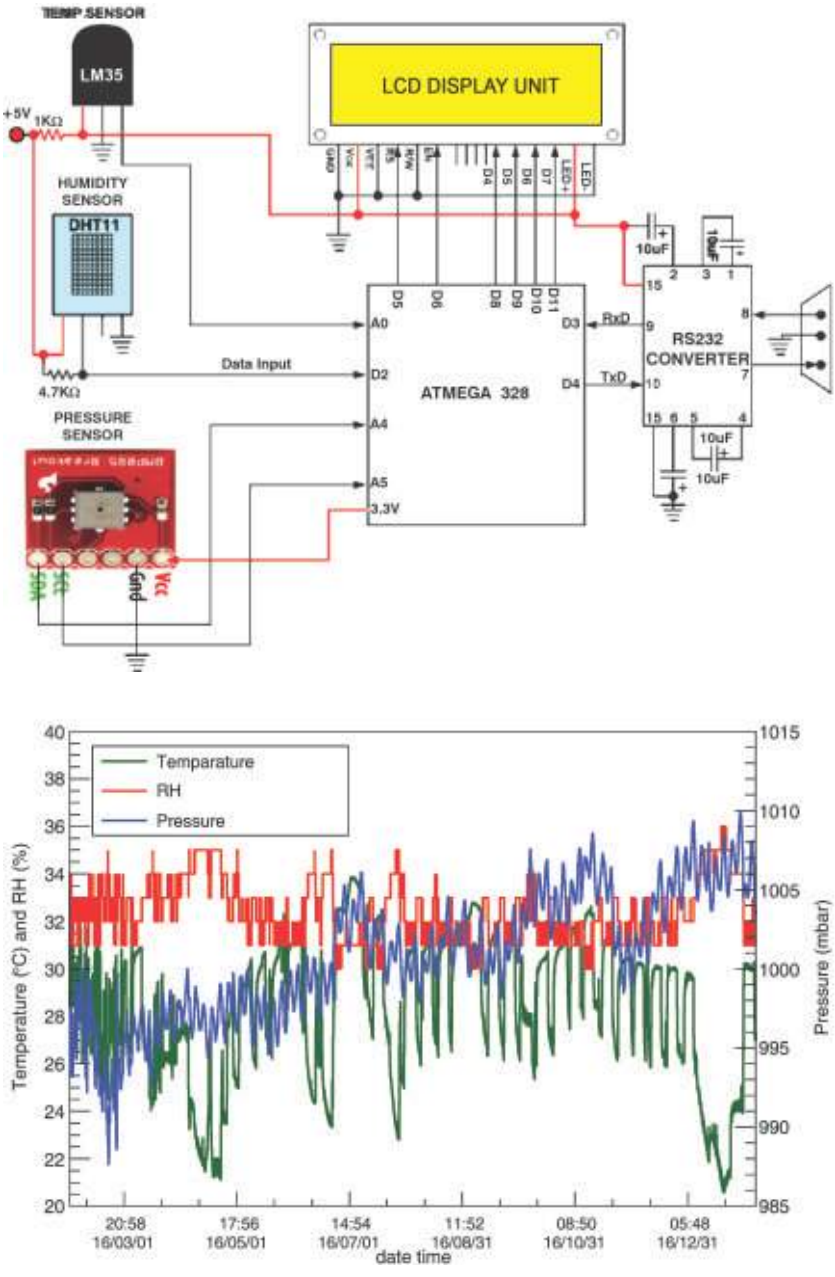
Development of electronics for detectors: *In collaboration with Dr. S. Das, Mr. D. Nag, Mrs. S. Rudra (University of Calcutta), Dr. P.K. Sahu, Mr. S. Sahu and Ms. S. Swain (IOP, Bhubaneswar).*

Several electronics modules such as data-logger, scaler have been developed required for the R&D of particle detectors.



(Top) Energy spectrum for the Fe^{55} X-rays. The red line is the Gaussian fitting curve to the 5.9 keV peak. (Bottom) The Gain and the energy resolution as a function of the voltage for both Ar/CO_2 70/30 and 90/10 mixtures. The error bars are smaller than the symbols.

Several Data logger modules to monitor and record the ambient parameters such as temperature, relative humidity and pressure have been fabricated. With this data logger continuous recording of temperature, atmospheric pressure, relative humidity and the time stamp can be done with a programmable sampling interval. This instrument is very economical. All the information like RH, temperature, pressure can be kept in one file. This data is necessary to correct the gain of a gas filled detector.



(Top) The circuit diagram of the data logger. (Bottom) Temperature, pressure and RH measured continuously for 9 months, as a function of date-time.

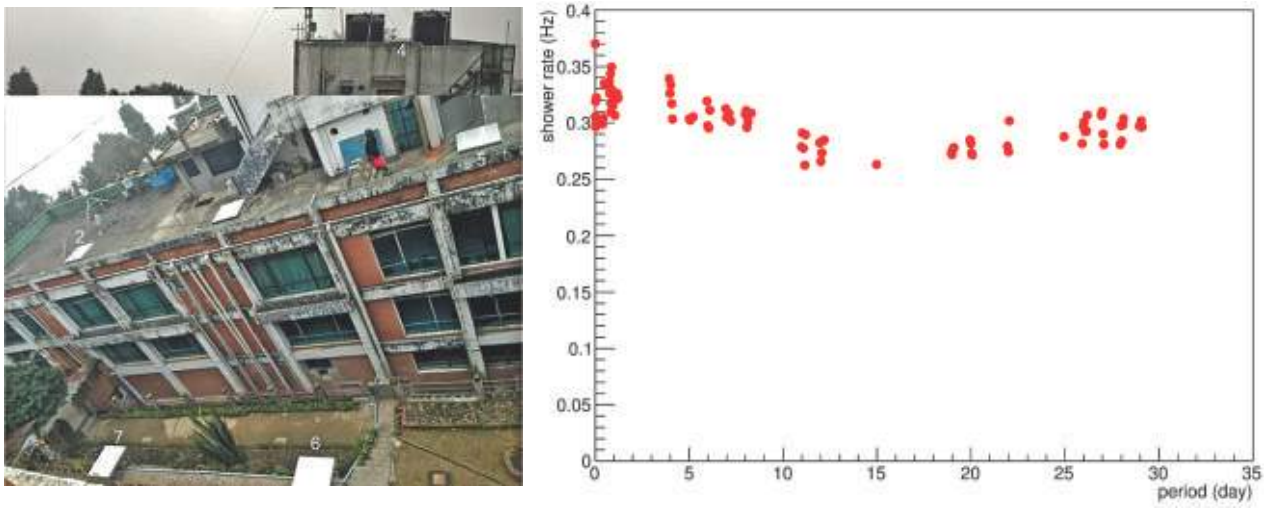
A cosmic ray air shower array at Darjeeling: *In collaboration with Dr. S. Das, Prof. S. K. Ghosh, Mr. D. Nag, Prof. S. Raha, Ms. S. Roy, S. Chatterjee, P. Chawla, S. Chakraborty, R. P. Adak, A. Maulik, S. Singh, S. Shaw (Vidyasagar University), N. Nandi (University of Calcutta).*

Fabrication and characterization of the plastic scintillator detectors have been carried out for the proposed cosmic ray air shower array under the IRHPA project at Darjeeling. An array of plastic scintillator detectors has been commissioned for detection of cosmic ray showers at an altitude of about 2200 meters above sea level in the Himalayas at the Centre for Astroparticle Physics & Space Sciences, Darjeeling campus of Bose Institute. During the first phase seven of these modules arranged in a hexagonal way keeping one at the centre of the hexagon will be commissioned. Each element of this array is a 1 m × 1 m plastic scintillator detector of thickness 2 cm, coupled with WLS fibers and a PMT.

Before setting up the array as a proof of principle three of these detectors are used to detect cosmic ray shower. The three-fold coincidence from three detectors placed on a horizontal plane is measured for about 1 month period. This mimics a cosmic ray air shower. It is found that the shower rate varies with time between 0.25–0.35 Hz.

After completion of phase I of this project, the objective will be to set up the complete mini-array of 64 such scintillator detectors coupled with WLS fiber and PMT, at Darjeeling campus, Bose Institute.

At Kolkata, a new and simple technique has been developed using plastic scintillator detectors for the study of angular variation of cosmic ray intensity near the sea level. A systematic study of the characteristics of the plastic scintillator paddle detector has been carried out. The yield uniformity of the detector has also been studied.



(Left) Cosmic ray air shower array at Darjeeling. (Right) Shower rate vs. time during mid November – mid December, 2016.

Publication(s)

Journals

1. Biswas, S.ALICE TPC upgrade for High-Rate operations. *Proceedings of Science*, *PoS* (ICPAQGP2015)094.
2. Biswas S , Das S, Ghosh SK, Nag D and Raha S (2017) Development of scintillator detector for detection of cosmic ray shower, *JINST* 12 C06026 doi:10.1088/1748-0221/12/06/C06026. Impact Factor: 1.2
3. Patra RN , Singaraju RN , Biswas S, Ahammed Z, Nayak TK, Viyogi YP (2017) Measurement of basic characteristics and gain uniformity of a triple GEM detector, *Nuclear Instruments and Methods in Physics Research* A 862 (2017) 25- 30. [arXiv:1705.03849] Impact Factor: 1.2
4. Patra RN , Singaraju RN , Biswas S, Ahammed Z, Nayak TK, Viyogi Y P (2017) Gain Uniformity and Characteristics Study of a Triple GEM Detector. *IEEE Xplore*: DOI: 10.1109/NSSMIC.2016.8069752.
5. Sahu S, Nag D , Rudra,S, Swain S, Biswas, S, Das S and Sahu P K (2017) Design and fabrication of data logger to measure the ambient parameters in gas detector R&D. *JINST* 12 C05006 doi:10.1088/1748-0221/12/05/C05006. Impact Factor: 1.2
6. Swain S, Adak RP , Biswas S, Hehner J, Patra R N, Rudra S, Sahu P K , and Sahu S (2017) A quad-GEM detector prototype operate d at very low gas gain. 2017 *JINST* 12 T07002 doi:10.1088/1748-0221/12/07/T07002. Impact Factor: 1.2

Conference proceedings

1. Nandi N, Roy S, Adak R P, Biswas S, Das S, Ghosh SK, Prasad SK, and Raha S (2017) Characterization of the Straw tube detector. *Proceedings of the DAE-BRNS Symposium on Nuclear Physics*. Volume 62 (2017), 1032-1033.
2. Shaw S, Nandi N , Chatterjee S, Chawla P, Roy S , Adak R P, Biswas S, Das S, Ghosh SK, and Raha S (2017) Study of cosmic ray with plastic scintillator detector, *Proceedings of the DAE-BRNS Symposium on Nuclear Physics*. Volume 62, (2017), 1030-1031.

Internal notes

1. Roy S, Nandi N, Adak R P, Biswas S, Das S, Ghosh SK, Prasad SK, and Raha S (2017), Study of the rate handling capacity of a straw tube detector. *CBM Progress Report* 2017, 74. ISBN 978-3-9815227-5-4.

Grants-in-Aid Schemes:

Title of the scheme	Project funded by
Investigation of the Applicability of Micro-pattern Gas Detectors in the High Rate FAIR-Experiment CBM	DST-SERB

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

1. Special Task Force meeting, August 22-23, 2017, VECC, Kolkata. Title: ALICE TPC Upgrade with GEM: Infrastructure and readiness at Bose Institute.
2. ALICE-India Collaboration meeting, 26-29 October 2017, Jammu University. Title: Detector development at Bose Institute.
3. CBM-India meeting, 15-17 February 2018, Falta. Title: GEM production plan and status at Bose Institute.
4. 31st CBM Collaboration meeting, 19-23 March 2018, GSI, Germany. Title: Detector development for CBM-MUCH at Bose Institute.
5. ALICE Collaboration meeting, 26-29 March 2018, VECC. Title: R&D at Bose Institute : Updates.

Social relevance of research performed at Bose Institute

The work is very essential for basic science research. 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.

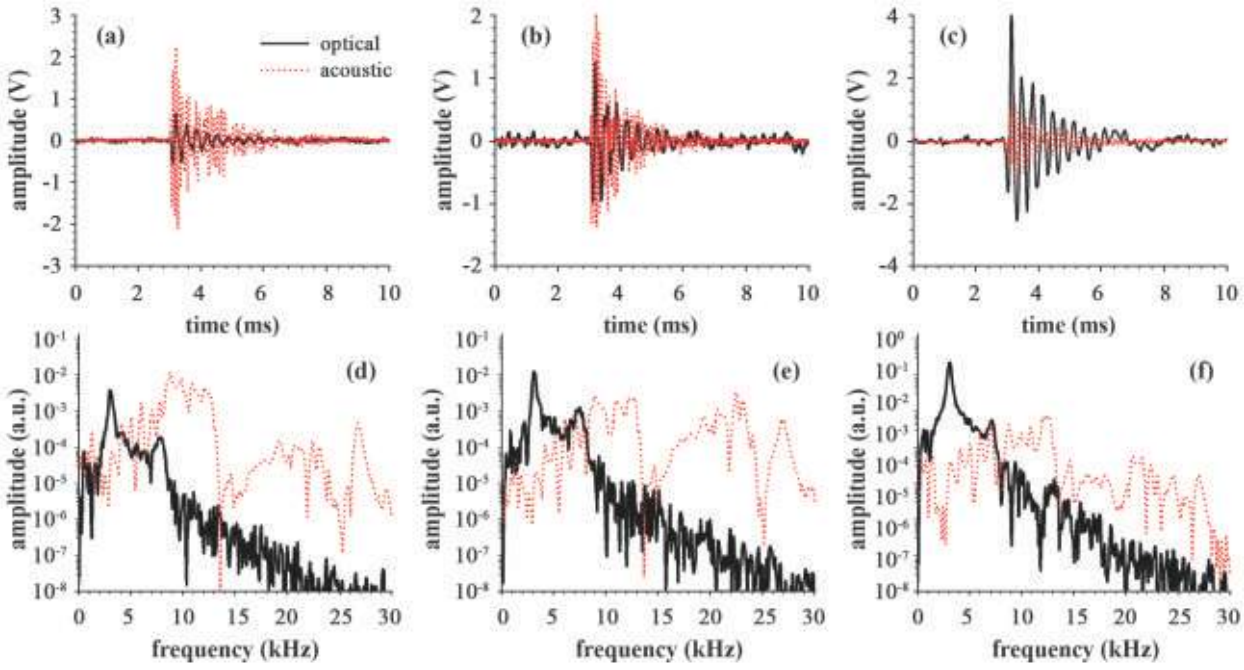
Dr. Barun K. Chatterjee

Professor

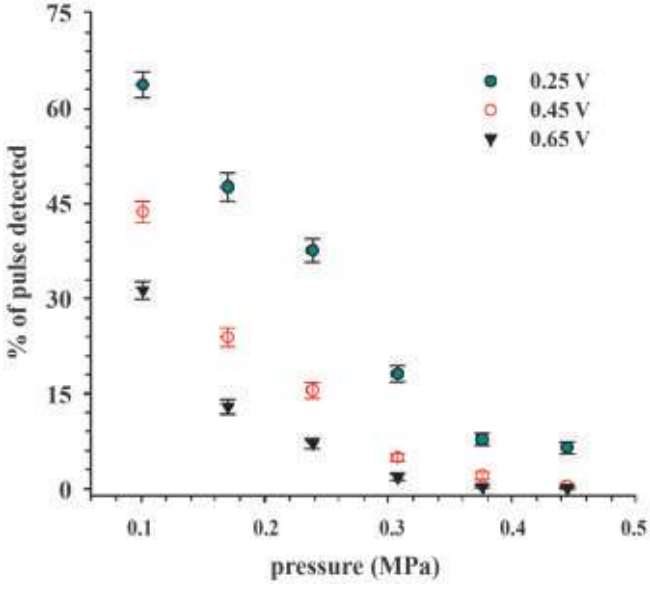
Scientific Reports

Study of liquid-vapor nucleation in superheated drop detectors

The sound emitted during vaporization of a superheated liquid droplet, or nucleation, has been studied using both an acoustic transducer and optically using a laser beam reflected off from a probe bubble in the vicinity of the nucleating liquid droplet. The two signals are found to compare quite well as shown below.



In a separate experiment, the emitted sound was studied as a function of the ambient pressure and it was observed that the sound emitted during liquid-vapor nucleation diminished in amplitude as the ambient pressure was increased. This was due to the fact that the velocity of sound in the superheated liquid increases very rapidly with pressure and so does the threshold for nucleation. The resulting amplitude of the acoustic pulse decreased with pressure.



This feature caused the loss of nucleation counts and hence the detection efficiency decreases with increasing pressure, necessitating a correction factor. Further experiments showed

that the optical detection method can detect pressure pulses even when acoustic pulses are too small to be detected by the acoustic transducer, thereby establishing the superiority of the new optical method over the usual acoustic transducer method.

Publications:

1. Chatterjee T, Chatterjee BK, Chakrabarti P (2017) Modelling of growth kinetics of *Vibrio cholerae* in presence of gold nanoparticles: effect of size and morphology**,** *Scientific Reports* **7**, *9671* DOI:10.1038/s41598-017-09357-0
2. Sarkar R, Mondal PK, Chatterjee BK (2017) Study of acoustic emission due to vaporisation of superheated droplets at higher pressure, *Physics Letters* A 381, 2531–2537
3. Sarkar R, Mondal PK, Datta M, Chatterjee BK (2017) A new optical method for the detection of bubble nucleation in Superheated Droplet Detector, *Review of Scientific Instruments* 88, 066106

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

i) Chaired a session in National Conference on Recent Trends in Condensed Matter Physics (31st October-3rd November 2017), at Bose Institute, Kolkata.

ii) Invited to deliver a lecture on "Bose Institute's contribution in physics" at the one day symposium on 100 years of Bose Institute: Acharya J.C. Bose and beyond (21st November 2017), at Bose Institute, Kolkata.

Dr. Sanjay K. Ghosh

Professor

Scientific Reports

Cosmic Ray studies: search for strangelets: *In collaboration with R. Bhattacharyya, S. Dey,. Maulik, Sibaji Raha, D. Syam*

Various phenomenological models presented over the years have hinted at the possible presence of strangelets, which are nuggets of Strange Quark Matter (SQM), in cosmic rays. One way to search for such rare events is through the deployment of large area Nuclear Track Detector (NTD) arrays at high mountain altitudes. Before the deployment of any such array can begin, a detailed study of the radiation background is essential. Also, a proper understanding of the response of detectors exposed to extreme weather conditions is necessary. With that aim, pilot studies were carried out at various high altitude locations in India such as Darjeeling (2200 m a.m.s.l), Ooty (2200 m a.m.s.l) and Hanle (4500 m a.m.s.l). Small arrays of CR-39 as well as high threshold Polyethylene Terephthalate (PET) detectors were given open air exposures for periods ranging from three months to two years. From the studies conducted so far, high threshold PET seems to be a very good choice as a NTD for the planned rare

event search.

Physics of strong interaction – Effective models: *In collaboration with, Rajarshi Ray, Kinkar Saha, and Sudipa Upadhaya, Soumitra Maity, Subhasis Samanta*

External Collaborator: Abhijit Bhattacharyya

The equation of state and fluctuations of conserved charges in a strongly interacting medium under equilibrium conditions form the baseline upon which variou s possible scenarios in relativistic heavy-ion collision experiments are built. Many of these quantities have been obtained in the lattice QCD framework with reliable continuum extrapolations. Recently the Polyakov Nambu – Jona-Lasiniomodel has been reparametrized to some extent to reproduce quantitatively the lattice QCD equation of state at vanishing chemical potentials. The agreement was precise except at low temperatures, possibly due to inadequate representation of the hadronic degrees of freedom in the model. This disagreement was also observed for some of the fluctuation and correlations considered. Here we address this issue by introducing the effects of hadrons through the Hadron Resonance Gas model. The total thermodynamic potential is now a weighted sum of the thermodynamic potential of thePolyakov – Nambu – Jona-Lasinio model and that of the Hadron Resonance Gas model. We find that the equation of state and the fluctuations and correlations obtained in this hybrid model agrees satisfactorily with the lattice QCD data in the low temperature regime.

Atmospheric Science: : *In collaboration with* D. *Ray, D., T. S. Bhattacharya, A. Chatterjee, A. Singha, S. K. Ghosh, & S. Raha*

A remarkable reduction in reaction rate was observed for oxidation of surface adsorbed benzo(a)pyrene (BaP) by gaseous ozone on model soot particles externally coated with sulfuric acid. A simple set up was developed to derive the model soot particles by burning kerosene in controlled conditions similar in wick lamps for household usage followed by cleaning the particulates chemically and thermally. The approximate specific surface area (ASSA) of the model soot particle ($\sim 5\ m^2g^{-1}$ was estimated by evaluating the monolayer surface coverage (Langmuir concentration, c^L_{Bap}) using the BaP ozonation kinetics on clean soot. Additionally non linear dependence of pseudo first order rate coefficients (k^I_{obs}) on ozone concentrations indicates a heterogeneous bimolecular reaction and equilibrium partition constant (K_{o_3}) and maximum first order rate constants (k_{max}) were evaluated by fitting the kinetics data with Langmuir-Hinshelwood model for both $soot_{Bap}$ and $soot_{Bap+H_2SO_4}$ samples. The higher K_{o_3} and k_{max} values for $soot_{Bap}$ supported the earlier observations that ozone has higher affinity for non-polar surface. The inaccessibility of BaP in $soot_{Bap+H2SO4}$ was confirmed by prolonged exposure to gaseous ozone. Less than 30% BaP was degraded after 3 hours in $soot_{Bap+H2SO4}$ whereas around 85% BaP was oxidized in $soot_{Bap}$ under the same conditions. The enhanced half life of BaP on $soot_{Bap+H2SO4}$ ($\sim t_{1/2} = 2$ hours) compared to that of $soot_{Bap}$ ($t_{1/2} = \sim 17$ min) at typical urban ozone concentration (100ppb) would possibly result in regional transport of BaP causing pollution at a pristine area.

Symposia/Conference Organized

1. Coordinator of NESST-BASE 2017, a summer training programme for North-East students in basic sciences held at Bose Institute, Darjeeling during May 22 – June 3, 2017.

2. Organized CBM-India meeting held at Falta, during February 15 – 17, 2018.
3. Organized CBM computing workshop held in Bose Institute, Salt lake, during February 19 – 20, 2018.
4. Chairman, Organizing Committee, International conference on "Aerosol climate change connection (AC3)" held in Darjeeling during April 25-27, 2017

Publication(s)

Referred journals

1. Bhattacharyya R, Dey S, Ghosh S K, Maulik A, Raha S, Syam D (2017) Study of radiation background at various high altitude locations in preparation for rare event search in cosmic rays. *JCAP 1704 (04), 035*.
2. Ray D, Chatterjee A, Majumdar D, Ghosh S K, & Raha S (2017) Polycyclic aromatic hydrocarbons over a tropical urban and a high altitude Himalayan Station in India: Temporal variation and source apportionment. *Atmospheric Research*, *197*, 331-341.
3. Ray D, Bhattacharya T S, Chatterjee A, Singha A, Ghosh, S K, & Raha S (2018) Hygroscopic Coating of Sulfuric Acid Shields Oxidant Attack on the Atmospheric Pollutant Benzo (a) pyrene Bound to Model Soot Particles. *Scientific reports*, *8*(1), 129.
4. Sarkar C, Chatterjee A, Majumdar D, Roy A, Srivastava, ., Ghosh, S K & Raha S (2017) How the Atmosphere over Eastern Himalaya, India is Polluted with Carbonyl Compounds: Temporal Variability and Identification of Sources. *Aerosol and Air Quality Research*, *17*(9), 2206-2223.

   (*with Prof. S. Raha, Dr. Supriya Das, Dr. Sidhartha Prasad, Dr. Saikat Biswas, Rathijit Biswas as a part of the ALICE Collaboration*)
5. Acharya S et al. (ALICE Collaboration) (2018) Pi-0 and eta-meson production in proton-proton collisions at sqrt(s) = 8 TeV. *Eur. Phys. J. C*: 78: 263.
6. Acharya S et al. (ALICE Collaboration) (2018) Measurement of Z^0-boson production at large rapidities in Pb-Pb collisions at sqrt(s_NN) = 5.02 TeV. *Phys. Lett.* B: 780: 372–383.
7. Acharya S et al. (ALICE Collaboration) (2018) D-meson azimuthal anisotropy in mid-central Pb-Pb collisions at sqrt(s_NN) = 5.02 TeV. *Phys. Rev.* Lett.: 120: 102301.
8. Acharya S et al. (ALICE Collaboration) (2018) Search for collectivity with azimuthal J/ψ-hadron correlations in high multiplicity p-Pb collisions at sqrt(s_NN) = 5.02 and 8.16 TeV. *Phys. Lett.* B: 780: 7-20.
9. Acharya S et al. (ALICE Collaboration) (2018) Production of deuterons, tritons, ^{3}He nuclei and their anti-nuclei in pp collisions at sqrt(s) = 0.9, 2.76 and 7 TeV. *Phys. Rev.* C: 97: 024615.
10. Acharya S et al. (ALICE Collaboration) (2018) Systematic studies of correlations between different order flow harmonics in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. *Phys. Rev.* C: 97: 024906.

11. Acharya S et al. (ALICE Collaboration) (2018) Production of ^{4}He and ^{4}He-bar in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV at the LHC. *Nucl. Phys.* A: 971: 1-20.

12. Acharya S et al. (ALICE Collaboration) (2017) Kaon femtoscopy in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. *Phys. Rev.* C: 96: 064613.

13. Acharya S et al. (ALICE Collaboration) (2018) Constraining the magnitude of the Chiral Magnetic Effect with Event Shape Engineering in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. *Phys. Lett.* B: 777: 151-162.

14. Acharya S et al. (ALICE Collaboration) (2017) J/ψ elliptic flow in Pb-Pb collisions at sqrt(s_NN) = 5.02 TeV. *Phys. Rev.* Lett.: 119: 242301.

15. Acharya S et al. (ALICE Collaboration) (2017) Charged-particle multiplicity distributions over a wide pseudorapidity range in proton-proton collisions at sqrt(s) = 0.9, 7 and 8 TeV. *Eur. Phys.* J. C: 77: 852.

16. Acharya S et al. (ALICE Collaboration) (2018) The ALICE Transition Radiation Detector: construction, operation, and performance. *Nucl. Instr. Meth.* A: 881: 88.

17. Acharya S et al. (ALICE Collaboration) (2018) First measurement of jet mass in Pb-Pb and p-Pb collisions at the LHC. *Phys. Lett.* B: 776: 249.

18. Acharya S et al. (ALICE Collaboration) (2018) J/ψ production as a function of charged-particle pseudorapidity density in p-Pb collisions at sqrt(s_NN) = 5.02 TeV. *Phys. Lett.* B: 776: 91.

19. Acharya S et al. (ALICE Collaboration) (2017) Measurement of deuteron spectra and elliptic flow in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV at the LHC. *Eur. Phys.* J. C: 77: 658.

20. Acharya S et al. (ALICE Collaboration) (2017) Searches for transverse momentum dependent flow vector fluctuations in Pb-Pb and p-Pb collisions at the LHC. *JHEP*: 09: 032.

21. Acharya S et al. (ALICE Collaboration) (2017) Measuring $K_S^0K^{\pm}$ interactions using Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. *Phys. Lett.* B: 774: 64.

22. J. Adam et al. (ALICE Collaboration) (2017) Anomalous broadening of the near-side jet peak in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. *Phys. Rev. Lett.*: 119: 102301.

22. J. Adam et al. (ALICE Collaboration) (2017) Evolution of the longitudinal and azimuthal structure of the near-side jet peak in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. *Phys. Rev. C*: 96: 034904.

23. J. Adam et al. (ALICE Collaboration) (2017) Insight into particle production mechanisms via angular correlations of identified particles in pp collisions at sqrt(s) = 7 TeV. *Eur. Phys. J. C*: 77: 569.

24. J. Adam et al. (ALICE Collaboration) (2017) Measurement of D-meson production at mid-rapidity in pp collisions at sqrt(s) = 7 TeV. *Eur. Phys. J. C*: 77: 550.

25. J. Adam et al. (ALICE Collaboration) (2017) Linear and non-linear flow modes in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. *Phys.Lett. B*: 773: 68.

26. J. Adam et al. (ALICE Collaboration) (2017) Measurement of electrons from beauty-hadron decays in p-Pb collisions at sqrt(s_NN) = 5.02 TeV and Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. JHEP: 07: 052.

27. J. Adam et al. (ALICE Collaboration) (2017) Centrality dependence of the pseudorapidity density distribution for charged particles in Pb-Pb collisions at sqrt(s_NN) = 5.02 TeV. *Phys.Lett. B*: 772: 567-577.

28. J. Adam et al. (ALICE Collaboration) (2017) Production of muons from heavy-flavour hadron decays in p-Pb collisions at sqrt(s_NN) = 5.02 TeV. *Phys. Lett. B*: 770: 459-472.

29. J. Adam et al. (ALICE Collaboration) (2017) Energy dependence of forward-rapidity J/ψ and ψ(2S) production in pp collisions at the LHC. *Eur. Phys. J. C*: 77: 392.

30. J. Adam et al. (ALICE Collaboration) (2017) Production of $\Sigma(1385)^{\pm}$ and Ξ(1530)0 in p-Pb collisions at sqrt(s_NN) = 5.02 TeV. *Eur. Phys. J. C*: 77: 389.

31. J. Adam et al. (ALICE Collaboration) (2017) $K^{*}(892)0$ and φ(1020) meson production at high transverse momentum in pp and Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. *Phys. Rev. C:* 95: 064606

32. J. Adam et al. (ALICE Collaboration) (2017) Azimuthally differential pion femtoscopy in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. *Phys. Rev. Lett.*: 118: 222301.

33. J. Adam et al. (ALICE Collaboration) (2017) Measurement of the production of high-pT electrons from heavy-flavour hadron decays in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. *Phys. Lett. B*: 771: 467-481.

34. J. Adam et al. (ALICE Collaboration) (2017) Production of π^{0} and η mesons up to high transverse momentum in pp collisions at 2.76 TeV. *Eur. Phys. J. C*: 77: 339.

35. J. Adam et al. (ALICE Collaboration) (2017) Enhanced production of multi-strange hadrons in high-multiplicity proton-proton collisions. *Nature Physics*: 13: 535-539.

36. J. Adam et al. (ALICE Collaboration) (2017) Flow dominance and factorization of transverse momentum correlations in Pb-Pb collisions at the LHC. PRL: 118: 162302.

37. J. Adam et al. (ALICE Collaboration) (2017) Measurement of azimuthal correlations of D-mesons and charged particles in pp collisions at sqrt(s) = 7 TeV and p-Pb collisions at sqrt(s_NN) = 5.02 TeV. *Eur. Phys. J. C*: 77: 245.

BOOKS:

Proceedings:

Biswas S (ed.), Das S (ed.), Ghosh S K (ed.). (2018) Advanced Detectors for Nuclear, High Energy and Astroparticle Physics (ADNHEAP 2017), *Springer Proc. Phys*. 201 pp. 2-232

Dr. A. Chatterjee

Assistant Professor

Scientific Reports

Methane emissions in India: A little growth observed during 2010-2015

Recent variations in atmospheric methane (CH4) concentrations in India are expected to be resulted due to the changes in tropical wetland, ruminant or rice emissions. As India has the world's largest ruminant population and produces ~ 20% of the world's rice, the changes in these sources could have significant implications for global warming. India's CH4 emissions for the period 2010–2015 were observed using a combination of satellite, surface and aircraft data. We used a high-resolution atmospheric transport model to simulate data and the fluxes were estimated. The average emissions of methane over this period were varied between ~19-24 with the average of ~22 Tg yr^{-1}. The results are consistent with the emissions reported by India to the United Nations Framework Convention on

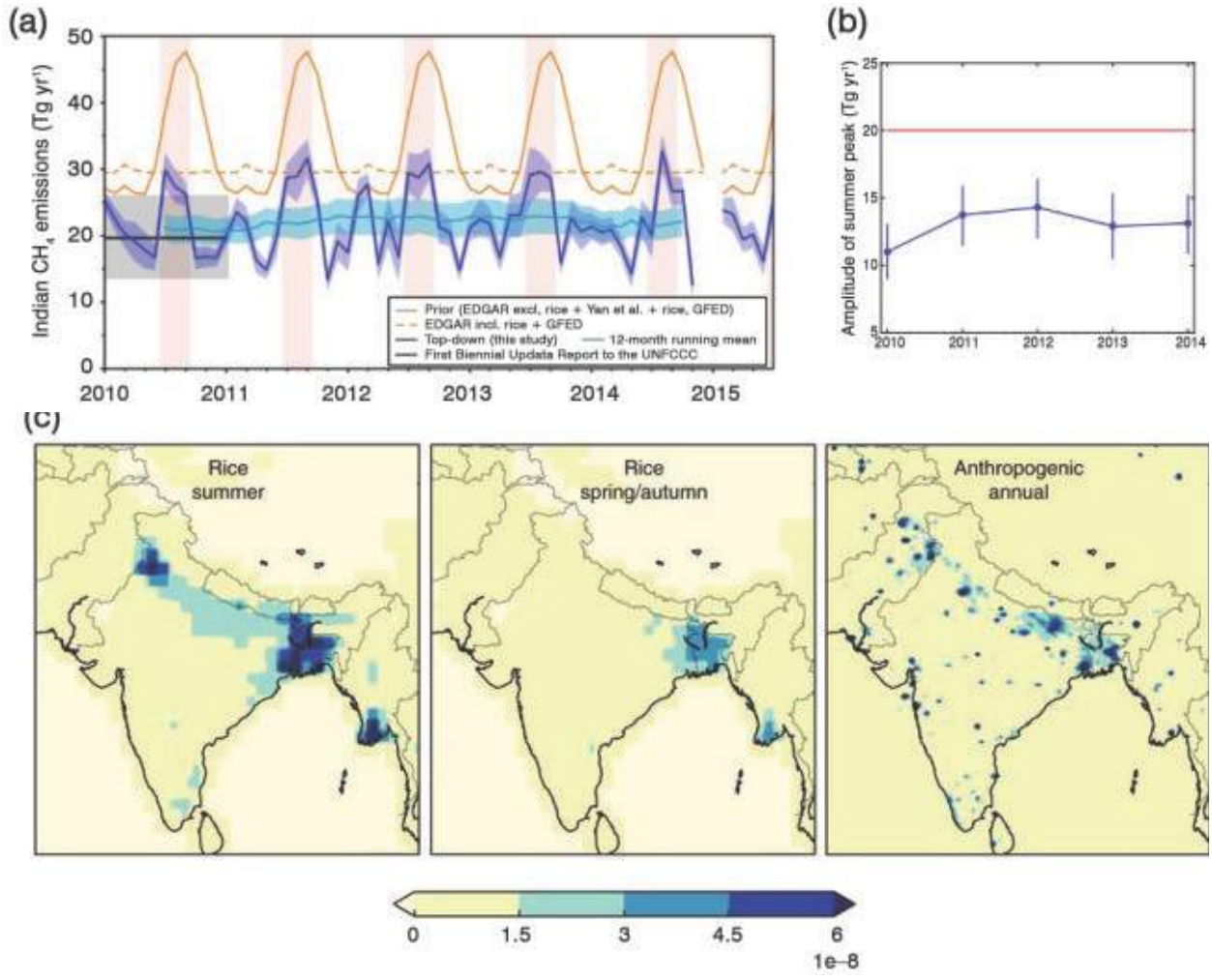


Fig 1: Annual variation of methane and source regions in India

Climate Change (UNFCCC). We observed that the annual emissions have not changed significantly between 2010 and 2015, suggesting that major CH4 sources did not change appreciably. These findings are in contrast to another major economy, China, which has shown significant growth in recent years due to increasing fossil fuel emissions. However, the trend in a global emission inventory has been overestimated for China due to incorrect rate of fossil fuel growth. Here, we find growth has been overestimated in India but likely due to ruminant and waste sectors.

Characterization of carbonyl compounds over eastern Himalaya in India

A study was conducted on atmospheric carbonyl compounds for the first time over a Himalayan atmosphere in India. Samples were collected from a high altitude hill station, Darjeeling (27.01°N,

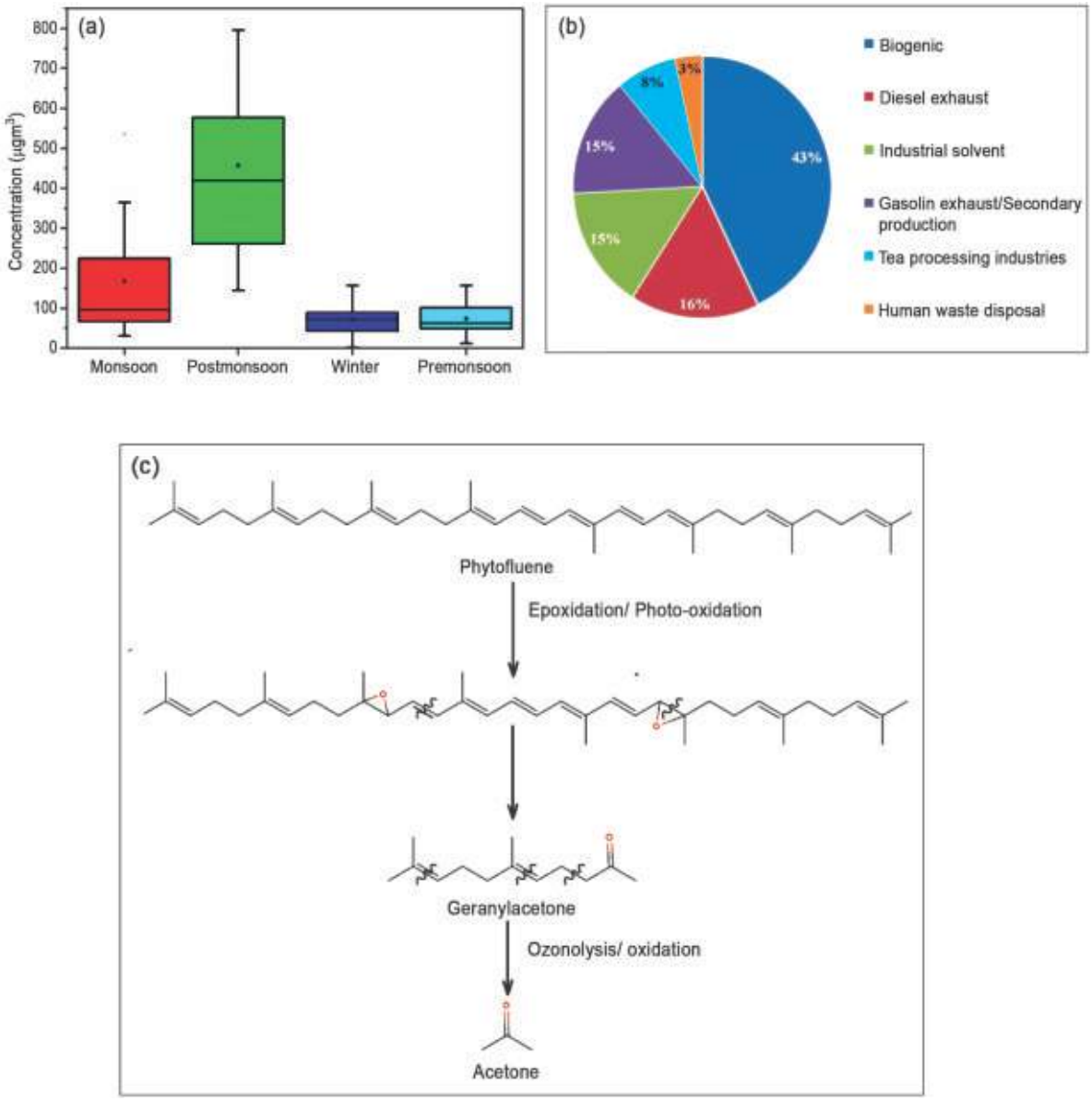


Fig 2: Temporal variation of carbonyl compounds, sources of carbonyl compounds and formation of acetone from Tea leaves over eastern Himalaya, India

88.15°E, 2200 masl) during June 2012 to May 2013. 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 the dominant species for its higher photochemical production from its precursor volatile organic compounds emitted from tea plants and tea processing units. Interestingly, the concentration of acetaldehyde and formaldehyde were found to be comparable with metro cities of India and world. The carbonyl compounds showed highest loading during postmonsoon when the solar radiative flux was minimum. Meteorological parameters like temperature and surface reaching solar radiative flux played the major roles for the seasonal variation of the carbonyl concentration over the hill station. Positive matrix factorization model showed that the biogenic emissions from tea plants and vehicular emissions were the major sources of carbonyl compounds over the hill station.

Polycyclic aromatic hydrocarbons over a tropical urban and a high altitude Himalayan Station in India: Temporal variation and source apportionment

The temporal variations and major sources of polycyclic aromatic hydrocarbons (PAH) intrinsic to PM_{10} were investigated over a tropical urban atmosphere on the Indo-Gangetic Plain (IGP) and for the first time over a high altitude urban atmosphere at eastern Himalaya in India. Samples were collected over Kolkata, a megacity and Darjeeling during the dry season (October 2015–May 2016). Fourteen PAHs were detected and quantified over Kolkata and Darjeeling during post-monsoon, winter and pre-monsoon. The maximum loading was observed during winter at Kolkata, whereas post-monsoon showed maximum loading at Darjeeling. The observed seasonality of PAHs at Kolkata *vis-a-vis* Darjeeling has been explored in the light of anthropogenic activities, boundary layer dynamics and meteorological parameters such as temperature, relative humidity, wind speed and solar radiation. The positive matrix factorization (PMF) model identified that the coal (26%), petrol (24%) and diesel (17%) combustion, commercial and household kitchens (18%) and municipal solid waste incineration (15%) are the possible contributors to the PM_{10} associated PAHs over Kolkata whereas diesel (37%), commercial and household kitchens (23%), coal (21%) and petrol (20%) are the possible PM_{10} associated PAH sources over Darjeeling.

Aerosols over Indo-Gangetic Plains and Indo-Himalayan Range during winter monsoon and summer monsoon

Both in-situ and space-borne observations reveal an extremely high loading of particulates over the Indo-Gangetic Plains (IGP), all year around. Four observational campaigns were conducted for sampling the ambient $PM_{2.5}$ and PM_{10} during winter and summer seasons of 2014–2015, at multiple locations (18 sites) in the IGP, Indo-Himalayan Range, and semi-arid sites, in order to accurately determine the temporal changes in the aerosol loading at the sites.

Hygroscopic Coating of Sulfuric Acid Shields Oxidant Attack on the Atmospheric Pollutant Benzo (a) pyrene Bound to Model Soot Particles

The interactions between the soot and sulfuric acid (H2SO4) significantly change the optical and chemical properties of soot particles and hence the substantial impacts on climate are observed. However, the influence of H2SO4 on heterogeneous chemistry on soot remains unexplored. Several

studies earlier have reported the oxidation rate coefficients for particulate polycyclic aromatic hydrocarbons which seem to overestimate their degradation in ambient atmosphere. This could be due to matrix effects which are hitherto not mimicked in laboratory experiments. For the first time, we have conducted a kinetic study which reports significant influence of H2SO4 coating on heterogeneous ozonation of benzo(a)pyrene (BaP) deposited on model soot, representative to atmospheric particles. The approximate specific surface area of model soot was estimated as a measure of the availability of surface molecules to a typical gaseous atmospheric oxidant. Heterogeneous bimolecular reaction kinetics and Raman spectroscopy studies suggested plausible reasons for decreased BaP ozonation rate in presence of H2SO4: 1. decreased partitioning of O3 on soot surface and 2. shielding of BaP molecules to gaseous O3 by acid-BaP reaction or O3 oxidation products.

Interaction between marine and anthropogenic aerosols over eastern Himalaya and urban atmosphere at IGP

We conducted studies in order to investigate the effect of the interaction between marine sea-salt aerosols and the polluted anthropogenic aerosols over high altitude Himalaya and Kolkata metro city at IGP. We observed that the huge amount of chloride was substituted from the sea-salt aerosols when marine aerosols interacted with the anthropogenic sulphate aerosols during monsoon. We observed that such interactions varied in different degrees and the function of the distance from the sea-coast.

Interaction between the size-segregated aerosols and the size-segregated rain drops

We conducted studies where we investigated how the aerosols of different size ranges get scavenged by the rain drops of different diameters. To do this we continuously monitored the number concentrations of size-segregated aerosols and the size-segregated raindrops during several rain events during monsoon 2015-2017. The other physical parameters associated with the rain like rain rate, drop velocity, cloud heights etc were also investigated.

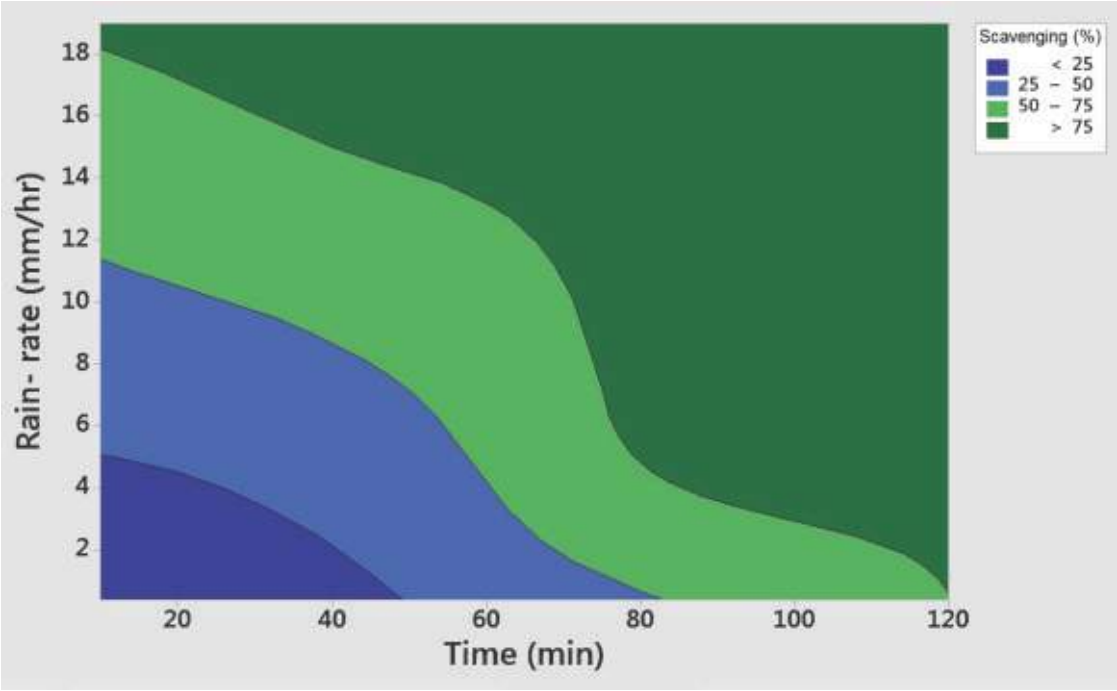


Fig 3: Aerosol scavenging depending on duration and types of rain

Exchange of Greenhouse Gases between the biosphere and the atmosphere at eastern Himalaya, India

We investigated how the Greenhouse gases like CO_2 and H_2O vapour are exchanged between biosphere and atmosphere for the first time at an eastern Himalayan site in India. The study was carried

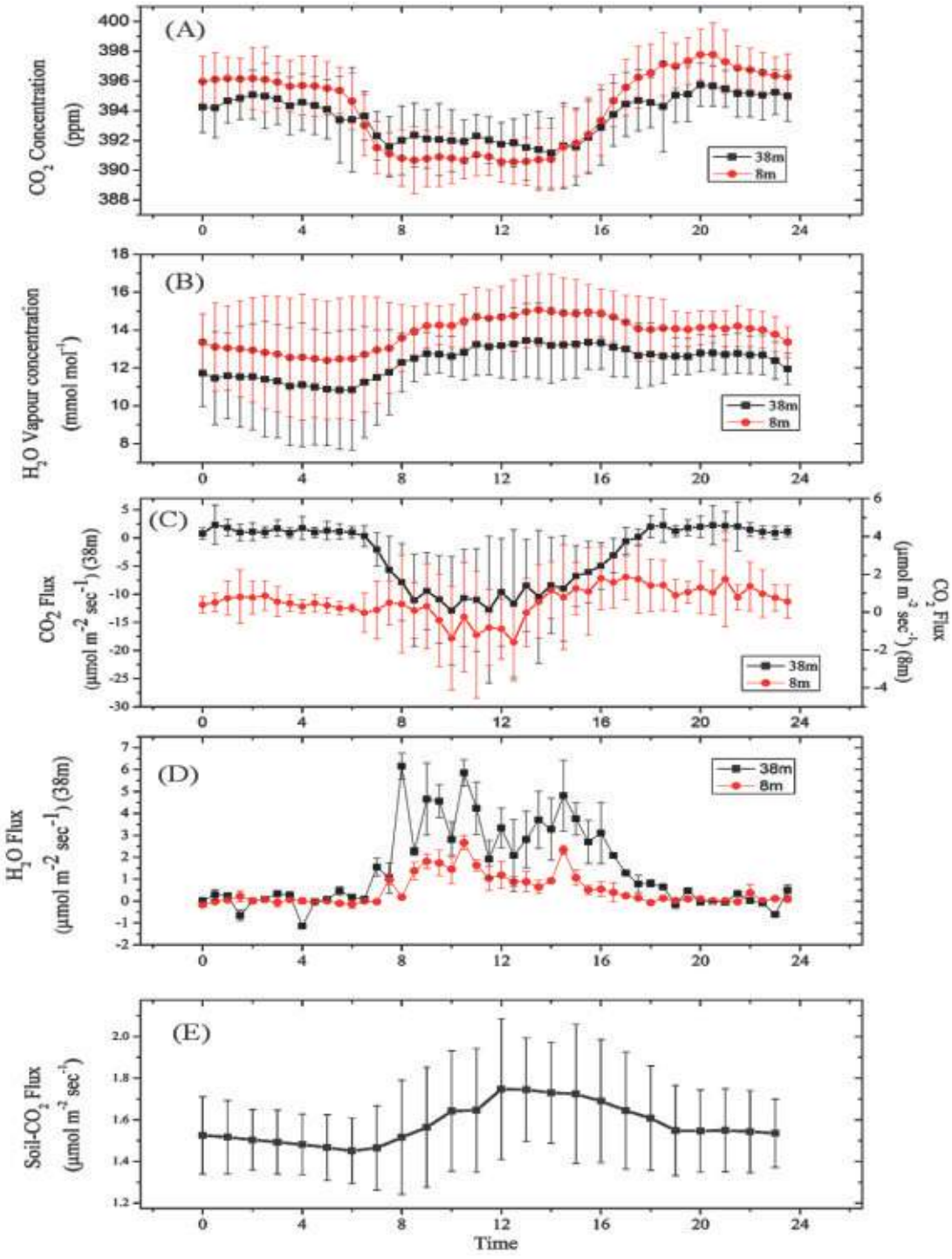


Fig 4: Diurnal variation of Greenhouse Gas fluxes over eastern Himalaya, India

out over a high altitude (2286 m asl) evergreen coniferous forest (27.04 ºN, 88.08 ºE) where we measured the fluxes of CO_2, H_2O vapour along with the sensible and latent energy using eddy covariance method both above (38 m) and within (8 m) the canopy, soil-CO2 flux and the vertical profile of CO_2 during spring (March-April) in 2015. The mean eddy flux of CO_2 above the canopy was -2.8 ± 6.5 μmol m^{-2} s^{-1} whereas that within the canopy was 0.6 ± 0.4 μmol m^{-2} s^{-1}. The mean flux of H_2O vapour above the canopy (1.5 ± 1.8 mmol m^{-2} s^{-1}) was three times higher than within the canopy (0.5 ± 0.6 mmol m^{-2} s^{-1}). The mean flux of CO_2 emitted from the soil surface was 1.6 ± 0.1 μmol m^{-2} s^{-1}. The diurnal variation showed high sequestration of CO_2 during daytime when the negative flux increased to larger than -10 μmol m^{-2} s^{-1}. We observed that precipitation significantly enhanced CO_2 sequestration (by ~four folds) as well as H_2O vapour emissions (by ~three folds) by the tall canopies. Overall, during the entire study period the net ecosystem exchange (NEE) was -656.5 g CO_2 m^{-2} suggesting that the evergreen coniferous forest at eastern Himalaya acts as a net sink of CO_2 during spring. This would enable us to estimate the sequestration of anthropogenic carbon emission by the eastern Himalayan forest ecosystem and contribute to the national greenhouse gases inventory.

SCIENTIFIC REPORT

Grants-in-aid Schemes

Title of the Scheme	Scheme funded by
Understanding the Role of Local and Transported Biogenic and anthropogenic Aerosols on Microphysical and Chemical Properties of Low-level Clouds over Eastern Himalaya, India	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)	MoEFCC
Study of Cosmic ray interactions and Cosmic Ray – Aerosol – Cloud connection in the context of regional climate change	DST

Publication (s)

International peer-reviewed journals

1. Ganesan A L, Rigby M., Lunt M F, Parker R J, Boesch H, Goulding N, Umezawa T, Zahn, A, Chatterjee A, Prinn R G, Tiwari Y K, Schoot M, Krummel P (2017) Atmospheric observations show accurate reporting and little growth in India's methane emissions, *Nature Communications*, *8*(1), 836.
2. Ray D, Chatterjee A, Majumdar D, Ghosh S K, & Raha S (2017) Polycyclic aromatic hydrocarbons over a tropical urban and a high altitude Himalayan Station in India: Temporal variation and source apportionment. *Atmospheric Research*, *197*, 331-341.
3. Ray D, Bhattacharya T S, Chatterjee A, Singha A, Ghosh S K, & Raha S (2018) Hygroscopic Coating of Sulfuric Acid Shields Oxidant Attack on the Atmospheric Pollutant Benzo (a) pyrene Bound to Model Soot Particles. *Scientific reports*, *8*(1), 129.

during 26-28 June 2017. "The Quality of Air over Eastern Himalaya in India: Threats to Human Health and Climate".

Seminars/ Symposia Organized at Bose Institute:

An international conference called "Aerosol Climate Change Connection (AC3)" was held at Darjeeling campus of Bose Institute during 25-27 April, 2017 as a part of the centenary celebration of Bose Institute. Many national and international scientists, students, scholars etc working in the field of atmospheric science participated in this assembly.

Dr. Supriya Das

Associate Professor

Scientific Reports

Characterization of GEM detector for ALICE and CBM experiments:*(in collaboration with Mr. R. P. Adak, Ms. S. Roy, Mr. S. Chatterjee, Mr. S. Chakraborty, Dr. S. Biswas, Prof. S. K. Ghosh, Dr. S. K. Prasad and Prof. S. Raha*)

We are actively working for the ALICE experiment at CERN, Geneva and CBM experiment of FAIR, Germany. A gas detector laboratory started functioning at CAPSS, Bose Institute. A 10 x 10 cm^2 triple GEM (Gas Electron Multiplier) detector prototype is built and tested with a gas mixture of Argon/CO_2 of 70:30 and 90:10-volume ratio. Tests were conducted using cosmic rays trigger, a ^{106}Ru-Rh β-source and a ^{55}Fe X-rays source. A plateau in the efficiency around 95% has been obtained at different operating voltages for the two Ar/CO_2 gas mixtures. The energy resolution of the detector was measured to be around 20% for FWHM around the plateau region. A time resolution of 10 ns has been achieved with the Ar/CO_2 70:30 gas mixture.

Uniformity in gain and energy resolution of the detector have been studied by dividing the detector in 7x7 zones and observing the response to a ^{55}Fe source for each zone separately. The RMS variations of gain and energy resolution are 8.8% and 6.7%, respectively over the entire area. These gain fluctuations can be used in simulations in order to quantify the overall detector response in experiments.

R&D on straw-tube detector for CBM experiment: (*in collaboration with Ms. S. Roy, Mr. R. P. Adak, Dr. S. Biswas, Prof. S. K. Ghosh, Dr. S. K. Prasad, Prof. S. Raha, N. Nandi (University of Calcutta).*

Straw tubes are one of the strong candidates for the 3rd and 4th stations of the CBM Muon Chamber (MUCH). Basic R&D have been carried out with one small straw tube detector prototype with premixed gas of Ar + CO_2 in 70:30 and 90:10 ratio using conventional NIM electronics. The variation of gain and energy resolution with rate per unit length is measured.

The count rate for Fe^{55} X-ray source is measured as a function of the applied HV. It is seen that a plateau is obtained from about 1600 V onwards. In the particular study the energy spectrum for the Fe^{55} X-rays is obtained. The absolute gain and energy resolution are measured by obtaining the mean position of 5.9

4. Sarkar C, Chatterjee A, Majumdar D, Roy A, Srivastava A, Ghosh S K, & Raha S (2017) How the Atmosphere over Eastern Himalaya, India is Polluted with Carbonyl Compounds? Temporal Variability and Identification of Sources. *Aerosol and Air Quality Research*, *17*(9), 2206-2223.
5. Sen A, Abdelmaksoud A S, Ahammed Y N, Banerjee T, Bhat M A, Chatterjee A & Gadi R (2017) Variations in particulate matter over Indo-Gangetic Plains and Indo-Himalayan Range during four field campaigns in winter monsoon and summer monsoon: Role of pollution pathways. *Atmospheric Environment*, *154*, 200-224.

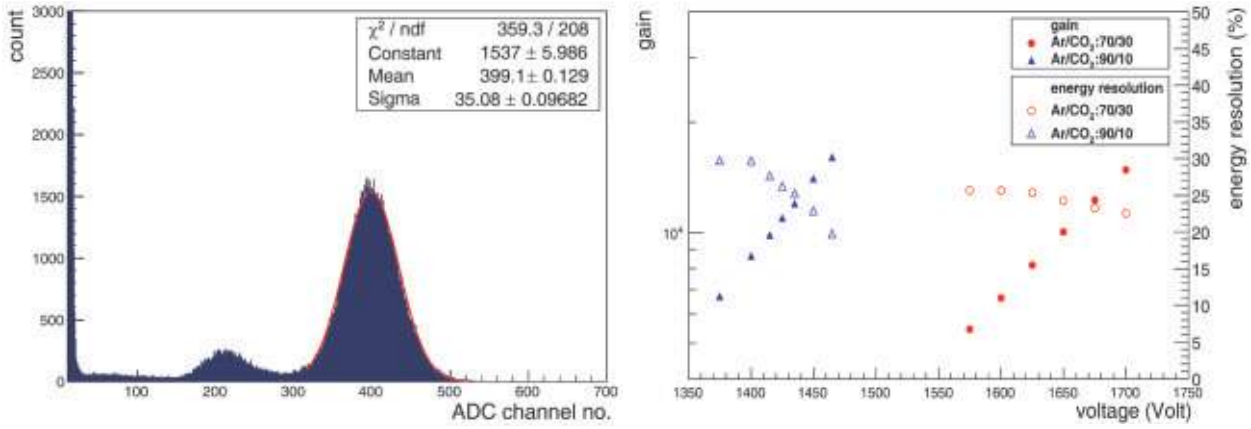
Conference publications:

1. Ghosh A, Chattejee A, Roy A, Ghosh SK, Raha S (2017) Effect of shifting cultivation activity over Eastern Ghat and adjacent areas on air quality over a tropical urban atmosphere in eastern india during pre-monsoon, 2016. *Aerosol Climate Change Connection* (AC3), Darjeeling, 25 – 27 April.
2. Ghosh A, Chattejee A, Roy A, Ghosh SK, Raha S (2017) Effect of downwind transported bio mass burning aerosols over Eastern Ghats and adjacent places on the air quality of a tropical urban atmosphere in eastern India during pre-monsoon 2016. *Understanding, predicting and projecting the climate change over Asian region* (UPCAR), Tirupati, 26-28 June.
3. Ghosh A, Chattejee A, Roy A, Ghosh SK, Raha S (2017) Temporal variability of aerosol size distribution over a high altitude Himalayan station in India International Tropical Mereorology symposium, Ahmadabad, 7-10 November
4. Sarkar C , Chatterjee A, Roy A , Ghosh A, Ghosh SK , Das SK, Raha S (2017) Long-term trend of PM2.5 and black carbon aerosols over eastern Himalaya in India; effect of meteorological parameters and long-range transport. *Aerosol Climate Change Connection* (AC3), Darjeeling, 25 – 27 April.
5. Isotopic evidence of secondary moisture source during the monsoon season in the east-central Himalayan region. Monsoon Workshop, Feb 23-24, 2016, *Indian Meteorological Society*, IITM, Pune.
6. Interactions Between Sea-Salt and Anthropogenic Aerosols over a Tropical Urban and High Altitude Himalayan Atmosphere in India. *Asia Oceania Geosciences Society*, 3-8 June, 2018.
7. Aerosol-Rain Interaction and its Impact on the Rainwater Acidity over Eastern Himalaya in India. *Asia Oceania Geosciences Society*, 3-8 June, 2018.
8. Effect of Aerosol on Fair Weather Electric Field at a High Altitude Station in Eastern Himalayas. *Asia Oceania Geosciences Society*, 3-8 June, 2018.
9. A New Approach to Analysis of Rain-Drop Size Distribution over Hill-Top Region in the Himalayas. Asia Oceania Geosciences Society, 3-8 June, 2018

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

Understanding, Predicting and Projecting Climate Change over Asian Region (UPCAR)" at Tirupati

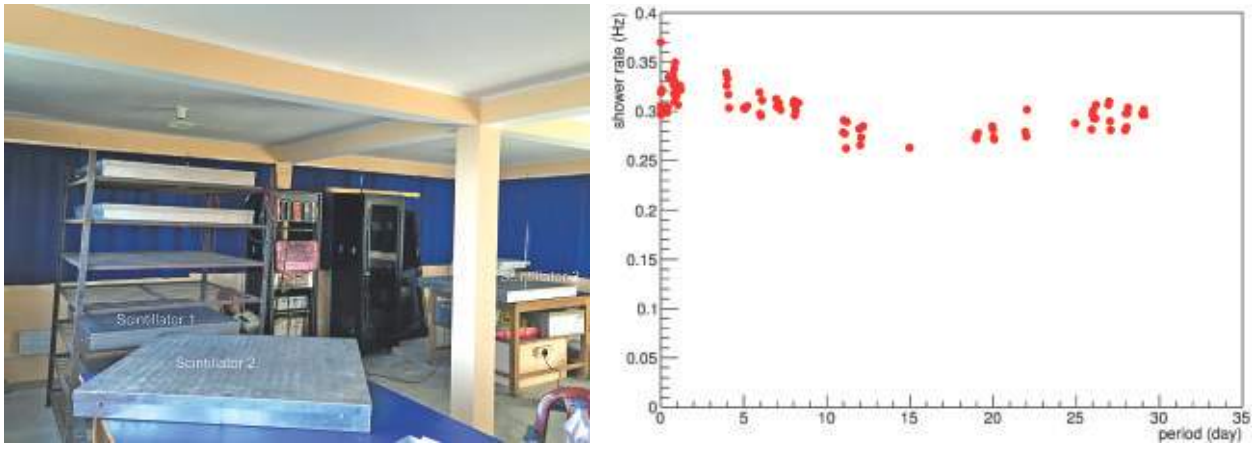
keV peak with Gaussian fitting, increasing the biasing voltage of the straw tube detector. It is observed that the gain increases exponentially whereas the energy resolution value decreases with the voltage. Possibility to use the straw tube detector in CBM MUCH is under investigation.



(Left) Energy spectrum for the Fe^{55} X-rays. The red line is the Gaussian fitting curve to the 5.9 keV peak. (Right) The Gain and the energy resolution as a function of the voltage for both Ar/CO_2 70/30 and 90/10 mixtures. The error bars are smaller than the symbols.

A cosmic ray air shower array at Darjeeling: *(in collaboration with Dr. S. Biswas, Prof. S. K. Ghosh, Mr. D. Nag, Prof. S. Raha, Ms. S. Roy, S. Chatterjee, P. Chawla, S. Chakraborty, R. P. Adak, A. Maulik, S. Singh, S. Shaw (Vidyasagar University), N. Nandi (University of Calcutta).*

Fabrication and characterization of the plastic scintillator detectors have been carried out for the proposed cosmic ray air shower array under the IRHPA project at Darjeeling. An array of plastic scintillator detectors has been commissioned for detection of cosmic ray showers at an altitude of about 2200 meters above sea level in the Himalayas at the Centre for Astroparticle Physics & Space Sciences, Darjeeling campus of Bose Institute. During the first phase seven of these modules arranged in a hexagonal way keeping one at the centre of the hexagon will be commissioned. Each element of this array is a 1 m × 1 m plastic scintillator detector of thickness 2 cm, coupled with WLS fibers and a PMT.



(Left) Cosmic ray air shower detector on a horizontal plane. (Right) Shower rate vs. time during mid November – mid December, 2016.

Before setting up the array as a proof of principle three of these detectors are used to detect cosmic ray air shower. The three-fold coincidence from three detectors placed on a horizontal plane is measured for about 1 month period. This mimics a cosmic ray air shower. It is found that the shower rate varies with time between 0.25–0.35 Hz.

After completion of phase I of this project, the objective will be to set up the complete mini-array of 64 such scintillator detectors coupled with WLS fiber and PMT, at Darjeeling campus, Bose Institute.

At Kolkata, a new and simple technique has been developed using plastic scintillator detectors for the study of angular variation of cosmic ray intensity near the sea level. A systematic study of the characteristics of the plastic scintillator paddle detector has been carried out. The yield uniformity of the detector has also been studied.

Design and Development of Common Readout Unit (CRU) for the ALICE experiment: *(in collaboration with Sanjoy Mukherjee)*

The Common Readout Unit (CRU) is a FPGA based PCIe40 cards to be used with all detectors after the upgrade of the ALICE experiment during the upcoming Long Shutdown period. This is a crucial and central equipment for the entire ALICE experiment being designed in developed in India in collaboration with CERN. The design of the card is at final stage and the mass production of the same will take place during the current year.

SCIENTIFIC REPORT

Publication(s)

Refereed journals

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

(1) S. Acharya et al. (ALICE Collaboration) (2018) Pi-0 and eta-meson production in proton- proton collisions at $\sqrt{s}$ = 8 TeV. Eur. Phys. J. C: 78: 263.

(2) S. Acharya et al. (ALICE Collaboration) (2018) Measurement of Z 0 -boson production at large rapidities in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Phys. Lett. B: 780: 372–383.

(3) S. Acharya et al. (ALICE Collaboration) (2018) D-meson azimuthal anisotropy in mid- central Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Phys. Rev. Lett.: 120: 102301.

(4) S. Acharya et al. (ALICE Collaboration) (2018) Search for collectivity with azimuthal J/ψ-hadron correlations in high multiplicity p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 and 8.16 TeV. Phys. Lett. B: 780: 7-20.

(5) S. Acharya et al. (ALICE Collaboration) (2018) Production of deuterons, tritons, 3 He nuclei and their anti-nuclei in pp collisions at $\sqrt{s}$ = 0.9, 2.76 and 7 TeV. Phys. Rev. C: 97: 024615.

(6) S. Acharya et al. (ALICE Collaboration) (2018) Systematic studies of correlations between different order flow harmonics in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Rev. C: 97: 024906.

(7) S. Acharya et al. (ALICE Collaboration) (2018) Production of 4 He and 4 He-bar in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV at the LHC. Nucl. Phys. A: 971: 1-20.

(8) S. Acharya et al. (ALICE Collaboration) (2017) Kaon femtoscopy in Pb-Pb collisions at$\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Rev. C: 96: 064613.

(9) S. Acharya et al. (ALICE Collaboration) (2018) Constraining the magnitude of the Chiral Magnetic Effect with Event Shape Engineering in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Lett. B: 777: 151-162.

(10) S. Acharya et al. (ALICE Collaboration) (2017) J/ψ elliptic flow in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Phys. Rev. Lett.: 119: 242301.

(11) S. Acharya et al. (ALICE Collaboration) (2017) Charged-particle multiplicity distributions over a wide pseudorapidity range in proton-proton collisions at $\sqrt{s}$ = 0.9, 7 and 8 TeV. Eur. Phys. J. C: 77: 852.

(12) S. Acharya et al. (ALICE Collaboration) (2018) The ALICE Transition Radiation Detector: construction, operation, and performance. Nucl. Instr. Meth. A: 881: 88.

(13) S. Acharya et al. (ALICE Collaboration) (2018) First measurement of jet mass in Pb-Pb and p-Pb collisions at the LHC. Phys. Lett. B: 776: 249.

(14) S. Acharya et al. (ALICE Collaboration) (2018) J/ψ production as a function of charged- particle pseudorapidity density in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Phys. Lett. B: 776: 91.

(15) S. Acharya et al. (ALICE Collaboration) (2017) Measurement of deuteron spectra and elliptic flow in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV at the LHC. Eur. Phys. J. C: 77: 658.

(16) S. Acharya et al. (ALICE Collaboration) (2017) Searches for transverse momentum dependent flow vector fluctuations in Pb-Pb and p-Pb collisions at the LHC. JHEP: 09: 032.

(17) S. Acharya et al. (ALICE Collaboration) (2017) Measuring K S 0 K ± interactions using Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Lett. B: 774: 64.

(18) J. Adam et al. (ALICE Collaboration) (2017) Anomalous broadening of the near-side jet peak in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Rev. Lett.: 119: 102301.

(19) J. Adam et al. (ALICE Collaboration) (2017) Evolution of the longitudinal and azimuthal structure of the near-side jet peak in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Rev. C: 96: 034904.

(20) J. Adam et al. (ALICE Collaboration) (2017) Insight into particle production mechanisms via angular correlations of identified particles in pp collisions at $\sqrt{s}$ = 7 TeV. Eur. Phys. J. C: 77: 569.

(21) J. Adam et al. (ALICE Collaboration) (2017) Measurement of D-meson production at mid-rapidity in pp collisions at $\sqrt{s}$ = 7 TeV. Eur. Phys. J. C: 77: 550.

(22) J. Adam et al. (ALICE Collaboration) (2017) Linear and non-linear flow modes in Pb- Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys.Lett. B: 773: 68.

(23) J. Adam et al. (ALICE Collaboration) (2017) Measurement of electrons from beauty-hadron decays in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV and Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. JHEP: 07: 052.

(24) J. Adam et al. (ALICE Collaboration) (2017) Centrality dependence of the pseudorapidity density distribution for charged particles i9n Pb-Pb collisions at $\sqrt{(s_{NN})}$ = 5.02 TeV. Phys.Lett. B: 772: 567-577.

(25) J. Adam et al. (ALICE Collaboration) (2017) Production of muons from heavy-flavour hadron decays in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Phys. Lett. B: 770: 459-472.

(26) J. Adam et al. (ALICE Collaboration) (2017) Energy dependence of forward-rapidity J/ψ and ψ(2S) production in pp collisions at the LHC. Eur. Phys. J. C: 77: 392.

(27) J. Adam et al. (ALICE Collaboration) (2017) Production of (1385) ± and (1530)0 in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Eur. Phys. J. C: 77: 389.

(28) J. Adam et al. (ALICE Collaboration) (2017) K ∗ (892)0 and φ(1020) meson production at high transverse momentum in pp and Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Rev. C: 95: 064606

(29) J. Adam et al. (ALICE Collaboration) (2017) Azimuthally differential pion femtoscopy in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Rev. Lett.: 118: 222301.

(30) J. Adam et al. (ALICE Collaboration) (2017) Measurement of the production of high-pT electrons from heavy-flavour hadron decays in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Lett. B: 771: 467-481.

(31) J. Adam et al. (ALICE Collaboration) (2017) Production of π 0 and η mesons up to high transverse momentum in pp collisions at 2.76 TeV. Eur. Phys. J. C: 77: 339.

(32) J. Adam et al. (ALICE Collaboration) (2017) Enhanced production of multi-strange hadrons in high-multiplicity proton-proton collisions. Nature Physics: 13: 535-539.

(33) J. Adam et al. (ALICE Collaboration) (2017) Flow dominance and factorization of transverse momentum correlations in Pb-Pb collisions at the LHC. PRL: 118: 162302.

(34 J. Adam et al. (ALICE Collaboration) (2017) Measurement of azimuthal correlations of D-mesons and charged particles in pp collisions at $\sqrt{s}$ = 7 TeV and p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Eur. Phys. J. C: 77: 245.

(35) Sahu S, Nag D, Rudra S, Swain S, Biswas S, Das S and Sahu PK (2017) Design and fabrication of data logger to measure the ambient parameters in gas detector R&D. *JINST* 12 C05006 doi:10.1088/1748-0221/12/05/C05006. Impact Factor: 1.2

(36) Biswas S, Das S, Ghosh SK, Nag D and Raha S (2017) Development of scintillator detector for detection of cosmic ray shower. *JINST* 12 C06026 doi:10.1088/1748-0221/12/06/C06026. Impact Factor: 1.2

Students Awarded Ph.D.:

Name of Students (University/ Year)	Titles of Thesis
Subhasis Samanta (C.U., 2017) (Jointly with Dr. Sanjay K. Ghosh)	Fluctuation-Correlation and Dimuon production in high energy heavy ion collision experiments

Grants-in-Aid Schemes

Title of schemes	Name of the funding agency
(As Co-PI) A Large Ion Collider Experiment (ALICE) Upgrade, Operation and Utilization (SR/MF/PS-01/2014-BI)	DAE-DST

Dr. Dhruba Gupta

Associate Professor

Scientific Reports

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

At present, the cosmological ^{7}Li problem is one of the important unresolved problems in nuclear astrophysics. The nuclear reactions that destroy ^{7}Be are thought to play a role in the observed anomaly in ^{7}Li. Accurate measurements of such nuclear reactions are required before one can invoke solutions beyond nuclear physics, particularly in the context of the newly conjectured light electrically neutral particles X that may have substantial interactions with nucleons. We continued our preparation for the experiment at HIE-ISOLDE, CERN, Geneva, Switzerland, to measure the transfer reaction ^{7}Be(d,p)^{8}Be* (IS 554). We decided to use the scattering chamber installed in the third beam line of HIE-ISOLDE. A set of strip detectors backed by pads in a diamond geometry, covering a large angular range, would be used in the scattering chamber. We are doing the Monte Carlo simulations for the experiment using NPTool, a framework based on Geant4 and ROOT for simulation and analysis of nuclear physics experiments. Using the code FRESCO, the DWBA calculations for the reaction ^{7}Be(d,p)^{8}Be* have also been carried out.

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

The production and destruction channels of ^{7}Be are both important in the study of the cosmological lithium problem. The ^{7}Beproduction channel goes through the radiative capture reaction ^{3}He + ^{4}He $\rightarrow$ ^{7}Be + γ. Since breakup reactions play a prominent role in loosely bound nuclei, the above

reaction can be studied by measuring the time reversed Coulomb breakup reaction of ^{7}Be, preferably in the presence of heavy targets. This would enable measurements at low relative breakup energies (astrophysical energies) between the fragments, thereby extracting information about the required radiative capture reaction. Breakup reaction calculations in the framework of prior-form DWBA are being continued in view of a planned experiment at a rare isotope facility.

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

The data analysis of the n-p pairing experiment (e644) was continued. The experiment was carried out at the rare isotope facility GANIL, Caen, France. The aim of the work is to study two nucleon n-p transfer reactions on two nuclei, ^{48}Cr and ^{56}Ni. The doubly magic nucleus ^{56}Ni is expected to show no pairing effects. The (p,^{3}He) and (d,α) reactions on these nuclei was carried out to investigate the competition between T = 1 and T = 0 pairing and probe n-p pairing. We are collaborating in this work with IPN, Orsay, France and doing a part of the data analysis at Bose Institute in the NPTool framework. The calibration of the double sided strip and CsI detectors of MUST2 using α-source runs have been completed.

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

We adopted the theoretical procedure of supersymmetric quantum mechanics to generate the resonance state wave functions of the unbound nucleus ^{15}Be. Theoretically, it is very difficult to tackle the unbound states by conventional methods. In the present work, we used a density dependent M3Y microscopic potential and generated a potential which is strictly isospectral with it although the two have widely different shapes. We could reproduce the energy and width of the 1.8 MeV ($5/2^{+}$) resonance state and did not find any other nearby resonances for ^{15}Be. It becomes apparent that the present framework is a powerful tool to theoretically complement the increasingly important accelerator based experiments with unbound nuclei.

Publications:

1. Dutta S K, Gupta D, Saha S K (2018) Resonance State Wave Functions of ^{15}Be using Supersymmetric Quantum Mechanics, *Phys. Lett. B* 776, 464

Symposium publication

1. Gupta D, Saha SK (2017) Nuclear reactions with ^{7}Be to study the cosmological lithium problem, *XXth Colloque GANIL 2017*
2. Saha SK, Gupta D (2017) Coulomb dissociation of ^{9}Li, *Xxth Colloque GANIL 2017*

Grants-in-Aid Schemes:

Title of the scheme	Scheme funded by
Astrophysical S-factor from nuclear reactions with a rare isotope beam of ^{7}Be (*With Prof. Swapan K Saha as Co-Investigator*)	ISRO

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

i) Attended the workshop XXth Colloque GANIL at Amboise, France during October 15 - 20, 2017 and presented a poster titled "Nuclear reactions with ^{7}Be to study the cosmological lithium problem".

ii) Visited and carried out collaborative research at the Institut de Physique Nucleaire, Orsay, France, October 3 - 8, 2017 for experiment e644 at GANIL; at CERN, Geneva, Switzerland, October 8 - 14, 2017 for upcoming experiment IS554 at HIE-ISOLDE, CERN.

Group Members:

Dr. Mandira Sinha (RA, Physics) visited Texas A&M University, USA to participate in an experiment involving exotic nuclei and attended the 50 yrs of Beam symposium during November 7-22, 2017 and presented a poster titled "The effect of breakup on elastic and fusion reactions involving loosely bound nuclei".

Dr. Sanat Kumar Das

Environmental Sciences Section

Scientific Reports

1. A New Approach to Analysis of Rain-drop Size Distribution over Hill-top Region in the Himalayas : in collaboration with Dr. A. Chatterjee, Prof. S. K. Ghosh and Prof. S. Raha

The Himalayas play an important role in the Asian monsoonal circulation and thereby, measurement of rain drop size distribution (DSD) which carries information of cloud microphysical characteristics is needed for prediction of Himalayan precipitation and addressing future of drinking water. The present study represents a long-term statistical analysis of DSD obtained from four years' of measurements during 2013-2016 using ground-based disdrometer installed at the highest location within the campus of Bose Institute at Darjeeling (27.01N, 88.25E, 2000 m above sea level) in the Eastern Himalayas. Data at every minute have gone through a quality control method to remove the unrealistic rain-drops following a new method of least square fitting using velocity-diameter relation which includes higher bigger and faster raindrops that are usually neglected in conventional methods. Normalized gamma distribution is fitted in using moment method and DSD parameters have been retrieved in every minute. The derived DSD parameters have been classified into three different seasons according to the monsoonal pattern as south-western 'Maritime Rain'(MR), north-eastern 'Continental Rain' (CR), and winter-time 'Topographical Rain' (TR). MR drops are bigger in size and higher in numbers than those in CR while TR drops are finer in size and lower in number. This variation is because TR is local rain within the valley region, MR is monsoonal rain coming from Bay of Bengal and CR is mainly associated with continental storms. The present study finds that liquid water content is maximum

($0.5 g.m^{-3}$) with 0.85 mm mean diameter (D_m) in convective rains but for short duration while it is $0.1 g.m^{-3}$ with Dm of about 0.7 mm in transition rains for long duration, and is minimum ($0.03 g.m^{-3}$) for wide range of rain drop size (0.4-0.7mm) in stratiform rains for longer duration. We conclude that transition and stratiform rains are useful sources of water over the Himalayas.

2. **Albedo over inhomogeneous surface of Antarctica: Field measurements using ground and Helicopter-based instruments : a**long with Dr. A. Chatterjee, Prof. S. K. Ghosh and Prof. S. Raha and in collaboration with Dr. M. V. Ramana, National Remote Sensing Centre, Hyderabad

An experiment for the measurements of solar radiation intensities using Pyranometer at different altitudes over Eastern Antarctica were carried out leading by Bose Institute scientist, Dr. Sanat Kumar Das. Such experiment is novel and unique for the first time of its own kind over Antarctica during 36th Indian Scientific Expedition to Antarctica. Pyranometer for this on-board helicaptor experiment had been borrowed from Dr. M. V. Ramana, National Remote Sensing Agency, Hyderabad. An initial results from ground and helicopter based measurements were made in Jan-Mar 2017 at Indian Antarctic Stations, Bharati and Maitri during the 36th Indian Scientific Expedition to Antarctica. Helicopter equipped with pyranometers made upward and downward irradiance measurements between 0.3-2.8μm. The Helicopter was flown for a total of 600 km over 6 hours on 3 different days over different underlying surfaces of Antarctica. Airborne albedo measurements have not, to the best of our knowledge, previously been carried out successfully over Antarctica. Concurrent with the flights, continuous ground based measurements with identical instrument were also carried out over a variety of Antarctica terrain (namely, snow, snow-melt and land under cloudy and non-cloudy conditions). Albedo was calculated as ratio between 5-minute averaged values of incoming and reflected radiation measurements by two pyranometers. The data integrity has been validated using standard calibration routines in conjunction with radiative transfer computations. The pyranometers performed well during straight and level portions of the flight as the pilot maintained a level platform (pitch and roll within

LHS figure shows the observer from Bose Institute, Dr. Sanat Kumar Das indicating first time the novel and unique set up of the experiment using a helicopter for in-situ measurement of intensities of solar radiation at different altitudes over Eastern Antarctica. RHS figure shows the image zooming over the Pyronometer installed in front of the helicaptor .

a degree). Analysis of the data showed variability of albedo from 0.16 over land surface to 0.65 over sea ice surface over Antarctica. In general, albedo increased with solar zenith irrespective of Antarctic terrain. Airborne albedos over Antarctica terrain showed slightly higher values at 3.0 km altitudes compared to lower altitudes (1.0km), as airborne radiometer measures irradiances that are greatly smoothed when compared to the point measurements at lower altitudes which are limited in their viewing angle. These measurements allowed detailed characterization of albedo over a wide range of Antarctica surface types, which are being used to validate satellite estimates and also to characterize conditions that satellite estimates do not sufficiently capture.

3. **Round-the-clock measurements of aerosol loading over Antarctica during January-February 2017 :** along with Dr. A. Chatterjee, Prof. S. K. Ghosh and Prof. S. Raha and in Collaboration with Dr. A. Taori, Regional Remote Sensing Center, Nagpur

A unique experiment had been carried out for round-the-clock measurement of aerosol loading into the atmosphere over Bharati (69.4 S, 76.18 E) which is one of Indian Scientific Stations over Eastern Antarctica. Antarctica provides an opportunity to study the natural forcing and the background values of various atmospheric constituents, in particular, the aerosols. Bose Institute atmospheric team leading by Dr. Sanat Kumar Das efforts to understand the impact of manmade activities and climate change are continued with more measurements made at Bharati. During the 36th Indian Scientific Expedition to Antarctica (36th ISEA), continuous sunphotmeter measurements using Microtops were carried out during day time to obtain Aerosol Optical Depth (AOD). AOD was also calculated using a Dual Imager System (DIS) installed at Bharati to study the round-the-clock variation of AOD (AOD_{DIS}). AOD_{DIS} values have been calculated using image processing method from the images taken at every minutes by DIS and compared with ground-based sunphotometer measurements (AOD_{Ground}) and AOD retrieved from space-borne lidar on-board CALIPSO satellite (AOD_{Space}). A comparative study shows that AOD_{DIS} is found to be fairly matched with AOD_{Ground} and AOD_{Space}. The data reveal a weak diurnal pattern in the AOD variability. Our day-night measurements obtaining AOD using multi-sensors from ground as well as space reveal that AOD values vary from 0.07 to 0.1 during daytime while during nighttime they reach a value of ~0.12. Our findings reported higher aerosol loading over Bharati than that of previous measurements which helps us to conclude that aerosol loading over Eastern Antarctica is in growing stage, demanding for more daily observations.

Handheld sunphotometer (Microtops) measurements running on a clear sky day near Bharati station over Antarctica during 36th ISEA.

Publication (s):

1. Taori A, **Das Sanat Kumar**, Goenka R, Gharai B, Rao P V N, Seshasai M V R., Thakur J (2018) 'Round-the-clock measurements of aerosol optical thickness over Antarctica made using a Dual Imager System during January-February 2017', Remote Sensing Letters, Volume 9 Issue 11, https://doi.org/10.1080/2150704X.2018.1508909

Papers in Conferences:

1. **Das Sanat Kumar**, Singh S, Chatterjee A, Singh Ajay K, Mitra A, Ghosh S K, Raha S (2018) A New Approach to Analysis of Rain-drop Size Distribution over Hill-top Region in the Himalayas,15th Annual Meeting Asia Oceania Geosciences Society, 3-8 June 2018, Honolulu, Hawaii.
2. Bhattacharyya T, Chatterjee A, **Das Sanat Kumar**, Ghosh S K, Raha S, Roy A, Singh S (2018) 'Fair weather electric field at Darjeeling: a high altitude station in Eastern Himalayas', 15th Annual Meeting Asia Oceania Geosciences Society, 3-8 June 2018, Honolulu, Hawaii.
3. Ghosh A, Chatterjee A, Roy A, **Das Sanat Kumar**, Ghosh S K, Raha S (2018) 'Interactions between Sea-salt and Anthropogenic Aerosols over a Tropical Urban and High Altitude Himalayan Atmosphere in India', 15th Annual Meeting Asia Oceania Geosciences Society, 3-8 June 2018, Honolulu, Hawaii.
4. Chatterjee A, Roy a, **Das Sanat Kumar**, Singh S, Ghosh A, Singh A K, Mitra A, Ghosh S K, Raha S (2018) 'Aerosol-Rain Interaction and Its Impact on the Rainwater Acidity over Eastern Himalaya in India', 15th Annual Meeting Asia Oceania Geosciences Society, 3-8 June 2018, Honolulu, Hawaii.
5. Ghosh A, Chatterjee A, Roy A, Sarkar C, Ghosh S. K., **Das Sanat Kumar**, Raha S (2017) " Effect of Shifting Cultivation Activity over Eastern Ghat and Adjacent Areas on Air Quality over a Tropical Urban Atmosphere in Eastern India During Premonsoon, 2016", Aerosol Climate Change Connection (AC3), Darjeeling, 25-27 April, 2017.
6. **Das Sanat Kumar**, Chatterjee A, Ghosh S K, Raha S (2017) 'Study on radiative effects of continental haze over Sundarban out-flowing from Indo-Gangetic Basin to Bay of Bengal'Understanding, predicting and projecting the climate change over Asian region (UPCAR), Tirupati, 26-28 June, 2017

Other Contributions

1. Co-Convener of the session IG09 (Interdisciplinary Sciences section), titled 'Big data, point cloud, and geospatial analytics in geosciences' in 15th Annual Meeting Asia Oceania Geosciences Society
2. Delivered a talk in 'Understanding, predicting and projecting the climate change over Asian region (UPCAR)', Tirupati on 'Study on radiative effects of continental haze over Sundarban out-flowing from Indo-Gangetic Basin to Bay of Bengal'
3. Joint-Convenerin "Aerosol Climate Change Connection (AC3)", Bose Institute, Darjeeling
4. Leading the Ocean-Atmosphere coupling study of Bose Instituteby conducting aerosol measurements on-board 'Sagar Manjusha' research vessel over Bay of Bengal during 27 Jun-14 Jul 2018.

Dr. Dipankar Home

Professor and Coordinator

Scientific Reports

The Quantum Cheshire Cat (QCC) is an effect introduced recently within the Weak Measurements framework. The main feature of the QCC effect is that a property of a quantum particle appears to be spatially separated from its position. The status of this effect has however remained unclear, as claims of experimental observation of the QCC have been disputed by strong criticism of the experimental as well as the theoretical aspects of the effect. In our work it is clarified in what precise sense the QCC can be regarded as an unambiguous consequence of the standard quantum mechanical formalism applied to describe quantum pointers weakly coupled to a system. In light of this clarification, the raised criticisms of the QCC effect are rebutted. We further point out that the limitations of the experiments performed to date imply that a loophole-free experimental demonstration of the QCC has not yet been achieved.

Distinct from the type of local realist inequality (known as the Collins–Gisin–Linden–Massar–Popescu or CGLMP inequality) usually used for bipartite qutrit systems, we formulate a new set of local realist inequalities for bipartite qutrits by generalizing Wigner's argument that was originally formulated for the bipartite qubit singlet state. This treatment assumes existence of the overall joint probability distributions in the underlying stochastic hidden variable space for the measurement outcomes pertaining to the relevant trichotomic observables, satisfying the locality condition and yielding the measurable marginal probabilities. Such generalized Wigner inequalities (GWI) do not reduce to Bell–CHSH type inequalities by clubbing any two outcomes, and are violated by quantum mechanics (QM) for both the bipartite qutrit isotropic and singlet states using trichotomic observables defined by six-port beam splitter as well as by the spin-1component observables.

Publication(s):

1. Das D, Mal S and D. Home (2018) *Testing local-realism and macro-realism under generalized dichotomic measurements*; *Physics Letters A* 382, 1085
2. Das D, Datta S, Goswami S, Majumdar AS and Home D(2017) *Bipartite qutrit local realist inequalities and the robustness of their quantum mechanical violation*; *Physics Letters A* 381, 3396.
3. Duprey Q, Kanjilal S, Sinha U, Home D and Matzkin A (2018) *The Quantum Cheshire Cat effect: Theoretical basis and observational implications*; *Annals of Physics* 391, 1.
4. Sasmal S, Pramanik T , Home D and Majumdar A S (2018) *A tighter steering criterion using the Robertson-Schrödinger uncertainty relation*; *Physics Letters A* 382, 27.
5. Shenoy H A, Aravinda S , Srikanth R and Home D (2017) *Can the use of the Leggett-Garg inequality enhance security of the BB84 protocol?*; *Physics Letters A* 381, 2478.

Grants-in-Aid Schemes:

Sl. No.	Title of the Project	Project funded by
1.	(*With Prof. Archan S. Majumdar of SNBNCBS, Kolkata as PI*) Fundamental aspects of quantum theory and quantum information: a multidisciplinary approach	DST
2.	(*With Prof. Alexandre Matzkin of Université de Cergy-Pontoise, France as PI, and Prof. Urbasi Sinha of Raman Research Institute, Bangalore as another Co-investigator*) Unveiling the nature of quantum reality: a theoretical and experimental approach employing non-destructive weak measurements	John Templeton Foundation

Dr. Parthasarathi Joarder

Associate Professor

Scientific Reports

Publications:

1. Biswas S, Bhattacharjee P, Majumdar P, Das S, Das M and Joarder P S (2017) Constraints on dark matter models from the observation of Triangulum-II with the *Fermi* Large Area Telescope, , *J. Cosm. Astropart. Phys.* 11, 003
2. Raychaudhuri S, Ghosh S and Joarder PS (2018) Spherical accretion in giant elliptical galaxies: multi-transonicity, shocks, and implications on AGN feedback**,** *Mon. Not. Roy. Astron. Soc.* (2018) Online version at: *https://academic.oup/advances-article-abstract/doi/10.1093/mnras/sty1554/5037947.*
3. Analysis of Fermi-LAT data from Tucana-II: Possible constraints on the Dark Matter models, Pooja Bhattacharjee, Sayan Biswas, Pratik Majumdar and Partha S. Joarder, *(Under the process of Revision in J. Cosm. Astropart. Phys.)* (2018), *arXiv:1800.07542v1* [astro-ph.HE] 20th Apr 2018.

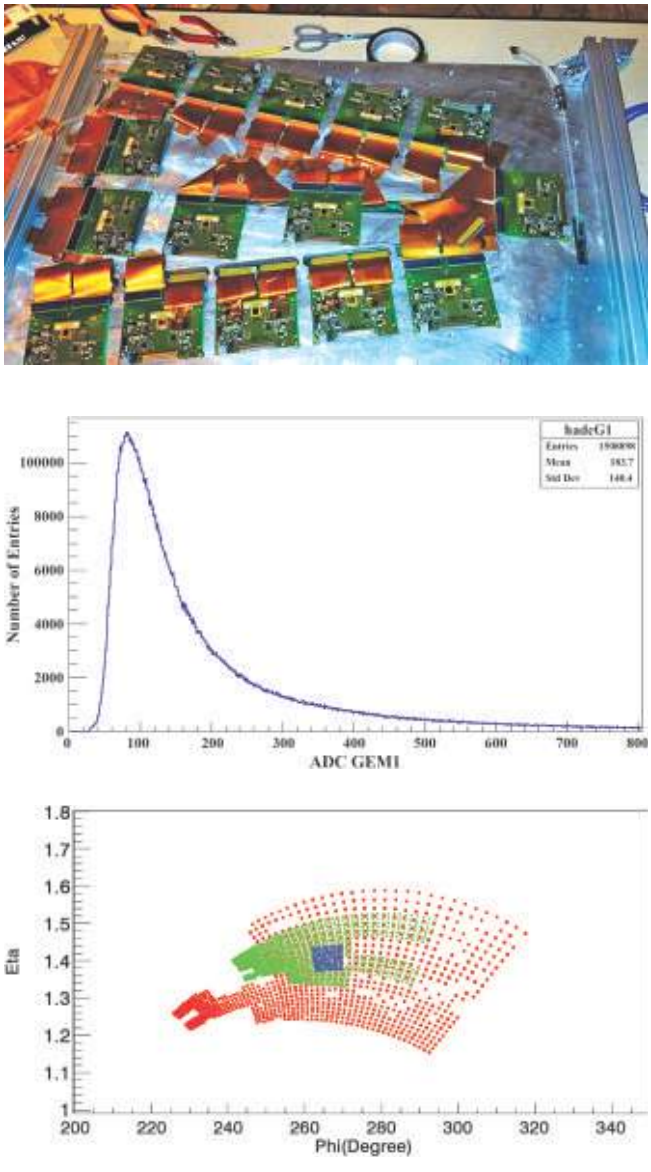
Dr. Sidharth Kumar Prasad

Assistant Professor

Scientific Reports

Study of jet production in proton-proton collisions with ALICE at LHC: *in collaboration with Rathijit Biswas, Dr. Supriya Das, Prof. Sanjay K. Ghosh, Prof. S. Raha ALICE Collaboration*

We are studying jet production cross sections and properties in proton-proton collisions at 2.76 TeV with ALICE at LHC. Jets are collimated showers of hadrons produced by fragmentation of large momentum partons in early stages of the collision. This study will provide a testing ground for the associated theory (perturbative quantum chromodynamics, pQCD) of jet production. In addition these measurements will form a baseline for similar measurements in nucleus-nucleus collisions to make final conclusions about the properties of the QGP medium formed in nucleus-nucleus collisions. The ongoing analysis using jets reconstructed with anti-kT algorithm at mid- rapidity is further extended to various jet resolution parameters (R = 0.2, 0.4, 0.6) and Monte Carlo (MC) simulations. The correction for the instrumental effects is achieved by performing MC simulations using GEANT3. Preliminary results were already presented and published as conference proceeding (link: https://arxiv.org/abs/1702.07646) for R = 0.4 and the work is ongoing towards the publication.



Figures above show one fully populated real size GEM chamber (left), hit distributions of three GEM chambers in eta-phi phase space (middle) and ADC spectra for one of the GEM chambers (right).

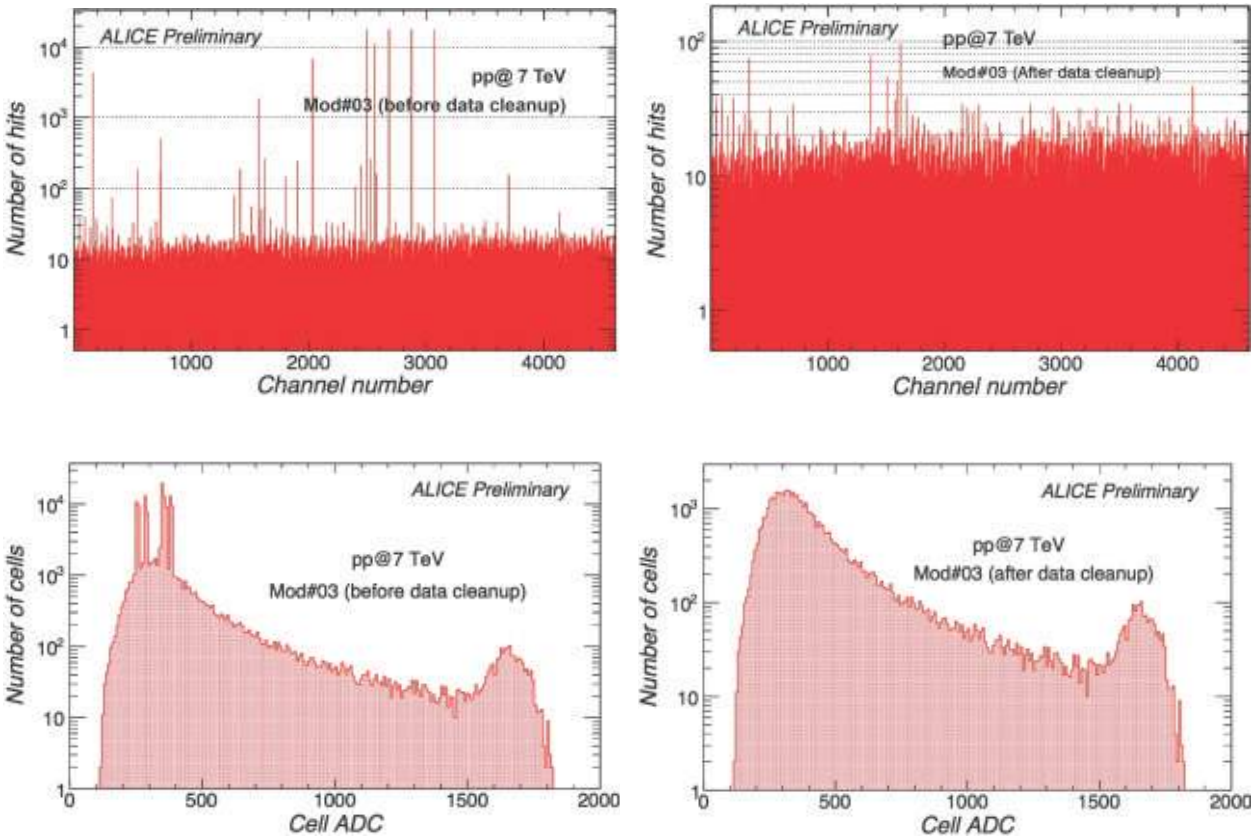
Testing a real size GEM detector for Much-CBM at CERN SPS: ***in collaboration with Dr. Supriya Das, Dr. Saikat Biswas, Prof. Sanjay K. Ghosh, Prof. S. Raha, External Collaborators from VECC Kolkata: Ajit Kumar, A. K. Dubey, J. Saini, V. Singhal, P. P. Bhaduri, E. Nandy, S. Chattopadhyay (CBM Collaboration)***

A trapezoidal shaped, large size, Gas Electron Multiplier (GEM) detectors would be employed

in the CBM experiment at FAIR, for the detection of muons in a very high particle rate environment. We have tested a real-size GEM prototype of MUCH chambers built in India using Pb + Pb collisions at CERN SPS beam facility. Three GEM chambers (two large size and one small size) with almost full module acceptance were populated with realistic self-triggered electronics and were exposed to spray of particles arising out of the collisions of Pb beam with a 1 mm thick Pb target. The effect of absorber in front of the GEM chamber was also studied using a 20 cm thick small iron plate. The analysis of the test beam data including event reconstruction, correlation of hits between three GEM chambers, tracking, and effect of 20 cm thick absorber is being carried out.

PMD – data cleanup and calibration: ***in collaboration with Rathijit Biswas, External Collaboration: Sinjini Chandra, Nachiketa Sarkar (VECC, Kolkata), Prof. Ankhi Roy (IIT, Indore), Manoj Jadhav (IIT, Bombay))***

PMD, a Photon Multiplicity Detector, is installed in ALICE experiment at LHC CERN and collecting data since 2009 for proton-proton, proton-lead, and lead-lead collisions at various centre-of-mass energies. PMD is an Indian contribution to the ALICE experiment. One of the important steps in the process of data analysis for obtaining physics observables is the cleanup and calibration of the data. This step involves identification and removal of noisy channels, estimation of noise level, and normalization of gain variations within the module. We are performing the offline PMD QA, cleanup and calibration for all available data sets.



Figures above show hit frequency (top panels) and ADC (bottom panels) distributions for 4608 cannels of one module before (left panels) and after (right panels) the removal of noisy channels.

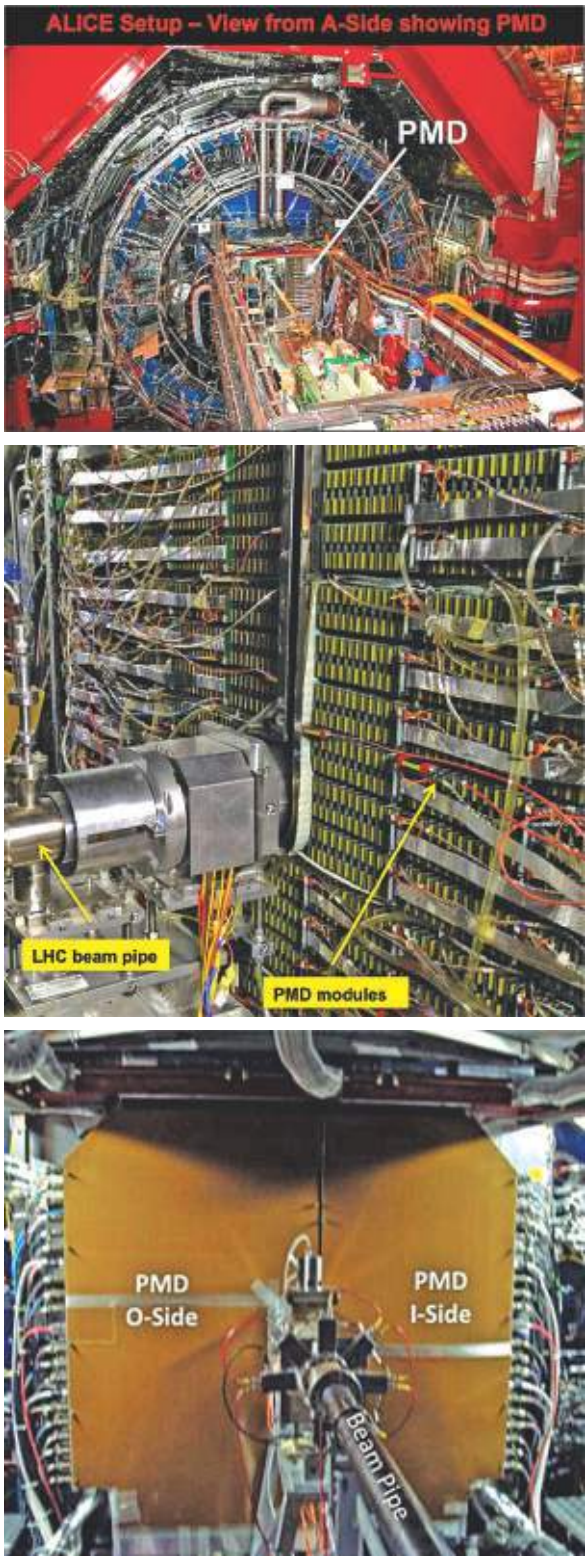
Water based cooling system for the CBM Muon Chamber: (*in collaboration with Dr. Supriya Das, Dr. Saikat Biswas, Prof. Sanjay K. Ghosh, Prof. S. Raha* (External Collaborators from VECC Kolkata: *Dr. Subhasis Chattopadhyay, Dr. Anand K. Dubey, J. Saini*)

We are developing a water based cooling system for the Much detector in the CBM experiment. India is building a GEM based muon detector in the CBM experiment at FAIR. One full size GEM chamber uses 15 Front End Electronic Boards (FEBs) for the readout. The FEBs dissipate around 90 W of heat per chamber, which needs to be taken out. Using a small prototype we tested and verified the proof-of-concept at Bose Institute and then a real size prototype was built and installed in the CERN SPS test beam during November-December 2016 with full heat load. The satisfactory performance of the cooling system in the test beam validated our scheme. The work is ongoing for the actual setup for the real experiment where there will be several such cooling modules to be integrated.

Figures above show a real size cooling plate (left), GEM chamber mounted on one side of the cooling plate (middle) and electronics mounted on other side of the cooling plate (right).

PMD repair and maintenance: (in collaboration with J. Saini, S. Muhuri (VECC Kolkata), Dr. R. Singh (NISER, Bhubaneswar)

The Photon Multiplicity Detector is a fully Indian contribution to the ALICE experiment. PMD is installed in 2009 in the experimental cavern (Point2 of LHC, CERN) for the detection of photons in the forward rapidity and since then collecting data for all LHC runs. We performed a massive repair and maintenance work for PMD during 2017 LHC shutdown at CERN. The goals of recovering all modules (which went bad due to long operations) in terms of high voltage, low



Figures above show PMD position in ALICE (left), PMD modules (middle) and fully commissioned PMD (right) in the ALICE cavern (Point2) at Large Hadron Collider, CERN.

voltage, readout electronics and data acquisition were successfully achieved and PMD is participating in the next LHC runs with full coverage.

Publication(s)

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) S. Acharya et al. (ALICE Collaboration) (2018) Pi-0 and eta-meson production in proton-proton collisions at sqrt(s) = 8 TeV. Eur. Phys. J. C: 78: 263.

(2) S. Acharya et al. (ALICE Collaboration) (2018) Measurement of Z^0-boson production at large rapidities in Pb-Pb collisions at sqrt(s_NN) = 5.02 TeV. Phys. Lett. B: 780: 372–383.

(3) S. Acharya et al. (ALICE Collaboration) (2018) D-meson azimuthal anisotropy in mid-central Pb-Pb collisions at sqrt(s_NN) = 5.02 TeV. Phys. Rev. Lett.: 120: 102301.

(4) S. Acharya et al. (ALICE Collaboration) (2018) Search for collectivity with azimuthal J/ψ-hadron correlations in high multiplicity p-Pb collisions at sqrt(s_NN) = 5.02 and 8.16 TeV. Phys. Lett. B: 780: 7-20.

(5) S. Acharya et al. (ALICE Collaboration) (2018) Production of deuterons, tritons, ^{3}He nuclei and their anti-nuclei in pp collisions at sqrt(s) = 0.9, 2.76 and 7 TeV. Phys. Rev. C: 97: 024615.

(6) S. Acharya et al. (ALICE Collaboration) (2018) Systematic studies of correlations between different order flow harmonics in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. Phys. Rev. C: 97: 024906.

(7) S. Acharya et al. (ALICE Collaboration) (2018)

Production of ^{4}He and ^{4}He-bar in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV at the LHC. Nucl. Phys. A: 971: 1-20.

(8) S. Acharya et al. (ALICE Collaboration) (2017) Kaon femtoscopy in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. Phys. Rev. C: 96: 064613.

(9) S. Acharya et al. (ALICE Collaboration) (2018) Constraining the magnitude of the Chiral Magnetic Effect with Event Shape Engineering in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. Phys. Lett. B: 777: 151-162.

(10) S. Acharya et al. (ALICE Collaboration) (2017) J/ψ elliptic flow in Pb-Pb collisions at sqrt(s_NN) = 5.02 TeV. Phys. Rev. Lett.: 119: 242301.

(11) S. Acharya et al. (ALICE Collaboration) (2017) Charged-particle multiplicity distributions over a wide pseudorapidity range in proton-proton collisions at sqrt(s) = 0.9, 7 and 8 TeV. Eur. Phys. J. C: 77: 852.

(12) S. Acharya et al. (ALICE Collaboration) (2018) The ALICE Transition Radiation Detector: construction, operation, and performance. Nucl. Instr. Meth. A: 881: 88.

(13) S. Acharya et al. (ALICE Collaboration) (2018) First measurement of jet mass in Pb-Pb and p-Pb collisions at the LHC. Phys. Lett. B: 776: 249.

(14) S. Acharya et al. (ALICE Collaboration) (2018) J/ψ production as a function of charged-particle pseudorapidity density in p-Pb collisions at sqrt(s_NN) = 5.02 TeV. Phys. Lett. B: 776: 91.

(15) S. Acharya et al. (ALICE Collaboration) (2017) Measurement of deuteron spectra and elliptic flow in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV at the LHC. Eur. Phys. J. C: 77: 658.

(16) S. Acharya et al. (ALICE Collaboration) (2017) Searches for transverse momentum dependent flow vector fluctuations in Pb-Pb and p-Pb collisions at the LHC. JHEP: 09: 032.

(17) S. Acharya et al. (ALICE Collaboration) (2017) Measuring $K_s^0K^{\pm}$ interactions using Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. Phys. Lett. B: 774: 64.

(18) J. Adam et al. (ALICE Collaboration) (2017) Anomalous broadening of the near-side jet peak in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. Phys. Rev. Lett.: 119: 102301.

(19) J. Adam et al. (ALICE Collaboration) (2017) Evolution of the longitudinal and azimuthal structure of the near-side jet peak in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. Phys. Rev. C: 96: 034904.

(20) J. Adam et al. (ALICE Collaboration) (2017) Insight into particle production mechanisms via angular correlations of identified particles in pp collisions at sqrt(s) = 7 TeV. Eur. Phys. J. C: 77: 569.

(21) J. Adam et al. (ALICE Collaboration) (2017) Measurement of D-meson production at mid-rapidity in pp collisions at sqrt(s) = 7 TeV. Eur. Phys. J. C: 77: 550.

(22) J. Adam et al. (ALICE Collaboration) (2017) Linear and non-linear flow modes in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. Phys.Lett. B: 773: 68.

(23) J. Adam et al. (ALICE Collaboration) (2017) Measurement of electrons from beauty-hadron decays in p-Pb collisions at sqrt(s_NN) = 5.02 TeV and Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. JHEP: 07: 052.

(24) J. Adam et al. (ALICE Collaboration) (2017) Centrality dependence of the pseudorapidity density distribution for charged particles in Pb-Pb collisions at sqrt(s_NN) = 5.02 TeV. Phys.Lett. B: 772: 567-577.

(25) J. Adam et al. (ALICE Collaboration) (2017) Production of muons from heavy-flavour hadron decays in p-Pb collisions at sqrt(s_NN) = 5.02 TeV. Phys. Lett. B: 770: 459-472.

(26) J. Adam et al. (ALICE Collaboration) (2017) Energy dependence of forward-rapidity J/ψ and ψ(2S) production in pp collisions at the LHC. Eur. Phys. J. C: 77: 392.

(27) J. Adam et al. (ALICE Collaboration) (2017) Production of $\Sigma(1385)^{\pm}$ and Ξ(1530)0 in p-Pb collisions at sqrt(s_NN) = 5.02 TeV. Eur. Phys. J. C: 77: 389.

(28) J. Adam et al. (ALICE Collaboration) (2017) $K^{*}(892)0$ and φ(1020) meson production at high transverse momentum in pp and Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. Phys. Rev. C: 95: 064606

(29) J. Adam et al. (ALICE Collaboration) (2017) Azimuthally differential pion femtoscopy in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. Phys. Rev. Lett.: 118: 222301.

(30) J. Adam et al. (ALICE Collaboration) (2017) Measurement of the production of high-pT electrons from heavy-flavour hadron decays in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV. Phys. Lett. B: 771: 467-481.

(31) J. Adam et al. (ALICE Collaboration) (2017) Production of π^{0} and η mesons up to high transverse momentum in pp collisions at 2.76 TeV. Eur. Phys. J. C: 77: 339.

(32) J. Adam et al. (ALICE Collaboration) (2017) Enhanced production of multi-strange hadrons in high-multiplicity proton-proton collisions. Nature Physics: 13: 535-539.

(33) J. Adam et al. (ALICE Collaboration) (2017) Flow dominance and factorization of transverse momentum correlations in Pb-Pb collisions at the LHC. PRL: 118: 162302.

(34) J. Adam et al. (ALICE Collaboration) (2017) Measurement of azimuthal correlations of D-mesons and charged particles in pp collisions at sqrt(s) = 7 TeV and p-Pb collisions at sqrt(s_NN) = 5.02 TeV. Eur. Phys. J. C: 77: 245.

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

(1) Delivered a talk on "PMD data taking status and progress on PMD QA and calibration" in the ALICE India Collaboration meeting organized by Jammu University during 26 to 29th October 2017 at Jammu University, Jammu (link: https://indico.cern.ch/event/664930).

(2) Delivered a talk on "Status of MUCH CBM Cooling" in the CBM India Collaboration meeting organized by VECC and Bose Institute jointly during 15 to 17th February 2018 at Falta, Kolkata (link: https://indico.gsi.de/event/6690/).

(3) Delivered a talk on "Photon Multiplicity Detector: Quality Assurance and Calibration" in the ALICE India Collaboration meeting organized by VECC during 26 to 29th March 2018 at VECC, Kolkata, India (link: https://indico.cern.ch/event/699247).

Dr. Probir Roy

INSA Senior Scientist

Scientific Reports

Minimal seesaw with complex μtau antisymmetry of neutrinos:

A complex (CP) extension of μtau permutation antisymmetry in the neutrino Majorana mass matrix is proposed. It can be realized for the Lagrangian density by appropriate CP transformations on the neutrino fields.The resultant form of M_{nu} is shown to be simply related to the complex (CP) extension of μtau permutation symmetry, with identical phenomenological consequences, though their group theoretic origins are quite different. We investigate those consequences in detail for the minimal seesaw induced by two right-chiral neutrinos N_1 and N_2 with the result that the Dirac phase is maximal ($=\Pi/2$ or $3\Pi/2$) while the Majorana phases are 0 or Π. We further provide an uptodate discussion of the $\beta\beta0nu$ process vis-à-vis ongoing and forthcoming experiments. Finally, a thorough treatment is given of baryogenesis via leptogenesis in this scenario, primarily with the assumption that the lepton asymmetry produced by the decays of N_1 only matters here with the asymmetry produced by N_2 being washed out. Tight upper and lower bounds on the mass of N_1 are obtained from the constraint of obtaining the correct observed range of the baryon asymmetry parameter and the role played by N_2 is elucidated thereafter.

Publication

1. Samanta R, Roy P and Ghosal A - "Consequences of minimal seesaw with complex μtau antisymmetry of neutrinos" - arXiv.1712.06555 [hep – ph], submitted to JHEP.

Dr. Swapan K. Saha

Professor

Scientific Reports

Search for higher excited states of ^{8}Be* to study the cosmological ^{7}Li problem: *in collaboration with Dr. Dhruba Gupta*

At present, the cosmological ^{7}Li problem is one of the important unresolved problems in nuclear astrophysics. The nuclear reactions that destroy ^{7}Be are thought to play a role in the observed anomaly

in ^{7}Li. Accurate measurements of such nuclear reactions are required before one can invoke solutions beyond nuclear physics, particularly in the context of the newly conjectured light electrically neutral particles X that may have substantial interactions with nucleons. We continued our preparation for the experiment at HIE-ISOLDE, CERN, Geneva, Switzerland, to measure the transfer reaction ^{7}Be(d,p)^{8}Be* (IS 554). We decided to use the scattering chamber installed in the third beam line of HIE-ISOLDE. A set of strip detectors backed by pads in a diamond geometry, covering a large angular range, would be used in the scattering chamber. We are doing the Monte Carlo simulations for the experiment using NPTool, a framework based on Geant4 and ROOT for simulation and analysis of nuclear physics experiments. Using the code FRESCO, the DWBA calculations for the reaction ^{7}Be(d,p)^{8}Be* have also been carried out.

Breakup of ^{7}Be in presence of heavy targets: *in collaboration with Dr. Dhruba Gupta*

The production and destruction channels of ^{7}Be are both important in the study of the cosmological lithium problem. The ^{7}Beproduction channel goes through the radiative capture reaction ^{3}He + ^{4}He → ^{7}Be + γ. Since breakup reactions play a prominent role in loosely bound nuclei, the above reaction can be studied by measuring the time reversed Coulomb breakup reaction of ^{7}Be, preferably in the presence of heavy targets. This would enable measurements at low relative breakup energies (astrophysical energies) between the fragments, thereby extracting information about the required radiative capture reaction. Breakup reaction calculations in the framework of prior-form DWBA arebeing continued in view of a planned experiment at a rare isotope facility.

Study of n-p pairing through two-nucleon transfer reactions: *in collaboration with Dr. Dhruba Gupta*

The data analysis of the n-p pairing experiment (e644) was continued. The experiment was carried out at the rare isotope facility GANIL, Caen, France. The aim of the work is to study two nucleon n-p transfer reactions on two nuclei, ^{48}Cr and^{56}Ni.The doubly magic nucleus ^{56}Ni is expected to show no pairing effects. The (p,^{3}He) and (d,α) reactions on these nuclei was carried out to investigate the competition between T = 1 and T = 0 pairing and probe n-p pairing. We are collaborating in this work with IPN, Orsay, France and doing a part of the data analysis at Bose Institute in the NPTool framework. The calibration of the double sided strip and CsI detectors of MUST2 using α-source runs have been completed.

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

We adopted the theoretical procedure of supersymmetric quantum mechanics to generate the resonance state wave functions of the unbound nucleus ^{15}Be. Theoretically, it is very difficult to tackle the unbound states by conventional methods. In the present work, we used a density dependent M3Y microscopic potential and generated a potential which is strictly isospectral with it although the two have widely different shapes. We could reproduce the energy and width of the 1.8 MeV ($5/2^{+}$) resonance state and did not find any other nearby resonances for ^{15}Be. It becomes apparent that the present framework is a powerful tool to theoretically complement the increasingly important accelerator based experiments with unbound nuclei.

Publications:

1. Dutta S K, Gupta D, Saha SK (2018) Resonance State Wave Functions of ^{15}Be using Supersymmetric Quantum Mechanics, *Phys. Lett. B* 776, 464

Symposium publication

1. Gupta D, Saha SK (2017) Nuclear reactions with ^{7}Be to study the cosmological lithium problem, *XXth Colloque GANIL 2017*
2. Saha SK, Gupta D (2017) Coulomb dissociation of ^{9}Li, *XXth Colloque GANIL 2017*

Grants-in-Aid Schemes:

Title of the scheme	Scheme funded by
Astrophysical S-factor from nuclear reactions with a rare isotope beam of ^{7}Be (*With Dr. Dhruba Gupta as PI*)	ISRO

SCIENTIFIC REPORT

Dr. Rajarshi Ray

Associate Professor

Scientific Reports

Physics of strongly interacting matter: *In collaboration with Rama Prasad Adak, Supriya Das, Sanjay K. Ghosh, Rajarshi Ray, Subhasis Samanta*

We estimate chemical freeze-out parameters in HRG and EVHRG model by fitting the experimental information of net-proton and net-charge fluctuations measured in Au + Au collisions by the STAR collaboration at RHIC. We observe that chemical freeze-out parameters obtained from lower and higher order fluctuations are though almost same for $\sqrt{s_{NN}}$ GeV, tend to deviate from each other at lower $\sqrt{s_{NN}}$. Moreover, these separations increase with decrease of $\sqrt{s_{NN}}$ and for a fixed $\sqrt{s_{NN}}$ increase towards central collisions. Furthermore, we observe an approximate scaling behaviour of $(\mu_B/T)/(\mu_B/T)_{central}$ with $(N_{part})/(N_{part})_{central}$ for the parameters estimated from lower order fluctuations for $11.5 \leq \sqrt{s_{NN}} \leq 200$ GeV. Scaling is violated for the parameters estimated from higher order fluctuations for $\sqrt{s_{NN}} = 11.5$ and 19.6 GeV. It is observed that the chemical freeze-out parameter, which can describe σ^2/M of net-proton very well in all energies and centralities, can not describe the $s\sigma$ equally well and vice versa.

2. *In collaboration with Abhijit Bhattacharyya (CU), Sanjay K. Ghosh, Soumitra Maity, Sibaji Raha, Kinkar Saha and Sudipa Upadhaya*

The Polyakov – Nambu – Jona-Lasinio model has been quite successful in describing various qualitative features of observables for strongly interacting matter, that are measurable in heavy-ion

collision experiments. The question still remains on the quantitative uncertainties in the model results. Such anestimation is possible only by contrasting these results with those obtained from first principles using the lattice QCD framework. Recently a variety of lattice QCD data were reported in the realistic continuum limit. We made a first attempt at reparametrizing the model so as to reproduce these lattice data. We found excellent quantitative agreement for the equation of state. Certain discrepancies in the charge and strangeness susceptibilities as well as baryon-charge correlation still remained. We discuss their causes and outline possible directions to remove them.

Publications

Refereed Journals

1. Adak R P, Das S, Ghosh S K, Ray R, and Samanta S (2017) Centrality dependence of chemical freeze-out parameters from net-proton and net-charge fluctuations using hadron resonance gas model. *Physical Review C* 96:014902 (R).
2. Bhattacharyya A, Ghosh S K, Maity S, Raha S, Ray R, Saha K and Upadhaya S (2017) Reparametrizing the Polyakov – Nambu – Jona-Lasinio model. *Physical Review D* 95:054005 (R).

Conference Proceedings:

1. Bhattacharyya A, Ghosh S K, Ray R and Samanta S (2017) Study Of Equation Of State And Fluctuations At Non Zero Magnetic Field In TheHadron Resonance Gas Model, *PoS ICPAQGP2015 075*.
2. Sur S, Bhattacharyya S, Ghosh S K, Deb P and Ray R (2017) A Finite Volume Study Of The Thermodynamic Properties Of Strongly Interacting Matter Using PNJL Model, *PoS ICPAQGP2015 072*.

Students Awarded Ph.D.

Name of the Student, University / Year	Title of the Thesis
Kinkar Saha (C.U. 2017)	Fluctuations in Strongly Interacting Systems

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

i. Participated in the Workshop in High Energy Physics Phenomenology (WHEPP) XV in December 2017 at Indian Institute of Science Education and Research, Bhopal, India.

ii. Chaired a session in the National Conference on Recent Trends in Condensed Matter Physics in October 2017 at Bose Institute, Kolkata, India.

iii. Served as resource person in the NESST-BASE 2017 program held at Mayapuri Campus, Bose Institute, Darjeeling, India, in May 2017.

iv. Served as member of organizing committee for the Advanced Detectors for Nuclear, High Energy and Astroparticle Physics in February 2017 at Bose Institute, Kolkata, India.

v. Participated in the CNT workshop on Quarkonia production and suppression in High Energy Heavy Ion Collisions in February 2017 at the University of Calcutta, Kolkata, India.

Dr. Soumen Roy

Associate Professor

Scientific Reports

Effects of heterogeneous spatial structures in game theory

Evolutionary game theory aims to model evolutionary dynamics in a population by drawing on the principles of game theory. Understanding the mechanisms of evolution of cooperation and its sustenance has gained momentum since the last few decades of the twentieth century. Spatially restricted interactions, such as in ecological systems, are rather common in nature. Our investigations show that interactions among the individuals in a population, when strongly influenced by spatial considerations -- lead to extremely non-trivial effects on the outcome of evolutionary games.

Publications

1.Sinha S, Grewal RK and Roy S (2018) Modeling bacteria-phage interactions and implications for phage therapy Advances in Applied Microbiology, 103, 103-141.

Grants-in-Aid Schemes:

Title of scheme:	Scheme funded by:
(As co-PI) Identification and validation of structural hotspots in signaling network of few blue-light responsive photoreceptors using complex networks and biophysical techniques	SERB (DST)

Participation in Conferences / Symposia / Workshops & Invited Talks delivered at various Organizations:

i) Delivered an invited talk at the symposium on networks at IIIT Delhi on October 28, 2017

Dr. Achintya Singha

Associate Professor

Scientific Reports

Probing lattice dynamics and electron-phonon coupling in the topological nodal-line semimetal ZrSiS using Raman spectroscopy: *in collaboration with Prof. Prabhat Mandal (SINP, Kolkata), Dr. Swastika Chatterjee (IIT Kharagpur) and Prof. Lin Wang, (Shanghai, China)*

Topological materials provide an exclusive platform to study the dynamics of relativistic particles in table-top experiments and offer the possibility of wide-scale technological applications. ZrSiS is a newly discovered topological nodal-line semimetal and has drawn enormous interests. In this report, we have investigated the lattice dynamics and electron-phonon interaction in single crystalline ZrSiS using Raman spectroscopy. Polarization and angle-resolved Raman results have been analyzed using crystal symmetries and theoretically calculated atomic vibrational patterns. Wavelength and temperature dependent Raman measurements show the complex interplay of electron and phonon degrees of freedom, resulting in resonant phonon and quasielastic electron scattering through inter-band transition.

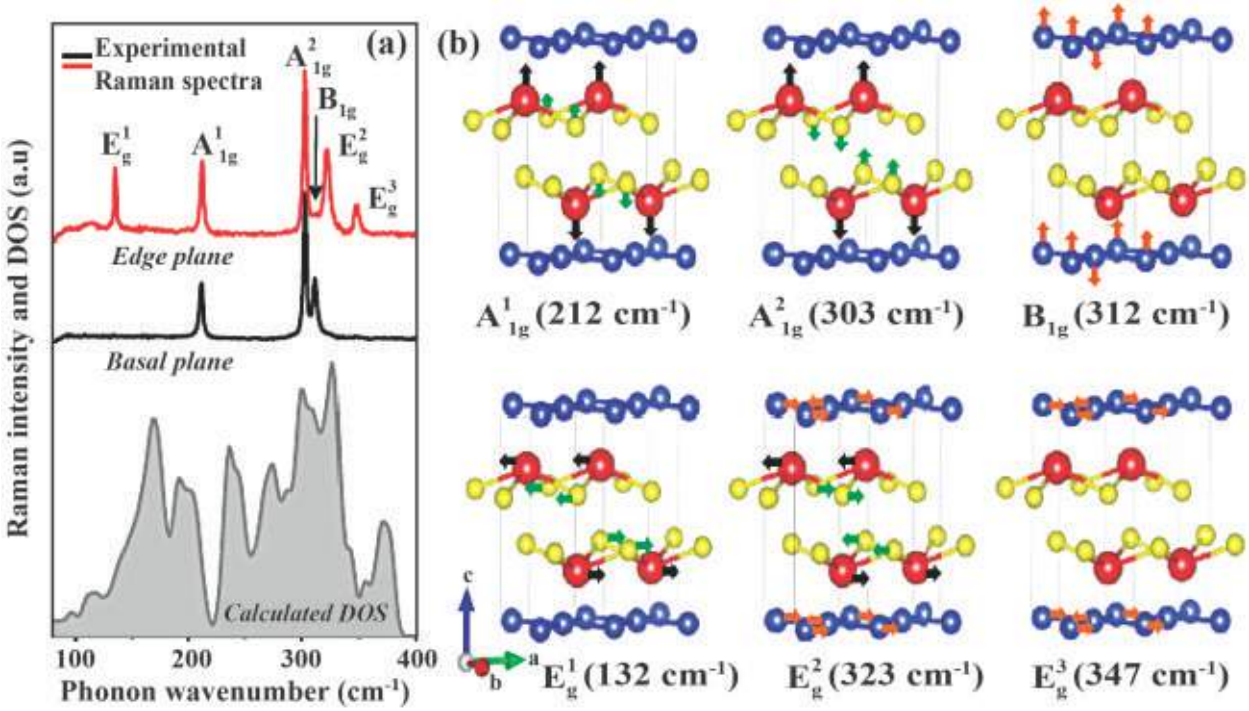


Figure 1: (a) Room-temperature Raman spectra of ZrSiS for basal plane (black curve) and edge plane (red curve) configurations. The shaded region in the lower panel represents the calculated phonon density of states for ZrSiS. (b) Vibration patterns corresponding to the Raman active modes of ZrSiS.

Our high-pressure Raman studies reveal vibrational anomalies, which are the signature of structural phase transitions. Further investigations through high-pressure synchrotron x-ray diffraction show

pressure-induced structural transitions and coexistence of multiple phases, which also indicate possible electronic topological transitions in ZrSiS. This study not only provides the fundamental information on the phonon subsystem, but also sheds some light in understanding the topological nodal-line phase in ZrSiS and other isostructural systems [***Phys. Rev. B* 97, 094112 (2018)**].

Electron and plasmon interaction in MoS2-metal NPs hybrid structures: *in collaboration with Shib Shankar Singha*

Interaction of two-dimensional (2D) transition metal dichalcogenides (TMDs) with noble metal nanoparticles (NPs) is of great interest from the perspective of fundamental science, as it develops an excellent platform to study plasmon-exciton interaction and charge transfer.

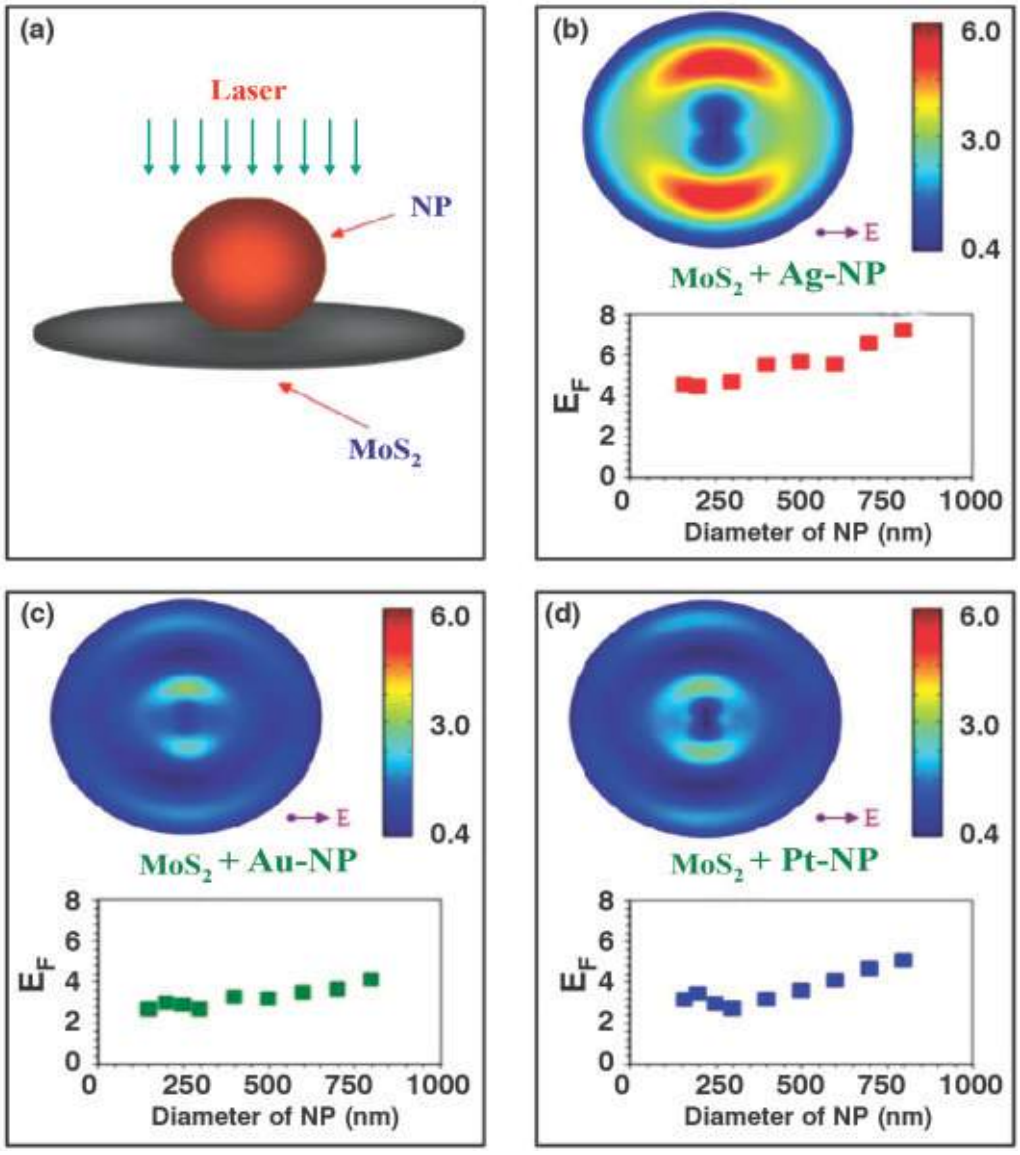


Figure 2: (a) Model for the calculation of the induced EM field at the surface of the MoS_2 flake in the presence of a metal NP. The color plot of the induced EM filed on the surface of MoS_2 and plot of the particle size dependent EF for (b) MoS_2-Ag, (c) MoS2-Au and (d) MoS_2-Pt.

Here, we report a method for the large-scale synthesis of noble metals (Ag, Au and Pt) NPs decorated MoS_2 flake. We find that the NPs can affect the photoluminescence (PL) emission in two ways, namely plasmone-exciton interaction and charge transfer. The types of doping-induced by the Ag, Au and Pt NPs are determined from the spectral weight of neutral and charged excitons in the PL spectra. Our results provide a quantitative estimation of the origin of PL emission from MoS_2 based 2D-0D heterostructures and suggest new avenues for 2D nanoelectronics, gas sensing, catalysis, and biosensing [**Journal of Alloys and Compounds 723, 722 (2017)**].

Emerging photoluminescence from bilayer MoS_2 films grown by pulsed laser deposition on different substrates: *in collaboration with Dr. Prabir Pal (NPL, New Delhi)*

We report the growth of continuous large area bilayer films of MoS_2 on different substrates by pulsed laser deposition (PLD). The bilayer large area crystalline nature of growth in the 2H-phase is determined by Raman spectroscopy. Cross-sectional transmission electron microscopy confirms the distinct thinnest ordered layered structure of MoS_2. Chemical analysis reveals an almost stoichiometric 2H-phase on both the substrates. The photoluminescence intensities of both the films match very well with those of the corresponding exfoliated flakes, as well as chemical vapor deposited (CVD) films as reported in the literature. The in-situ post growth annealing with optimal film thickness acts as a solid phase epitaxy process which provides continuous crystalline layers with a smooth interface and regulates the photoluminescence properties [**Journal of Applied Physics 122, 015304 (2017)**].

SCIENTIFIC REPORT

Publications

1. Bayan S, Gogurla N, Midya A, Singha A, Ray S K (2017) Plasmon mediated enhancement and tuning of optical emission properties of two dimensional graphitic carbon nitride nanosheets, *Nanotechnology* 28, 485204 (9pp). Impact Factor: 3.440
2. Bayan S, Midya A, Gogurla N, Singha A, Ray S K (2017) Origin of Modified Luminescence Response in Reduced Graphitic Carbon Nitride Nanosheets, *The Journal of Physical Chemistry C* 121, 19383 (9pp). Impact Factor: 4.536
3. Barvat A, Prakash N, Satpati B, Singha S S, Kumar G, Singh D K, Dogra A, Khanna S P, Singha A, Pal P (2017) Emerging photoluminescence from bilayer large-area 2D MoS_2 films grown by pulsed laser deposition on different substrates, *Journal of Applied Physics* 122, 015304 (9pp). Impact Factor: 2.068.
4. Deb S, Basu S, Singha A, Dutta T K (2018) Development of a 2-Nitrobenzoate-Sensing Bioreporter Based on an Inducible Gene Cluster, *Frontiers in Microbiology* 9, 254 (12pp). Impact Factor: 4.076
5. Ghatak S K, Majumdar D, Singha A, Sen K (2017) Peanut proteins in selective sensing of Bi-III at trace concentrations. *Journal of the Indian Chemical Society* 94, 773 (8pp).
6. Mondal A, Pal S, Sarkar A, Bhattacharya T S, Das A, Gogurla N, Ray S K, Kumar P, Kanjilal D, Devi K D, Singha A, Chattopadhyay S, Jana D (2018) Raman spectroscopic analysis on Li, N and (Li, N) implanted ZnO, *Materials Science in Semiconductor Processing* 80, 111 (7pp). Impact Factor: 2.359.

7. Pal S, Gogurla N, Das A, Singha S S, Kumar P, Kanjilal D K, Singha A, Chattopadhyay S, Jana D, Sarkar A (2018) Clustered vacancies in ZnO: Chemical aspects and consequences on physical properties, *Journal of Physics D: Applied Physics* 51, 105107 (12pp). Impact Factor: 2.588
8. Ray D, Bhattacharya T S, Chatterjee A, Singha A, Ghosh S K, Raha S (2018) Hygroscopic Coating of Sulfuric Acid Shields Oxidant Attack on the Atmospheric Pollutant Benzo (a) pyrene Bound to Model Soot Particles, *Scientific reports* 8, 129 (8pp). Impact Factor: 4.259
9. Singha S S, Nandi D, Bhattacharya T S, Mondal P K, Singha A (2017) Photoluminescence modulation due to conversion of trions to excitons and plasmonic interaction in MoS_2-metal NPs hybrid structures, *Journal of Alloys and Compounds* 723, 722 (7pp). Impact Factor: 3.133
10. Singha R, Samanta S, Chatterjee S, Pariari A, Majumdar D, Satpati B, Wang L, Singha A, Mandal P (2018) Probing lattice dynamics and electron-phonon coupling in the topological nodal-line semimetal ZrSiS, *Phys. Rev. B* 97, 094112 (12pp). Impact Factor: 3.836

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

I) Delivered Oral presentation at International Conference on Nanoscience and Technology (ICONSAT 2018) held from 21 to 23 March, 2018 at IISc Bengaluru, India.

ii) Acted as resource person and delivered a talk in 'Students' Training Programme at Bose Institute from 11th to 13th December 2017

Group Members

Mr. Shib Shankar Singha (SRF, Physics) presented poster on "MoS_2 nanoflower functionalized with Au nanoparticles: An efficient substrate for Bio-sensor" in National Conference on Recent Trends in Condensed Matter Physics (RTCMP-2017) held during October 31 – November 3, 2017 at Bose Institute, Kolkata, West Bengal.

Mr. Tara Shankar Bhattacharya (SRF, Physics) presented poster on "Plasmon-exciton interaction in Au-WS_2 (0D-2D) hybrid nanostructures" in National Conference on Recent Trends in Condensed Matter Physics (RTCMP-2017) held during October 31 – November 3, 2017 at Bose Institute, Kolkata, West Bengal.

Mr. Sreyan Raha (JRF, Physics): presented poster on "Polarized Raman scattering from individual Ge Nanowire" in National Conference on Recent Trends in Condensed Matter Physics (RTCMP-2017) held during October 31 – November 3, 2017 at Bose Institute, Kolkata, West Bengal.

Awards / Honors received

Group Members

Mr. Tara Shankar Bhattacharya (SRF, Physics): received best poster prize on "Plasmon-exciton interaction in Au-WS_2 (0D-2D) hybrid nanostructures" in National Conference on Recent Trends in Condensed Matter Physics (RTCMP-2017) held during October 31 – November 3, 2017 at Bose Institute, Kolkata, West Bengal.

Dr. T. P. Sinha

Professor

Scientific Reports

Lattice dynamics and electron transport in double perovskites: in collaboration with *Saswata Halder*

Double perovskite oxides A_2RMO_6 (A = Ba, Sr, Ca; Ln = Nd, Sm, Ho, Lu; M = Ru, Sb, Ta) have been studied as promising host for various applications in the domains of renewable sources of energy which include photocatalysis, photovoltaic and thermoelectricity. The optical, electrical and photo induced properties of the synthesised materials have been investigated both in the experimental and theoretical domains. First principles density functional theory calculations have been implemented to calculate the theoretical optical and thermoelectric properties and are correlated to the experimental results.

Perovskite oxides for photovoltaic application: *in collaboration with Md. Sariful Sheikh*

Double perovskite oxides Ln_2NiMnO_6 (Ln = La, Eu, Dy and Lu) have been introduced as the promising light absorbing materials for photovoltaic application. Ln_2NiMnO_6 powders have been synthesised using the low cost sol-gel method. Structural, optical, electrical and photo sensing properties of the synthesised materials have been studied. Solar cells of the prepared materials have been fabricated using the simple spin coating technique and its photovoltaic performance is studied.

Antiferromagnetism in perovskite oxides: *in collaboration with Ram Awdhesh Kumar*

In this study, the temperature dependent dc magnetic susceptibility of the materials xBa_2FeNbO_6–(1-x)$LaFeO_3$ [x = 0.1, 0.3, 0.5] has been investigated in the temperature range from 300 K to 900 K with an applied magnetic field of 2 kOe. The effect of lattice distortion on the magnetic properties has been explored. The anti-ferromagnetic behaviour of the materials is analysed from the temperature dependence magnetization study.

Publications

1. Dutta A, Mandal S, Kumari P, Mukhopadhyay PK, Biswas SK and Sinha TP (2017) Crystal Structure and Dielectric Properties of Microwave Ceramics CaLa(CaM)O6 [M = Nb, Sb], *Journal of Electronic Materials*, vol. 46, pp. 1189-1194.
2. Dutta A, Singh SK, Murthy VRK, Mukhopadhyay PK and Sinha TP (2018) Crystal structure, Raman spectroscopy and microwave dielectric properties of $xBa_3MgNb_2O_9$–(1-x)Ba_2InNbO_6 [x=0.4, 0.6, 0.8], *Materials Research Bulletin*, vol. 100, pp. 178-183
3. Halder S, Dutta A and Sinha TP (2017) Time–temperature superposition in the grain and grain boundary response regime of A_2HoRuO_6 (A = Ba, Sr, Ca) double perovskite ceramics: a conductivity spectroscopic analysis, *Royal Society of Chemistry Advances*, vol. 7, pp. 43812-43825.

4. Halder S, Sheikh Md S, Ghosh B and Sinha TP (2017) Electronic structure and electrical conduction by polaron hopping mechanism in A_2LuTaO_6 (A= Ba, Sr, Ca) double perovskite oxides, *Ceramics International*, vol. 43, pp. 11097-11108.

5. Halder S, Sheikh Md. S, Ghosh B and Sinha TP (2017) Octahedral distortion induced phonon vibration and electrical conduction in A_2NdSbO_6 (A = Ba, Sr, Ca), *Materials Chemistry and Physics*, vol. 199, pp. 508-521.

6. Kumar R A, Dutta A, Mukhopadhyay PK and Sinha TP (2018) Antiferromagnetic behaviour and dielectric relaxation of xBa_2FeNbO_6-(1-x)$LaFeO_3$ [x = 0.1, 0.3, 0.5] *Journal of Alloys and Compounds*, vol. 730, pp. 201-207.

7. Sakhya AP, Rai DP, Sheikh Md S, Mukherjee M, Dutta A and Sinha TP (2017) Origin of the optical anisotropy and the electronic structure of Ru-based double perovskite oxides: DFT and XPS studies, *Royal Society of Chemistry Advances*, vol. 7, pp. 43531- 43539.

8. Sheikh Md S, Sakhya AP, Dutta A and Sinha TP (2017) Light induced charge transport in La_2NiMnO_6 based Schottky diode, *Journal of Alloys and Compounds*, vol. 727, pp. 238-245.

9. Sheikh Md S, Ghosh D, Dutta A, Bhattacharyya S and Sinha TP (2017) Lead free double perovskite oxides Ln_2NiMnO_6 (Ln = La, Eu, Dy, Lu), a new promising material for photovoltaic application, *Materials Science and Engineering* B, vol 226, pp. 10-17.

10. Sheikh Md S, Sakhya A P, Dutta A and Sinha TP (2017) Dielectric relaxation of $CH_3NH_3PbI_3$ thin film, *Thin Solid Films*, vol. 638, pp. 277-281.

11. Sheikh Md S, Sakhya A P, Sadhukhan P, Dutta A, Das S and Sinha TP (2017) Dielectric relaxation and Ac conductivity of perovskites $CH_3NH_3PbX_3$ (X = Br, I), *Ferroelectrics,* vol. 514, pp. 146-157.

12. Sheikh Md S, Chanda S, Dey A, Dutta A, Ray PP and Sinha TP (2017) Investigation of light induced charge transport properties in Dy_2NiMnO_6 perovskite based Schottky diode, *Ferroelectrics*, vol. 518, pp. 204-211.

Participation in Conferences/ Symposia/ Workshops and Invited talks delivered at various organizations

(i) Delivered a series of lectures on *Materials Synthesis and Characterization* at IIT-ISM, Dhanbad during 6-7 June 2017.

(ii delivered an invited talk on *X-ray photoemission and Raman spectroscopies of double perovskite oxide* Sr_2SmNbO_6 in the National Conference on Advances in Spectroscopic Techniques and Materials (ASTM-2018) held at IIT-ISM, Dhanbad during March 14-16, 2018.

Participation of Group Members:

Saswata Halder presented a paper on '*Time-temperature superposition in grain and grain-boundariey response regime of* A_2HoRuO_6 *(A = Ba, Sr, Ca) double perovskite ceramics: A*

Conductivity Spectroscopic Analysis' at the National Conference on Recent Trends in Condensed Matter Physics in Bose Institute, Kolkata during 31st October – 3rd November, 2017.

Md. Sariful Sheikh presented a paper on (i)'***Optoelectronic properties of La_2NiMnO_6 thin film for photovoltaic applications***' **at** the Smart Materials: Methods and Applications 2017 at IISER Kolkata during 20th – 22nd April, 2017; (ii) '*A study on the optical properties of double perovskite oxide Sm_2NiMnO_6 and related potential applications*' at the National Conference on Recent Trends in Condensed Matter Physics in Bose Institute, Kolkata during 31st October – 3rd November, 2017; and (iii) '*Synthesis and optical properties of multiferroic perovskite oxide $(KNbO_3)_{1-x}+(La_2NiMnO_6)_x$ for photovoltaic application*' at the6thInternational Conference on Advances in Energy Research (ICAER 2017), at IIT Bombay, Mumbai, India during 12th-14th December 2017.

Ram Awdhesh Kumar participated at (i) the Smart Materials: Methods and Applications 2017 at IISER Kolkata during 20 – 22nd April, 2017; (ii) the SASChem 2017 at IISER Kolkata during 29 – 30th August, 2017; and also presented a paper on (iii) '*Dielectric relaxation and magnetic properties of xBa_2FeNbO_6-(1-x)$LaFeO_3$ [x = 0.1, 0.3, 0.5]*' at the National Conference on Recent Trends in Condensed Matter Physics in Bose Institute, Kolkata during 31st October – 3rd November, 2017.

Ritwik Maity presented a paper on (i) '*The AC conductivity and photocatalytic study of Mn doped $SmFeO_3$*' at the National Conference on Recent Trends in Condensed Matter Physics in Bose Institute, Kolkata during 31stOctober – 3rdNovember, 2017 (awarded Best Poster Presentation); (ii) '*Spectroscopic and Photocatalytic study of $BaFe_{1/2}Ta_{1/2}O_3$*' at the National Conference on Advances in Spectroscopic Techniques and Materials (ASTM-2018) during 14th– 16th March, 2018 and also participated (iii) at the SASChem 2017 at IISER Kolkata during 29th– 30th August, 2017; and (iv) the International Conference on Condensed Matter Physics at ISI Kolkata during 14th–16th November, 2017.

Moumin Rudra presented a paper on (i) '*Dielectric behavior of Pr_2NiTiO_6 double perovskite oxide*' at the SASChem 2017 at IISER Kolkata during 29th– 30th August, 2017; (ii) '*Enhancement of Seebeck Coefficient in Bi – PAni Composite synthesized by in-situ polymerization*' at the National Conference on Recent Trends in Condensed Matter Physics at Bose Institute, Kolkata during 31st October – 3rd November, 2017; and also participatedat (iii) the International Conference on Condensed Matter Physics at ISI Kolkata during 14th–16th November, 2017.

Chayan Kumar Mitra presented a paper on '*Temperature controlling cryostat system to measure magnetic field induced strain of ferromagnetic shape memory alloy*' at the National Conference on Recent Trends in Condensed Matter Physics in Bose Institute, Kolkata during 31st October – 3rd November, 2017 (awarded Best Poster Presentation).

Tushar Kanti Bhowmik presented a paper on (i) '*Synthesis, structural and dielectric properties of double perovskite oxide La_2CrNiO_6*' at the National Conference on Advances in Spectroscopic Techniques and Materials (ASTM-2018) at Bose Institute, Kolkata during 14th– 16th March, 2018 and also participatedat (ii) the SASChem 2017 at IISER Kolkata during 29th– 30thAugust, 2017; and (iii) the International Conference on Condensed Matter Physics at ISI Kolkata during 14th–16thNovember, 2017.

Ranjan Sutradhar presented a paper on '*Non-covalent interactions of adenine tautomers with Au, Ag*

nanoparticles: A theoretical approach' at the National Conference on Recent Trends in Condensed Matter Physics in Bose Institute, Kolkata during 31st October – 3rd November, 2017.

Sumana Gop presented a paper on '*Bonding of metal nanoparticles with DNA base (adenine)*' at the National Conference on Recent Trends in Condensed Matter Physics in Bose Institute, Kolkata during 31st October – 3rd November, 2017.

Himadri Sekhar Tripathi participated at the National Conference on Recent Trends in Condensed Matter Physics in Bose Institute, Kolkata during 31st October – 3rd November, 2017.

Students Awarded Ph.D.

	Name of the Student (University, Year)	Title of Thesis
1.	Anup Pradhan Sakhya (C U, 2017)	Photo Physical Properties And Electrical Transport in Rare Earth Based Perovskite Oxides
2.	Rajesh Mukherjee (C U, 2017)	Structural, Optical And Electrical Properties Of Some Rare Earth Based Double Perovskite Oxides
3.	Sayantani Das (CU, 2017) (*As Co-supervisor*)	Transport Properties of Dilute Magnetic II-VI Semiconductors
4.	Md. Monwar Hoque (JU, 2017)	Dielectric Relaxation and AC Conductivity in $A(B_{1/3}B_{2/3})O_3$ (A = Ba, Sr, & Ca; B = Ni, Mg & Zn; B = Ta, Sb & Nb)

Bose Institute Centenary Meeting on "Future of Science" on 27-28 November, 2017

Prof. Charles Bennett, Thomas J. Watson Research Center, Yorktown Heights, New York; delivered distinguished lecture on November 27, 2017.

Prof. Jagadish Shukla, Distinguished University Professor, George Mason University (GMU), President, Institute of Global Environment and Society (IGES) , Research Hall, Room 105, George Mason University, MSN: 2B3 4400. University Drive, Fairfax, VA 22030 USA; delivered distinguished lecture on November 27, 2017.

Dr. M. Rajeevan, Secretary to the Government of India, Ministry of Earth Sciences, Prithvi Bhavan, Lodi Road, New Delhi; delivered distinguished lecture on November 27, 2017.

Prof. Eran Elinav, Dept. of Immunology, Wolfson Bldg, Room 211, Weitzman Institute of Science, Rehovot-761000, Israel; delivered distinguished lecture on November 27, 2017.

OUTREACH & 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 has initiated a rural biotechnology programme. Under this programme the people from rural sector are given training for Musroom cultivation, Piscicultute, Sericulture and Apiculture.

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 given hand-on training on the different aspects of Astroparticle Physics.

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 2017: May 22 – June 3, 2017.

The Tenth North-East Students' Summer Training on BAsic SciEnces (NESST-BASE) was held at Darjeeling during May 22 – June 3, 2017. NESST-BASE2017 has been a part of Centenary Celebration of Bose Institute. 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 state authorities selected the students. 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. This year popular lectures were delivered by Dr. Debiprosad Duari, Director, Research & Academic, M. P. Birla Institute of Fundamental Research, M. P. Birla Platarium, Kolkata on "Our Solar System" and Prof. Tapas K. Kundu, JNCASR, Bangalore on "Epigenetics and Cancer: Genes, habit and disease".

(b) Rural Biotechnology programmes:

Scheduled Tribe Specific Rural Biotechnology Programme has started its journey in the year 2014 which is financed by Department of Science & Technology, Government of India for the development of Socio-economic status of Scheduled Tribe community people throughout the West Bengal. The major objectives of this programme is socio-economic upliftment, generation of awareness, empowerment of womenof the Scheduled Tribe people in West Bengal through various programmes viz Sericulture, Agriculture, Orchard, Mushroom cultivation, Vermicompost production, Fishery, Apiculture, Piggery, Food Processing, Goat rearing, Rainwater harvesting for agriculture as well as drinking purpose, Country chicken rearing, Betel Leaf Cultivation, Crab Culture etc. Throughout the year 151 personas as project Supervisor and Village Trainer are in constant touch with the village people to aware them about various income generation programmes and successful implementation of these programmes among the villagers who have their land or no land. In the year 2017-2018,this programme is spread over 13 districts of West Bengal namely Birbhum, South 24 Parganas, Purulia, Bankura, Jhargram, Paschim Medinipur, Purba Bardhaman, Murshidabad, Dakshin Dinajpur, Nadia, Hooghly, North 24 Parganas, Purba Medinipur and about 3000 beneficiaries have been benefited through its various Programmes.

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 2017, 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 3 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 452 applications were received from which 143 candidates were shortlisted for the Written Exam. Based on the performance of the Written Test, 40 candidates were called for interview and 12 selected. Of these 11 students joined the program in 2017.

SERVICE DEPARTMENTS

Acharya J.C. Bose Biotechnology Innovation Centre (Madhyamgram Experimental Farm)

Madhyamgram Experimental Farm (MEF) is the translational research hub of Bose Institute. Its components are agricultural fields, greenhouses, advanced biotechnology laboratory (Acharya J C Bose Biotechnology Innovation Centre) and Centre for translational animal research. MEF serves all scientists, research personnel and students of Bose Institute working in diverse Biological and Biomedical area.

The activities of MEF in the last year are as follows:

Agricultural fields: Following scientists have availed the field facility for **rice** cultivation for the purpose of seed multiplication and pure line maintenance: Dr. Anupama Ghosh, Dr. Anirban Bhuinya, Dr. Subha Chowdhury, Prof. Sampa Das, Prof. D. N. Sengupta and Prof. A. N. Lahiri Majumder. Research on **mustard**, one of the most important oilseed crops, is always a priority area for the Plant scientists of Bose Institute. In the Ravi season Prof. Debabrata Basu and Prof. S. R. Sikdar have grown mustard for their respective research programmes.

Sesame is an upcoming oilseed crop. Prof S Sikdar and Dr G Gangopadhyay are working on this crop. In the last Kharif season, Dr Gangopadhyay did phenotyping of some recombinant lines of different generations for the development of improved sesame genotypes with particular reference to plant architecture and high oil content.

The other crops cultivated at the different times of the last year are as follows: **tomato** (Dr. Anirban Bhuinya, Dr. Pallob Kundu and Prof. Debabrata Basu), **pigeon pea** (Prof. Sampa Das), **chick pea** (Prof. Debabrata Basu), **maize** (Dr. Anupama Ghosh), **ground nut** (Dr. Shubho Chaudhuri) and **mung bean** (Prof. Amita pal).

MEF has a sizable population of mango orchard and other tree plants. A considerable amount of it is under annual lease (tender basis) for revenue generation. We are extending it with new plantation in the hitherto unutilized land for short and long-term income.

Greenhouses: MEF has several greenhouses to nurture the transplanted plants from *in vitro* to *ex vitro* condition. The scientists of Division of Plant Biology mostly use this facility for crops like rice, mustard, tomato, mung bean, tobacco and *Arabidopsis* to name a few.

Advanced biotechnology laboratory: The fully equipped laboratories of Acharya J C Bose Biotechnology Innovation Centre offer all the faculty members and students of Bose Institute to use this facility. The students and research personnel routinely use gel electrophoresis, RT-PCR, Speed Vac machine, Densitometer, Spectrophotometer, Nano drop, gel-doc system, centrifuge, HPLC etc. Additionally, dedicated inoculation as well as fungal and plant tissue culture rooms are in operation.

Outreach programme: MEF organized a Hands-on-Training programme on "Basic and Applied Physical and Biological Sciences for the High School Students" from 11th to 13th December 2017 as a part of the Centenary Celebration of Bose Institute. Thirty five students of Class XI-XII along with their teachers from seven schools in the vicinity of MEF attended this programme. They performed experiments on Microbiology, Physics of Nanomaterials, and Plant Biotechnology. They also learnt techniques to use of animals in drug development/translational medical research. The students also visited the CB and MC of BI, attended lectures on Crop improvement and 'Fun with Mathematics'.

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(2 machine)

K) Atomic Absorption Spectrophotometer

L) FTIR

This year several new equipments have been procured

A) Next Generation Sequencer (ABI)-Ion torrent

B) HPLC(Waters)-PDA, Florescence and IR detector along with preparative pump

C) FPLC(GE Healthcare)-Having precise analysis software, updated column, pH sensor, conductivity sensor

D) MALDI-Tof Tof (Bruker)

E) LC MS(Waters)

F) Fluorescent Image Analyzer

G) Plate Centrifuge

H) RT PCR (7500 FAST)

7500 FAST RT PCR (ABI)

HPLC (WATERS)

FPLC (GE Healthcare)

Next Generation Sequencer (Applied Biosystem)

Maldi Tof Tof

LC MS

Typhoon Scanner

The CIF is used extensively not only by the researchers of this institute but also those for other institutes. One of the most used equipments is the DNA sequencer. As many as 8000 DNA samples were sequenced during the last financial year. More than 10% of the samples belonged to external user category, who had to get the work done after making necessary payments. The confocal microscope is another equipment that is heavily used. In this case too the external user component is about 10%. The addition of the FPLC System has proved to be a boon to protein scientists who can use this equipment to purify their proteins in large amounts for performing crystallization and other biophysical studies. In recent times a LC/MS/MS platform has been purchased out of the grants received from the DBT sponsored project entitled *"Multi-dimensional Research to Enable Systems Medicine: Acceleration using a Cluster Approach"* that is being executed in collaboration with NIBMG (the nodal organization). This state of the art platform for performing proteomics

experiments is now stationed at the Unified Academic Campus. The MALDI –TOF/TOF and the LC/MS/MS system together will now serve as a complete platform for performing proteomic studies. 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 equipment such as HPLC, Confocal microscope, FACS, GC-MS and NMR, RT PCR, MALDI-Tof etc are used extensively by both in-house and outside users on charge basis.

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.
- Automatic weather station is installed to collect meteorological data along with a sonic anemometer for different components of wind velocity

- Lightning detector and electric field monitor has been installed to study the variation of atmospheric electric field

Major findings (2017-18)

- An array of seven plastic scintillator detectors has been com-missioned for detection of cosmic ray air showers at an altitude of about 2200 meters above sea level in the Himalayas at the Centre for Astroparticle Physics & Space Sciences, Darjeeling campus of Bose Institute. The detector system is continuously measuring the number of cosmic ray showers. From this array it has been found that at an altitude of about 2200 meter the average air shower rate is ~ 1.65 Hz with an RMS of 0.24 and the7-fold coincidence rate has been found to be ~ 0.04 Hz with anRMS of 0.02.So far the detector system has been operated using a NIMelectronics system where the data acquisition is done manually.
- In a new study, two widely used methods of determining the etch-rate ratio in poly-ethylene terephthalate (PET) nuclear track detector are compared. Their application in different regimes of ion's energy loss has been investigated. A new calibration curve for PET is also presented.
- A study was conducted on atmospheric carbonyl compounds for the first time over a Himalayan atmosphere in India. Samples were collected from a high altitude hill station, Darjeeling (27.01°N, 88.15°E, 2200 masl) during June 2012 to May 2013. 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 the dominant species for its higher photochemical production from its precursor volatile organic compounds emitted from tea plants and tea processing units. Interestingly, the concentration of acetaldehyde and formaldehyde were found to be comparable with metro cities of India and world. The carbonyl compounds showed highest loading during postmonsoon when the solar radiative flux was minimum. Meteorological parameters like temperature and surface reaching solar radiative flux played the major roles for the seasonal variation of the carbonyl concentration over the hill station. Positive matrix factorization model showed that the biogenic emissions from tea plants and vehicular emissions were the major sources of carbonyl compounds over the hill station.
- The temporal variations and major sources of polycyclic aromatic hydrocarbons (PAH) intrinsic to PM_{10} were investigated over a tropical urban atmosphere on the Indo-Gangetic Plain (IGP) and for the first time over a high altitude urban atmosphere at eastern Himalaya in India. Samples were collected over Kolkata, a megacity and Darjeeling during the dry season (October 2015–May 2016). Fourteen PAHs were detected and quantified over Kolkata and Darjeeling during post-monsoon, winter and pre-monsoon. The maximum loading was observed during winter at Kolkata, whereas post-monsoon showed maximum loading at Darjeeling. The observed seasonality of PAHs at Kolkata *vis-a-vis* Darjeeling has been explored in the light of anthropogenic activities, boundary layer dynamics and meteorological parameters such as temperature, relative humidity, wind speed and solar radiation. The positive matrix factorization (PMF) model identified that the coal (26%), petrol (24%) and diesel (17%) combustion,

commercial and household kitchens (18%) and municipal solid waste incineration (15%) are the possible contributors to the PM_{10} associated PAHs over Kolkata whereas diesel (37%), commercial and household kitchens (23%), coal (21%) and petrol (20%) are the possible PM_{10} associated PAH sources over Darjeeling

- Studies have been conducted to investigate the effect of the interaction between marine sea-salt aerosols and the polluted anthropogenic aerosols over high altitude Himalaya and Kolkata metro city at IGP. We observed that the huge amount of chloride was substituted from the sea-salt aerosols when marine aerosols interacted with the anthropogenic sulphate aerosols during monsoon. We observed that such interactions varied in different degrees and the function of the distance from the sea-coast.
- In a separate study, the process of exchange of Greenhouse gases like CO_2 and H_2O vapour between biosphere and atmosphere has been investigated for the first time at an eastern Himalayan site in India. The study was carried out over a high altitude (2286 m asl) evergreen coniferous forest (27.04 ºN, 88.08 ºE) where we measured the fluxes of CO_2, H_2O vapour along with the sensible and latent energy using eddy covariance method both above (38 m) and within (8 m) the canopy, soil-CO2 flux and the vertical profile of CO_2 during spring (March-April) in 2015. The mean eddy flux of CO_2 above the canopy was -2.8 ± 6.5 μmol m^{-2} s^{-1} whereas that within the canopy was 0.6 ± 0.4 μmol m^{-2} s^{-1}. The mean flux of H_2O vapour above the canopy (1.5 ± 1.8 mmol m^{-2} s^{-1}) was three times higher than within the canopy (0.5 ± 0.6 mmol m^{-2} s^{-1}). The mean flux of CO_2 emitted from the soil surface was 1.6 ± 0.1 μmol m^{-2} s^{-1}. The diurnal variation showed high sequestration of CO_2 during daytime when the negative flux increased to larger than -10 μmol m^{-2} s^{-1}. We observed that precipitation significantly enhanced CO_2 sequestration (by ~four folds) as well as H_2O vapour emissions (by ~three folds) by the tall canopies. Overall, during the entire study period the net ecosystem exchange (NEE) was -656.5 g CO_2 m^{-2} suggesting that the evergreen coniferous forest at eastern Himalaya acts as a net sink of CO_2 during spring. This would enable us to estimate the sequestration of anthropogenic carbon emission by the eastern Himalayan forest ecosystem and contribute to the national greenhouse gases inventory.

Centre for Translational Animal Research (Central Animal House & Research Facility) (CTAR/CAF)

(The Centre was inaugurated by Dr. Harsh Vhardhan, Honorable Union Minister, Ministry of Science & Technology & Earth Sciences, Govt. of India on 2nd May, 2015)

CPCSEA, Ministry of Environment, Forests & Climate Change, Govt. of India Registration Number: 1796/GO/EReBiBt/S/14/CPCSEA (Education, Research for Educational purpose, Breeding in-house and breeding for trading of small animals)

This is a state of the art translational animal research centre with environmentally controlled "Centralized Animal House" for Developmental and Toxicology Research" along with all facilities for breeding, maintenance, experimentation on small laboratory animals and it has been exclusively developed in a plinth area of 15,000 sq. ft. This Animal facility will be utilized for experimental research in accordance with the principles of good laboratory practices and CPCSEA, Ministry of Environment, Forest & Climate Change, Government of India guidelines. Further, it facilitates research and development in partnership with academic Institutions, Industries and funding agencies for drug discovery-cum-validation and devices of translational medical research with the basic objective of advancement of biological knowledge which is useful for saving the lives and /or alleviating the suffering of human being, animals and plants. However such experiments are performed with due care so as to minimize the pain inflicted on animals. The Centre is also involved in skilled manpower development through education and training in laboratory animal care and experimental techniques. The main objective of the Centre is to supply defined strains of laboratory animals like mice, rats, guinea pigs, hamsters and rabbits for Bio-medical Research to the scientific community of Bose Institute and other Institutes of the Eastern and North eastern part of India.

In house Facilities:

All the animal rooms in CTAR/CAF have a controlled environment with 20-26°c temperature, 50-60 relative humidity, 0.3 micron HEPA filtered air supply at 15-20 ACPH and 12/12 light/dark cycle maintained. The CTAR/CAF maintains most mouse rooms under Specific Pathogen Free (SPF) conditions. Health monitoring of the animal colonies is done every quarter. Depending on the requirements of the approved research protocol, the CTAR imports new strains of animals from commercial suppliers and/or collaborators from abroad. The CTAR/CAF handles breeding, maintenance and supply of healthy laboratory animals to support the ongoing research of Bose Institute. In addition, the CTAR/CAF provides orientation and training to all authorized animal facility users to assure high standards of humane, ethical and responsible use of animals in their research. It also provides veterinary assistance including anesthesia of animals, surgical procedures on animals, Post-operative care of animals, collection of biological samples, administration of medications and treatments, and record keeping as per Govt. of India regulations.

The CTAR/CAF is dedicated to provide quality laboratory animals for research and 24 hX7d caring of animals.

All projects run in the CTAR are cleared by the **Institutional Animal Ethics Committee** (IAEC, duly constituted by CPCSEA, Ministry of Environment, Forest & Climate Change, Govt. of India, Registration Number: 1796/GO/EReBiBt/S/14/CPCSEA (Education, Research For Educational purpose, Breeding in-house and breeding for trading of small animals).

The CTAR/CAH currently houses four species of laboratory animals:

Mice (In breed Swiss, BALB/C, C57BL/6J & N:NIH(S) NUDE (ATHYMIC)), **Rats** (out bred stocks like Wistar, Sprague Dawley, **Rabbit (**New Zealand White (Out Bred)) and **Guineapigs** (Dunkin Hartley (Out Bred), NIH: Coloured (Out Bred)).

- **Animal allotted for research : 3640**
- **Rabbit/mouse polyclonal antibody produced : 41**
- **Trained manpower : 12**
- **Students training : 68**
- **Total IAEC approved project : 124**
- **Disease model : Tumor, Diabetes, Obesity, Ulcer, Allergy, PCOS, Cyptorchidism and wound model.**

In house guidelines

All Principal Investigators requesting the use and services of CTAR/CAH facilities, their projects should be approved by the **Institutional Animal Ethics Committee (IAEC).**

- All the animal facility users should undergo orientation and training in proper handling and management of animals.
- Animal work should be started only after the IAEC approval of the research project.
- The approved protocol should be strictly followed; any modification in the protocol should be cleared by the IAEC.
- Only authorized people are allowed to enter the animal block with all the protective clothing - apron, cap, facemask and designated sandals.
- Experiments should be performed with due care and humanity.
- All the animal users should follow Russell and Burch's 3 'R's concept (Refinement: minimize pain and suffering of the animals by using appropriate anesthetics and analgesics. Reduction: use of fewer animals without compromising scientific output, quality of research and animal welfare. Replacement: use non-sentient materials which replace the use of conscious living vertebrate animals completely or partially or relatively).

The Scientist-in-Charge/Veterinarian should be kept informed of animal use plans, especially animal orders and breeding requirements, well in advance.

IAEC approval of the research project:

1) For NEW Projects: please fill and submit the **"IAEC-BI- Form B.**
2) For ongoing projects reaching their "IAEC approved end date" (3rd year); Project extensions/renewals need to be resubmitted via a new "IAEC-BI-Form B" application as well.

   The IAEC meets twice a year: (usually June/July and December/January). So do make sure your project renewals are requested and approved before the original IAEC approved end date.
3) If your project reaches its 1st or 2nd year then you will need to submit the **"IAEC-BI-project yearly progress report".**
4) Any ongoing project modifications (in the numbers /strains of experimental animals to be used, procedures to be operated on animals (surgeries, irradiation, etc.), new drugs/chemicals to be applied/administered... etc), new collaborators or end animal users added to the project need to be specified and re-submitted as well in the **Form B format** clearly highlighting the project modifications/add-ons from the original proposal in a specific color.
5) The **"IAEC-BI-Animal import request form"** is to be filled if your project involves the import of new live animals. Please complete and submit **"IAEC-BI-requisition form"** to order animals for your research purposes. Request must be made at least 60 business days prior to start of your desired experimental schedule.
6) Please note that **IBSC (Bio-safety)** approval is required for most animal based research projects and for the use of related bio-hazardous drugs/reagents or procedures.

Please do make sure your animal based research project is also submitted and approved by the IBSC if required. Please take extra care that your IBSC projects and corresponding IAEC projects have identical project titles.

List of different IAEC Forms and Documentations:

1. **IAEC-BI-Form-B**
2. **IAEC-BI-Form C & D**
3. **IAEC-BI-Animal requisition Form**
4. **IAEC-BI Animal import Form**
5. **IAEC-BI-annual progress report**

Management:

There are two in-house regulatory bodies, governing the Centre and the use of all animals on campus: the **Independent Management Committee** and the **Institutional Animal Ethics Committee (IAEC)**.

1. Independent Management Committee

• The Director, Bose Institute	:	Chairman
• Prof. Gaurisankar Sa, DMM (Director's Nominee)	:	Executive Chairman
• Dr. Gaurab Gangopadhyay, DPB	:	Member
• Dr. Kaushik Biswas, DMM	:	Member
• Mrs. Noreen Bhattacharjee, Dy. Registrar	:	Member
• Shri Sumanta Ghosh, Jr. Overseer	:	Member
• Dr. Kuladip Jana, DMM	:	Scientist-In-Charge

2. Institutional Animal Ethics Committee (IAEC)

• Prof. Gaurisankar Sa, DMM	:	Chairman
• Prof. Debabrata Basu, DPB	:	Member
• Dr. Sudipta Saha, Bio-Infomatics	:	Member
• Prof. P. K. Samanta	:	Veterinarian
• Dr. Kuladip Jana, DMM	:	Scientist-In-Charge
• Dr. Soumendra Darbar	:	CPCSEA main Nominee
• Dr. Sarbani Hazra	:	CPCSEA Link Nominee
• Dr. Anupindi Raghuram	:	Outside Scientist Nominee
• Dr Sharmistha Biswas	:	Socially Aware Nominee

Future Plan of the Centre

In view of global competitiveness, there is an urgent as well as strong need to synthesise molecules as new chemical entities which may be considered for IPR protections provided data on these entities can be generated in specific genetically engineered strains, species and animal models for disease like diabetes, hyperlipidaemia, hypertension, immunodeficiency and cancer etc. It becomes crucial for the laboratories to develop facilities where these activities are thoroughly evaluated and labs are able to provide data, which is acceptable to regulatory authorities. Unless we able to get these opportunities more within the Country, it would be extremely difficult for the Scientists as well as institutions to obtain global marketing rights for drugs**. Hence, it is an utmost need to set up here a state-of-the-art well-equipped transgenic/ knockout/ Xenograft mouse laboratory for the Scientists of Eastern & North Eastern part of India.**

Contact

Centre for Translational Animal Research
(Centralized Animal Facility)
Madhyamgram Experimental Farm
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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 (2017-2018)

Characterization of carbonyl compounds over eastern Himalaya in India:

A study was conducted on atmospheric carbonyl compounds for the first time over a Himalayan atmosphere in India. Samples were collected from a high altitude hill station, Darjeeling (27.01°N, 88.15°E, 2200 masl) during June 2012 to May 2013. 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 the dominant species for its higher photochemical production from its precursor volatile organic compounds emitted from tea plants and tea processing units. Interestingly, the concentration of acetaldehyde and formaldehyde were found to be comparable with metro cities of India and world. The carbonyl compounds showed highest loading during postmonsoon when the solar radiative flux was minimum. Meteorological parameters like temperature and surface reaching solar radiative flux played the major roles for the seasonal variation of the carbonyl concentration over the hill station. Positive matrix factorization model showed that the biogenic emissions from tea plants and vehicular emissions were the major sources of carbonyl compounds over the hill station.

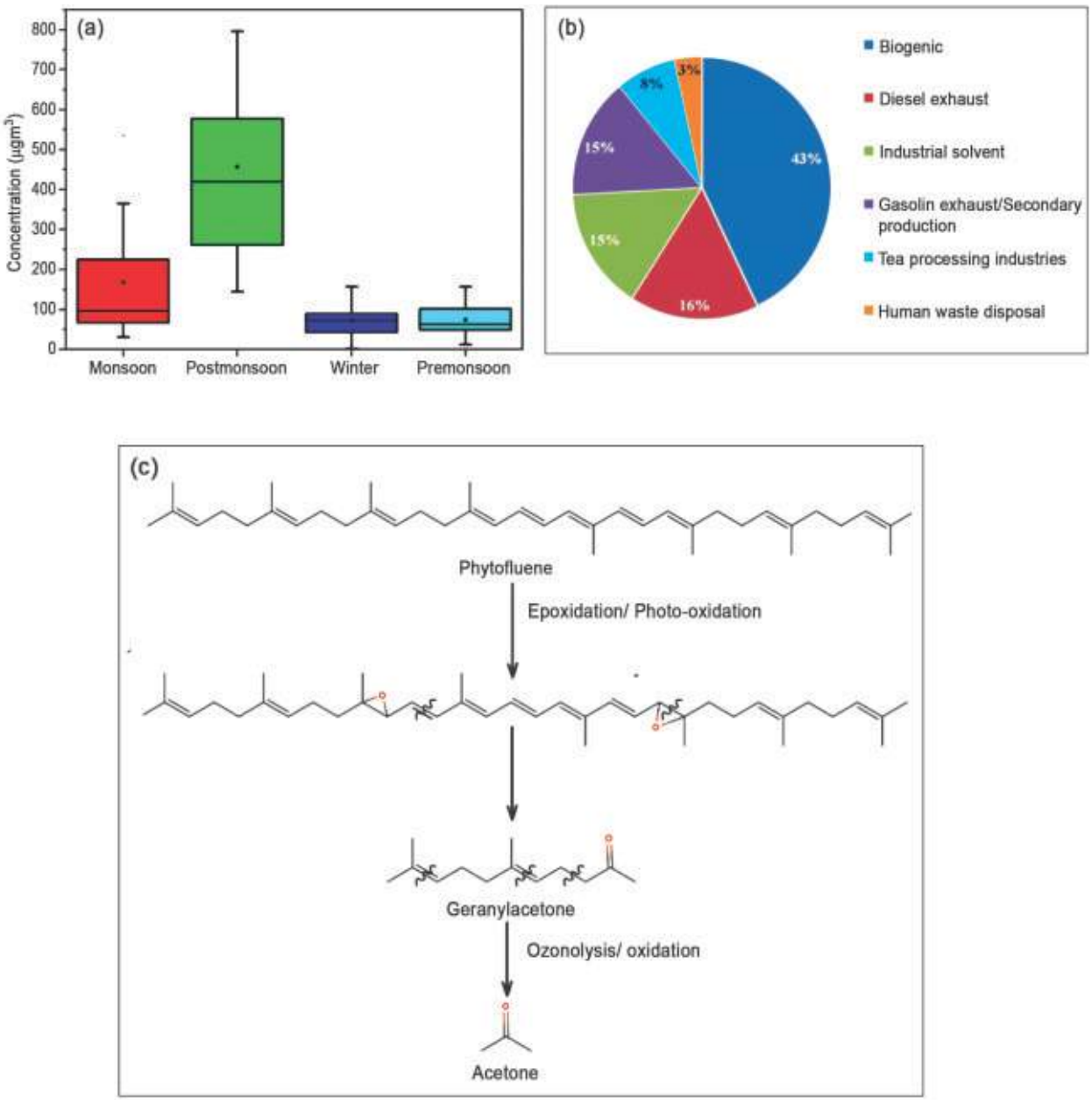


Fig 1: Temporal variation of carbonyl compounds, sources of carbonyl compounds and formation of acetone from Tea leaves over eastern Himalaya, India

Polycyclic aromatic hydrocarbons over a tropical urban and a high altitude Himalayan Station in India: Temporal variation and source apportionment:

The temporal variations and major sources of polycyclic aromatic hydrocarbons (PAH) intrinsic to PM_{10} were investigated over a tropical urban atmosphere on the Indo-Gangetic Plain (IGP) and for the first time over a high altitude urban atmosphere at eastern Himalaya in India. Samples were collected over Kolkata, a megacity and Darjeeling during the dry season (October 2015–May

2016). Fourteen PAHs were detected and quantified over Kolkata and Darjeeling during post-monsoon, winter and pre-monsoon. The maximum loading was observed during winter at Kolkata, whereas post-monsoon showed maximum loading at Darjeeling. The observed seasonality of PAHs at Kolkata *vis-a-vis* Darjeeling has been explored in the light of anthropogenic activities, boundary layer dynamics and meteorological parameters such as temperature, relative humidity, wind speed and solar radiation. The positive matrix factorization (PMF) model identified that the coal (26%), petrol (24%) and diesel (17%) combustion, commercial and household kitchens (18%) and municipal solid waste incineration (15%) are the possible contributors to the PM_{10} associated PAHs over Kolkata whereas diesel (37%), commercial and household kitchens (23%), coal (21%) and petrol (20%) are the possible PM_{10} associated PAH sources over Darjeeling

Hygroscopic Coating of Sulfuric Acid Shields Oxidant Attack on the Atmospheric Pollutant Benzo (a) pyrene bound to Model Soot Particles:

The interactions between the soot and sulfuric acid (H2SO4) significantly change the optical and chemical properties of soot particles and hence the substantial impacts on climate are observed. However, the influence of H2SO4 on heterogeneous chemistry on soot remains unexplored. Several studies earlier have reported the oxidation rate coefficients for particulate polycyclic aromatic hydrocarbons which seem to overestimate their degradation in ambient atmosphere. This could be due to matrix effects which are hitherto not mimicked in laboratory experiments. For the first time, we have conducted a kinetic study which reports significant influence of H2SO4 coating on heterogeneous ozonation of benzo(a) pyrene (BaP) deposited on model soot, representative to atmospheric particles. The approximate specific surface area of model soot was estimated as a measure of the availability of surface molecules to a typical gaseous atmospheric oxidant. Heterogeneous bimolecular reaction kinetics and Raman spectroscopy studies suggested plausible reasons for decreased BaP ozonation rate in presence of H2SO4: 1. decreased partitioning of O3 on soot surface and 2 shielding of BaP molecules to gaseous O3 by acid-BaP reaction or O3 oxidation products.

Interaction between marine and anthropogenic aerosols over eastern Himalaya and urban atmosphere at IGP:

We conducted studies in order to investigate the effect of the interaction between marine sea-salt aerosols and the polluted anthropogenic aerosols over high altitude Himalaya and Kolkata metro city at IGP. We observed that the huge amount of chloride was substituted from the sea-salt aerosols when marine aerosols interacted with the anthropogenic sulphate aerosols during monsoon. We observed that such interactions varied in different degrees and the function of the distance from the sea-coast.

Interaction between the size-segregated aerosols and the size-segregated rain drops:

We conducted studies where we investigated how the aerosols of different size ranges get scavenged by the rain drops of different diameters. To do this we continuously monitored the number concentrations of size-segregated aerosols and the size-segregated raindrops during several rain events during monsoon 2015-2017. The other physical parameters associated with the rain like rain rate, drop velocity, cloud heights etc were also investigated.

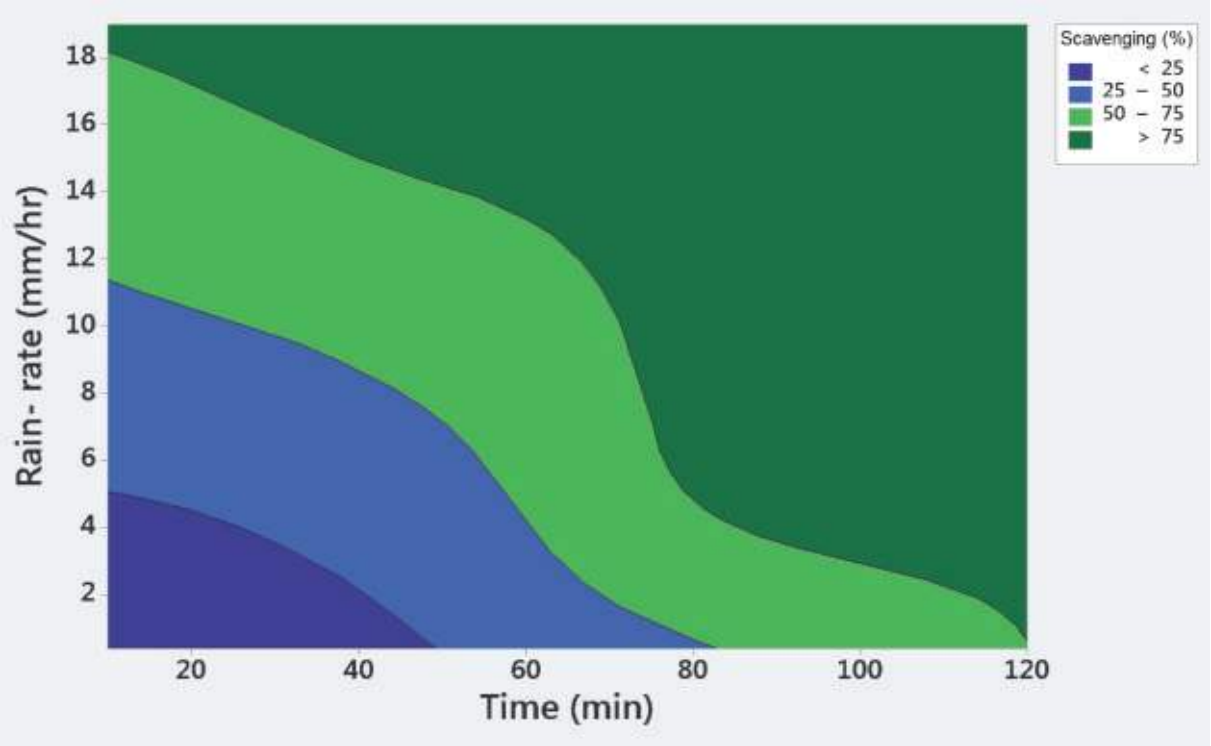


Fig 2: Aerosol scavenging depending on duration and types of rain

Exchange of Greenhouse Gases between the biosphere and the atmosphere at eastern Himalaya, India:

We investigated how the Greenhouse gases like CO_2 and H_2O vapour are exchanged between biosphere and atmosphere for the first time at an eastern Himalayan site in India. The study was carried out over a high altitude (2286 m asl) evergreen coniferous forest (27.04 ºN, 88.08 ºE) where we measured the fluxes of CO_2, H_2O vapour along with the sensible and latent energy using eddy covariance method both above (38 m) and within (8 m) the canopy, soil-CO2 flux and the vertical profile of CO_2 during spring (March-April) in 2015. The mean eddy flux of CO_2 above the canopy was -2.8 ± 6.5 μmol m^{-2} s^{-1} whereas that within the canopy was 0.6 ± 0.4 μmol m^{-2} s^{-1}. The mean flux of H_2O vapour above the canopy (1.5 ± 1.8 mmol m^{-2} s^{-1}) was three times higher than within the canopy (0.5 ± 0.6 mmol m^{-2} s^{-1}). The mean flux of CO_2 emitted from the soil surface was 1.6 ± 0.1 μmol m^{-2} s^{-1}. The diurnal variation showed high sequestration of CO_2 during daytime when the negative flux increased to larger than -10 μmol m^{-2} s^{-1}. We observed that precipitation significantly enhanced CO_2 sequestration (by ~four folds) as well as H_2O vapour emissions (by ~three folds) by the tall canopies. Overall, during the entire study period the net ecosystem exchange (NEE) was -656.5 g CO_2 m^{-2} suggesting that the evergreen coniferous forest at eastern Himalaya acts as a net sink of CO_2 during spring. This would enable us to estimate the sequestration of anthropogenic carbon emission by the eastern Himalayan forest ecosystem and contribute to the national greenhouse gases inventory.

Grants-in-Aid Schemes

Title of Project	*Project funded by*
1. Understanding the Role of Local and Transported Biogenic and anthropogenic Aerosols on Microphysical and Chemical Properties of Low-level Clouds over Eastern Himalaya, India	DST
2. Study on Biosphere-Atmosphere Exchange of Carbon dioxide, Water Vapor and Energy in a Tropical High Altitude Forest Canopy at Eastern Himalaya, India	MoES
3. National Carbonaceous Aerosol Program (NCAP)-	MoEFCC
4. Study of Cosmic ray interactions and Cosmic Ray – Aerosol – Cloud connection it the context of regional climate change	DST

Publications

***International peer-reviewed journals*:**

1. Ray D, Bhattacharya TS, Chatterjee, A, Singha, A, Ghosh, S K, & Raha S (2018) Hygroscopic Coating of Sulfuric Acid Shields Oxidant Attack on the Atmospheric Pollutant Benzo (a) pyrene Bound to Model Soot Particles. *Scientific reports*, *8*(1), 129.
2. Ray D, Chatterjee A, Majumdar D, Ghosh SK, & Raha S (2017) Polycyclic aromatic hydrocarbons over a tropical urban and a high altitude Himalayan Station in India: Temporal variation and source apportionment. *Atmospheric Research*, *197*, 331-341.
3. Sarkar C, Chatterjee A, Majumdar D, Roy A, Srivastava A, Ghosh S K, & Raha S (2017) How the Atmosphere over Eastern Himalaya, India is Polluted with Carbonyl Compounds? Temporal Variability and Identification of Sources *Aerosol and Air Quality Research*, *17*(9), 2206-2223.

Conference publications

1. Ghosh A, Chattejee A, Roy SK, Ghosh A, Raha S (2017) Effect of shifting cultivation activity over Eastern Ghat and adjacent areas on air quality over a tropical urban atmosphere in eastern india during pre-monsoon, 2016. *Aerosol Climate Change Connection (AC3),* Darjeeling, 25 – 27 April.
2. Ghosh A, Chattejee A, Roy A, Ghosh SK, Raha S (2017) Effect of downwind transported bio mass burning aerosols over Eastern Ghats and adjacent places on the air quality of a tropical urban atmosphere in eastern India during pre-monsoon 2016. *Understanding, predicting and projecting the climate change over Asian region* (UPCAR), Tirupati, 26-28 June.
3. Ghosh A, Chattejee A, Roy A, Ghosh SK, Raha S (2017) Temporal variability of aerosol size distribution over a high altitude Himalayan station in India. International Tropical Mereorology symposium, Ahmadabad, 7-10 November.

4. Sarkar C, Chatterjee A, Roy A, Ghosh A, Ghosh SK, Das SK, Raha S (2017) Long-term trend of PM2.5 and black carbon aerosols over eastern Himalaya in India; effect of meteorological parameters and long-range transport. *Aerosol Climate Change Connection (AC3)*, Darjeeling, 25 – 27 April.
5. Interactions Between Sea-Salt and Anthropogenic Aerosols over a Tropical Urban and High Altitude Himalayan Atmosphere in India. Asia Oceania Geosciences Society, 3-8 June, 2018.
6. Aerosol-Rain Interaction and its Impact on the Rainwater Acidity over Eastern Himalaya in India. Asia Oceania Geosciences Society, 3-8 June, 2018.
7. Effect of Aerosol on Fair Weather Electric Field at a High Altitude Station in Eastern Himalayas. Asia Oceania Geosciences Society, 3-8 June, 2018.
8. A New Approach to Analysis of Rain-Drop Size Distribution over Hill-Top Region in the Himalayas. Asia Oceania Geosciences Society, 3-8 June, 2018.

Falta Experimental Farm

The main activity of Falta Experimental Farm of Bose Institute is primarily to control the Rural Biotechnology Programme/Scheduled tribe Specific Rural Biotechnology Programme (RBP/STSRBP) of the Institute. Planning and monitoring the whole programme are done from this centre. Demonstration programmes of most of the projects taken up in the RBP/STSRBP are maintained at this centre. Regular training programmes are also organized at this centre for the NGO peoples and beneficiaries. In 2017-18 four training programmes (2-8 May 2017, 23-29 May 2017, 12-16 March 2018 and 19-23 March 2018) were organized at Falta Experimental Farm and 106 trainees were trained on various aspects of Rural Biotechnology Programme. In 2017-18 thirty-five NGOs were provided fund to work under STSRBP. The work under this programme was going on in 140 villages covering 6 districts of West Bengal namely Purulia, Bankura, Birbhum, Jhargram, Paschim Medinipur& South 24 Parganas. About 2,300 tribal families were directly benefitted from this programme. Through 35 NGOs almost 105 supervisor/village trainers were involved to look after the project work. As a part of Centenary Celebration of Bose Institute (1917-2017) a conference on "Rural Biotechnology Programme and Economic Development of Scheduled Tribe People, Present Status and Future" was organised at this farm during 11-13 February 2018.

In the FY 2017-2018eight Animal Health Camps were organized under the Scheduled Tribe-Specific Rural Biotechnology Programme in different project sites. Our Resource persons, veterinary surgeon Dr.NiharKanti Ghosh and Dr.Asim Prasad Chattopadhyay and other resource persons and project staffs conducted those Animal Health Camps in collaboration with Animal Resource Department, Government of West Bengal. 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	Pig	Hen/ duck	Total
1.	02.11.17	Jujardhara, Block: Binpur II, Jhargram, W.B.	37	66	303	2	494	865
2.	03.11.17	Kankrajhore, Amlasol, Block: Binpur II, Jhargram, W.B.	60	185	534	24	925	1668
3.	03.11.17	Bagdoba, Block: Binpur II, Jhargram, W.B.	28	47	134	10	400	591
4.	06.11.17	Chowbatta, Block: Md. Bazar, Birbhum, W.B.	91	259	209	106	620	1194
5.	07.11.17	Bagdola, Block: Md. Bazar, Birbhum, W.B.	72	100	140	31	303	574
6.	07.11.17	Tildanga, Block: Md. Bazar, Birbhum, W.B.	82	92	194	-	553	839
7.	09.11.17	Dakshin Durgapur, Patharpratima, South 24 Parganas	104	124	182	03	1096	1405
8.	10.11.17	Krishnapur, Patharpratima, South 24 Parganas, W.B.	113	139	188	19	1281	1627
		TOTAL	**587**	**1012**	**1884**	**195**	**5672**	**8763**

The following Table depicts the year-round activity done through different NGOsin the FY 2017-2018

Sl. No.	Name of the Programme	No. of Units
1.	Chicken rearing	470
2.	Duck rearing	104
3.	Goat rearing	352
4.	Sheep rearing	13
5.	Pig rearing	88
6.	Fishery	204
7.	Bee-keeping	13
8.	Mushroom	76
9.	Vermicompost	149
10.	Agriculture (in bigha)	405
11.	Kitchen gardening	122
12.	Orchard (in bigha)	17
13.	Concrete Tank for rainwater harvesting for drinking	232
14.	Polypond for rainwater harvesting for irrigation	1
15.	Food processing	1
16.	Crab Culture	29
17.	Betel Leaf Cultivation	4
18.	Concrete pond	2
19.	Toilet construction	18
	Total	2,300

Some programme-wise photographs and brief descriptions are given below:

Fig. 1: Glimpses of students' participation in the Scheduled Tribe Specific Rural Biotechnology Programme. a) Construction of rain water harvesting tank for drinking purpose was encouraged to the NGOs in the project site to educate and aware tribal students about harvesting of rain water for drinking purpose. Three to five tanks were constructed per school in the project site of most of the NGOs. Students and teachers were standing in front of the rain water harvesting tanks in AgayaPrathamik Vidyalaya, Birbhum (a) and Bhutadhi Primary School, Purulia (b); c) In Bhutadhi Junior High School students were taking part in nutrition gardening; d) In HuchukparaPrathamik Vidyalaya, Birbhum students had taken part in mushroom cultivation and the students were standing with their fully mature mushroom beds. These mushrooms were utilized by the school in the Mid-Day Meal programme.

Animal Health Camp:

Fig. 2: Photographs of different activities of Animal Health Camp. a) Inaugural programme of the Animal Health Camp organized at Dakshin Durgapur, Pathar Pratima, South 24 Parganas on 09.11.2017; b) Dr. Asim Prasad Chattopadhyay, Resource Person in STSRBP, BI and other project personnel were distributing medicines to the beneficiaries for their domestic animals at Krishnapurvillage, Pathar Pratima, South 24Parganas on 10.11.2017; c) Dr. NiharKanti Ghosh, resource person Bose Institute was giving vaccine to the cows at Chowbatta village, Md. Bazar Block, Birbhum on 06.11.17; d) Project personnel of Bose Institute was giving vaccine to goats and sheep at Dakshin Durgapur, Pathar Pratima, South 24 Parganas on 09.11.2017. Eight Animal Health Camps were organized in 2017-18 and 587 beneficiaries brought their domestic animals (8,763 Nos) in the camps and the animals were either vaccinated or provided with preventive medicines.

Orchard Programme:

Fig. 3: Different activities on orchard programme. a) Tribal beneficiaries were mixing fertilizers for manuring orchard plants planted one year ago at Basantapur village, Purulia. This has been done as a part of maintenance work of the orchard; b) The tribal beneficiaries were carrying mixed manures for manuring the orchard plants.

Agriculture Programme:

Fig. 4: a) A tribal beneficiary in his agriculture field at Pathar Pratima, South 24 Parganas. He cultivated green chilli, a major cash crop in Sunderban belt; b) A tribal beneficiary with a broccoli grown in her agriculture field at Birbhum; c) A tribal beneficiary showing her harvested capsicum at Kankrajhor village, Jhargram.

Animal Husbandry Programme:

Goat Rearing:

Fig. 5. Photographs of Animal Husbandry Programme at different project sites. Distribution of goats in the goat rearing programme atLakshmijanardanpur (a) and Kasiabadh village, South 24 Parganas (b); c) One beneficiary with her goats received from the project at Purandhi village, Md. Bazar, Birbhum.

Chicken & Duck rearing:

Fig. 6. a) Distribution of chicken birds to the tribal beneficiary at Paschim Dwarakapur, Pathar Pratima, South 24 Parganas; b) One beneficiary with her reared chickens at Sunderban; c) One tribal beneficiary at Jhalda, Purulia with her ducklings received from the project.

Some Success Stories Under The Scheduled Tribe Specific Rural Biotechnology Programme:

Success story 1 (SS-1): Ganesh Majhi of Krishnadaspur village, Block –Pathar Pratima, Dist-South 24 Parganas was provided financial support (₹ 70,000/-) to set up a Betel leaf cultivation unit in his 7 katha land. Sri Majhi's contribution in this project were his labour and ₹ 40,000/-. After one year he became a successful betel leaf cultivator in the Sundarban area. Production of betel leaf from his unit is 20,000 pcs per month which has a market value of ₹ 800/- per 1000 pcs leaves. His annual income is about ₹ 1,92,000/-.

Success story 2 (SS-2): BudhanKisku of Palshdanga village, Block-Sainthia, Dist- Birbhum cultivated pea, tomato and green chilly in his 10 katha land in agriculture programme as per our technical guidance and he earned approximately ₹ 25,000/- by selling the crops. He had been given financial support of ₹ 6,000/- in the form of seeds, manure, pesticides and other cultivation support from the project.

Success story 3 (SS-3): Vermicompost production is a very successful project that has been taken up under the Scheduled Tribe Specific Rural Biotechnology Programme of Bose Institute. It has great implication in organic crop production. Through this project Bose Institute is trying to develop awareness and expansion of vermicompost production among the tribal beneficiaries. LaksmiKanta Mura of Amlasol village, Block –Binpur-II, Dist- Jhargram started Vermicompost program last year after getting financial and technical support from Bose Institute. Bose Institute helped Sri Mura in constructing vermicompost pit and provided him required earthworm and other materials worth ₹ 15,600/-. Mr. Mura has sold earthworms to Binpur-II Block Development Office as well as the project beneficiaries, worth ₹ 18,000/- He has utilized 10 quintal vermicompost into his own agriculture fields which has a market value of ₹ 10,000/-. Moreover, he has a stock of 2 quintal vermicompost along with 60,000 pcs of earthworms which has a market value of ₹ 2,000/- + ₹ 30,000/- = ₹ 32,000/-. So, the total income generated through this program is ₹ 60,000/-.

Success story 4 (SS-4): With the help of financial and technical support from Bose Institute through the NGO, AlorSparshaw Welfare Society Sri SanatonKisku of Molladanga village, Sian, Dist- Birbhum undertook vermicomposting programme. Mr. Kisku sold earthworms to other tribal beneficiaries involved in the project and earned ₹12,000/-. He also earned ₹ 8,600/- by selling vermicompost. He utilized 5 quintal vermicompost worth ₹ 5,000/- in his own agriculture field. Moreover, he has a stock of 8 quintal vermicompost worth ₹ 8,000/- along with 20,000 numbers of earthworms worth ₹ 10,000/-. So, his total income from this project is about ₹ 43,400/-. Mr. Kisku got material support worth ₹ 15,200/- from the project.


SS-5


SS-6

Success story 5 (SS-5): Sri Robin Murmu of Ghosaldanga village, Block –Sriniketan, Dist- Birbhum cultivated Potato in his 8 katha land in the agriculture programme under Scheduled Tribe Specific Rural Biotechnology Programme of Bose Institute through the NGO, GhosaldangaAdibasiSeva Sangha. Sri Murmu got material support in the form of disease free potato seeds (60 kg) and fertilizers worth ₹ 2,610/- from Bose Institute through the NGO. Sri Murmu's inputs in this project

are his labour and ₹ 4,640/-. Sri Murmu sold the total harvest (50 kg x 30 bags of potato) in the local market @Rs:700/- per 50 kg bag and earned ₹ 21,000/-.

Success story 6 (SS-6): Mushroom cultivation in Paschim Sundalpur High School, Vill- Paschim Sundalpur, Block-Sainthia, Dist-Birbhum. The NGO, AlorSparshaw Welfare Society successfully implemented this project through school students and teachers. Harvested mushrooms are used to prepare curry to feed 300 students once in a week for three months in the winter season in the Mid-Day Meal of the school.


SS-7


SS-8

Success story 7 (SS-7): Crab Cultivation, Beneficiary: Sukumar Bhakta of Paschim Dwarikapur village, Block-Pathar Pratima, Dist- South 24 Parganas. Sri Bhakta got the support of ₹ 10,800/- in terms of various components necessary for crab cultivation. He earned ₹ 47,786/- by selling crabs in the Pathar Pratima market and he has a plan for crab cultivation in double scale in the next year.

Success story 8 (SS-8): Sri Mohan Hembram of Ghosaldanga village, Block –Sriniketan, Dist-Birbhum, undertook fishery programme in his 20 katha pond through the NGO, GhosaldangaAdibasiSeva Sangha with technical and financial support (₹ 15,170/-) of Bose Institute. Earlier Sri Hembram's earning from the same pond was about ₹ 10,000/- per year. But in 2017 while he started this programme under the guidance of Bose Institute with necessary pond preparation components along with fingerlings(30 kg) he got 600 kg fish production worth 60,000/-.

Participation in Poush mela and Foundation Day of Bose Institute:

Fig. 7. a) Bose Institute participated in Poush Mela 2017 at Santiniketan to demonstrate its activities under Scheduled Tribe-Specific Rural Biotechnology Programme. Photograph showing gathering in the Bose Institute stall. Through this participation we could aware bigger mass regarding our Scheduled Tribe-Specific Rural Biotechnology Programme through live demonstrations and could help selling of products produced by the tribal beneficiaries working under this project. This participation also helped the beneficiaries to create market linkage; b) Last few years demonstration of activities under Scheduled Tribe-Specific Rural Biotechnology Programme were also exhibited during the Foundation day celebration programme of Bose Institute by displaying posters and live models. On 30th November 2017 Officiating Director, Prof. Siddhartha Roy and Prof. S.R Sikdar, Coordinator of Scheduled Tribe-Specific Rural Biotechnology Programme were visiting the stall.

Fig. 8. Some snap shots of the Conference on "Rural Biotechnology Programme &Economic Development of Scheduled Tribe People, Present Status & Future" organized as a part of Centenary Celebration of Bose Institute (1917-2017) at Falta Experimental Farm during 11-13 February 2018. a) Group photo of the participants on the inaugural day; b) lighting of the lamp by Dr. M.V. Rao, IAS, Additional Chief Secretary, Department of Co-operation, Government of West Bengal and Chief Guest, Dr. Ambika Charan Banerjee, Prof. S.R. Sikdar & Sri Sobhan Roy Chowdhury; c) Prof. Subrata Mazumder, Convener Centenary Celebration Committee, BI addressing to the audience during the inaugural programme; d) One NGO participant was taking part in discussion in the

interactive session; e) Prof. S.R. Sikdar was visiting an NGO stall at the conference venue; f) Prof. Sikdar was felicitating Prof. Dipankar Home, Chairman, Centenary Celebration Committee, BI & Officiating Director on that day; g) Prof. Sikdar was felicitating Mr. Hirak Ghosh, Retired IAS & Former Chairman, Advisory Committee, Rural Biotechnology Programme, BI; h) Prof. Dipankar Home was giving away participation certificate to one of the participants.

Conference Report: As a part of the Centenary Celebration of Bose Institute, Falta Experimental Farm organized a three-day long Conference at Falta Experimental Farm on "Rural Biotechnology Programme &Economic Development of Scheduled Tribe People, Present Status & Future" during 11-13th February 2018. Dr. M.V. Rao, IAS,Additional Chief Secretary, Department of Co-operation, Government of West Bengal inaugurated the programme as Chief Guest. Representatives from each of the 27 NGOs who were working under the Scheduled Tribe Specific Rural Biotechnology Programme of Bose Institute participated in the conference. Besides the inaugural address by Dr. M.V. Rao other speakers were Prof. Dipankar Home (Officiating Director, Bose Institute on that time and Chairman Centenary Celebration Committee, BI), Prof. Subrata Mazumder (Convener, Centenary Celebration Committee), Prof. S.R. Sikdar (Organizing Secretary of the Conference & Coordinator RBP/STSRBP, BI), Prof. Koustub Panda (CU), Prof. PapiyaNandy(Former Director JBNSTS)Prof. Samir KSamanta (Ex-Professor, BCKV), Dr.MahadebPramanick (BCKV), Dr. Rajib Nath (BCKV), Dr. B.K. Datta (Director, VIB, Nimpit), Sri SahadebBasak (Organic Farmer), Dr. Asim Prasad Chattopadhyay, Dr. K.C. Mandal, Dr. Anup K Datta, Smt. Srabani Sikdar, Sri L.C. Porel, Sri B. Bhakta (all are resource persons in Rural Biotechnology Programme of Bose Institute), Dr. Anup Mondal (Project Manager, RGCA/MPEDA), Sri Mahitosh Guha Biswas (Commercial Mushroom Spawn Producer). Mr. Hirak Ghosh, Retired IAS & Former Chairman Advisory Committee, Rural Biotechnology Programme, Bose Institute, Chair the Valedictory session. In all the three days there were special interactive sessionwith the NGO people. All the 27 NGOs presented their work through posters and some NGOs bring their products and sale in the stall.

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 of Acharya Jagadis Chandra Bose. Presently the Museum is a repository of the significant scientific instruments designed by J.C. Bose, commemorative items, and 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, Institutes and other Museums from both India and abroad 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. To commemorate the Centenary year, a large number of original Laboratory/ College notebooks have been digitized and kept on display during important occasions. 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.350.00; 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

T.K. Maji, Amitava Bhattacharya and Rajbrat Ram participated at i) the 21st National Science Exhibition at Agradoot Krirangan, New Barrackpore during

Somnath Das, T.K. Maji and **Rajbrat Ram** participated in the India International Science Festival (IISF-2017) at Anna University, Chennai held during 13.10.17 to 16.10.17.

Publication

Chatterjee, I. (2017) Preserving the Sacred Heritage of India through Museums. *J. of Indian Museums*, LXXI: 5, p.p. 38-41.

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 44,858 as on 31.03.2016 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 2017
Books	14858
Theses	591
Bound Volumes of Journals	28985

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 2017-2018:

- Book(s) added in 2017-2018 : 41 **nos.**
- Thesis added : 24 nos.

Available Back Volume Journals:

Elsevier Backfiles on Science Direct	Wiley Blackwell Journal Back files
1. Biochemistry, Genetics and Molecular Biology 2. High Energy Physics 3. Cell Press	1. Biotechnology, Biochemistry and Biophysics 2. Physics 3. Immunology 4. Microbiology

E. 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

F. Scientific Softwares Available:

Sl. No.	Software(s)	Publishers
1.	Grammarly@edu writing support Suite	Kite India
2.	Pathway Studio Plant Desktop	Elsevier
3.	Metamorph (Molecular Devices), Multiuser subscription.	Molecular Devices
4.	Gaussian09 for (Multiprocessor) Windows Version for 2 Users, Gauss VIEW 5 Windows Version for 2 users	Scube Scientific Software Pvt. Ltd.
5.	SPSS Software--- (2 users)	IBM India Pvt.Ltd.
6.	Sigma Plot 12- Five user perpetual license-1 Set	Systat Software Incorporation
7.	Vector NTI static non-expiring academic license A13786 X 2	Invitrogen BioServices India Pvt. Ltd.
8.	EndNote™ X8 Desktop Version for Windows & MAC	Thomson Reuters

G. 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
No. of Readers	5437
Internet Accessed (in hours)	22032
Photocopies	40020
Download of Articles (from Online Journals) (Approx.)	250000+

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 DeliveryService	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 Institute. 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 NewsWe 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.

Seminar on Predatory Journals on 23rd June 2017 at Lecture Hall, Bose Institute Centenary Campus, by Dr. Aditi Bandhyopadhya of Adelfi University, USA

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. Banhi Sikha Chaudhuri attended Indkoha: two-day International conference held on 26 – 27 August at Swami Vivekananda Auditorium, Heritage Institute of Technology, Kolkata as Chairperson of a Panel discussion on 'Experience in Using / Popularizing Koha'
- National Digital Library, IIT Kharagpur facilitate Dr. Banhi Sikha Chaudhuri for tireless contribution as a nodal officer (2018).
- Dr.Banhi Sikha chaudhuri selected for "Indira Priyadarshini Gold Medal Award-2017 by GEPRA,Tamilnadu

New Initiative

RFID Project : Stock verification is an important part of any library , particularly for an old establishment like Bose Institute Library. It was pending for a long time (from 1988). To solve such problem, this year we implemented RFID technology which will fully digitize Bose Institute Library. The project has already been initiated and work is going on. We have submitted a brief report to the audit.

Workshop

The Workshop as well as the Workshop Superintendent is the nucleus of the maintenance activities including the proposed projects at the seven campuses of the Bose Institute. Workshop is situated at Main Campus and its branches are i) Machine Shop ii) Carpentry section iii) Store iv) Transport & v) Electrical unit at main Campus and at Centenary Campus. The activities of the said units are as follows.

Machine Shop – The shop consists of a few nos. of lathe, shaping, drill, grinding machine etc. This shop is actually named as mechanical section because under the umbrella of this section there are some other units like fabrication wing, the wing where the prototype models of the instruments (using which Sir J.C.Bose conducted his various famous experiments) as well as various types of instruments like gradient mixtures, gel tray etc. are being manufactured against the requisitions of internal Scientist and Officers.

Carpentry Section- This section deals with all furniture manufacturing, repairing jobs etc as per the requirements of Scientists, officers etc.

Store- Workshop store maintains the materials (civil, electrical, mechanical ,plumbing, building and furniture related materials etc. required for all seven campuses.

Transport:- Workshop Superintendent personally deals with the allocation of internal transports as per requirement of Scientists, different internal offices, outside guests etc. Except this outside transports are being utilised as per requirement when internal transports are not affordable.

Electrical Unit: This section 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 project in other five nos. campuses.

The remarkable jobs as well as other maintenance job of Workshop in the year 17-18 :

i) Study & monitoring of all the electrical drawings of Unified Campus including planning for execution of substation etc. are being done to give a proper shape of the electrical system.

ii) Study & day to day monitoring 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.

Bose Institute Centenary Meeting on "Future of Science" on 27-28 November, 2017

Prof. Dr. Yaakov (Kobi) Benenson, Associate Professor, Head, Synthetic Biology Group, Dept. of Biosystems Science and Engineering, ETH Zurich, Mattenstrasse 26, 4058 Bassel, Switzerland; delivered distinguished lecture on November 28, 2017.

Prof. Sankar Ghosh, Chair, Silverstein and Hutt Family Professor, Dept. of Microbiology and Immunology, Columbia University, New York; delivered distinguished lecture on November 28, 2017.

Prof. Karlheinz Langanke, Schlossgartenstrabe 2, 64289 Darmstadt; delivered distinguished lecture on November 28, 2017.

LIST OF PERSONNEL

Administration

Prof. Siddhartha Roy, ***Professor & Director (Officiating)***

Prof. Samir Ranjan Sikdar, ***Professor & In-charge, Registrar's Office***

Smt. Noreen Bhattacharjee, ***Deputy Registrar***

Centenary Campus: Subir Sen, Sougata Banerjee, Achintya Mukherjee, Rina Roy, Sisir Chakraborty, Dhrubajyoti Sen (superannuated on 30.11.2017), Susanta Kr. Das (superannuated on 31.01.2018), Manik Ch. Das (superannuated on 31.01.2018), Mantu Bhattacharjee, Debdas Nandy, Somnath Das, Kamal Singh, Supriya Das, Satya Swarup Behera, Ananya Malgope, Nitin Sharma, Ruby Sarkar, Sudam Jana, Babli Marick, Gopa Dasgupta, Rina Das, Sanjoy Krishna Chaki, Debasis Koley, Angshuman Bhowmik, Biplab Malakar, Atanu Deb, Shaubhik Ghosh, Arpita Bose, Mahendra Nath, Shee Hemanta Kr. Sahoo, Goutam Behera, Gouranga Paramanik, Animesh Jana, Ratan Saha, Sumanta Ghosh, Satyabrata Chatterjee, Khairul Basar, Molla Kanai Hazra, Prafulla Bhunya, Duryodhan Nayak, Bablu Mandal, Sukanta Chakraborty, Jagabandhu Nayak.

Main Campus: Tarun Kumar Maji, Amitabha Bhattacharya, Ishani Chatterjee, Chandra Kanta Sasmal, Rajbrat Ram , Sarada Devi, Madhusudhan Marick, Sanat Kr. Dhara, Kalicharan Turi, Munna Turi, Rajkumari Balmiki, Sk. Md. Kallu.

Acharya J.C. Bose Biotechnology Innovation Centre

(Madhyamgram Experimental Farm)

Faculty: The Director, Bose Institute (Chairman), Dr. Gaurab Gangopadhyay (Scientist-In-Charge)

Staff Members: Mr. Amit Kumar Ghosh, Mr. Pulak Kumar Roy, Mr. Asis Kumar Dalal, Mr. Rabin Talukdar (superannuated on 31.10.2017), Mr. Laxmi Kanta Pradhan, Sk Inal Ali, Mr. Mahesh Dasgupta, Mr. Bhanu Kisku

Research personnel (project):

Dr. Sambit Datta (RA), Dr. Milan Kumar Samanta (Extended SRF), Mr. Abhishek Mukherjee (STA)

Biochemistry Department

Faculty: Prof. B. Bhattacharyya (INSA Sr. Scientist), Prof. Pinakpani Chakrabarti (Professor & Chairman), Prof. Rajagopal Chattopadhyaya, Professor (superannuated on 30.11.17), Dr. Subrata Sau, Professor, Dr. Srimonti Sarkar, Professor, Dr. Ajit Bikram Datta, Associate Professor & Wellcome Trust-DBT India Alliance Intermediate Fellow, Dr. Abhrajyoti Ghosh, Assistant Professor.

Students/RA/Project Assistant: Dr. Tanaya Chatterjee (DST Women Scientist), Ms. Ananya Jana, Mr. Aditya Prasad Behera (terminated on 31.07.17), Mr. Sukhendu Mondal (terminated on 30.09.17), Mr. Shankari Prasad Datta (terminated on 28.09.18), Mr. Soumitra Polley (terminated on 31.08.17), Ms. Nabanita Saha (terminated on 01.01.18), Ms. Atrayee Ray (terminated on 11.08.17), Ms. Shamila Sarwar (terminated on 31.01.18), Mr. Supriyo Bera, Mr. Pritam Naskar, Mr. Mousam Roy, Mr. Swapan Kumar Jana, Mr. Soham Seal, Ms. Chandrima Bhattacharyya, Mr. Debabrata Sinha, Mr. Shayantan Mukherji, Dr. Shreyasi Dutta, Mr. Dhritiman Dey (terminated on 31.03.18), Ms. Somi Patranabis (resigned on 28.07.17), Dr. Shreyasi Dutta, Dr. Chumki Bhattacharjee, Mr. Argha Bhowmick, Mr. Sayandeep Gupta, Mr. Manish Sarkar (joined on 10.07.17), Ms. Ankita Das (joined on 29.01.18), Ms. Nabanita Patra (joined on 29.01.18).

Staff Members: Mr. Subhash Chakraborty, Mr. Asim Kumar Poddar, Mrs. Debarati Kanjilal, Mr. Dulal Chandra Mondal (superannuated on 30.11.17), Mr. Atanu Pramanik, Mr. Tuhin Saha, Mr. Kisun Turi.

Bioinformatics Centre

Faculty: Prof. Pinakpani Chakrabarti, Scientist-In-Charge, Prof. Tapash Chandra Ghosh, Professor, Dr. Shubhra Ghosh Dastidar, Associate Professor, Dr. Zhumur Ghosh, Asstt. Professor, Dr. Sudipto Saha, Asstt. Professor.

Students/RA/Project Assistant : Krishnendu Banerjee, Tanmoy Jana, Arijita Sarkar, Sreyashi Majumder, Byapti Ghosh, Souvik Sinha, Saran N, Debadrita Basu, Troyee Das, Debasree Sarkar, Debarun Acharya, Sharmistha Majumder, Sibun Parida, Debangana Chakraborty, Abhirupa Ghosh, Kamlika Sen, Ranjan Kumar Maji, Arpana Verma, Debarati Paul, Sazia Firdaus, Aranyak Goswami, Kakoli Biswas.

Staff Members: Mrs. Sujata Roy, Mr.Sanjib Gupta, Mr.Jibananda Mondal.

Biophysics Department

Faculty: Prof. Siddhartha Roy, Professor, Prof. Gautam Basu, Professor & Chairman, Dr. Anirban Bhunia, Associate Professor, Dr. Subhrangsu Chatterjee, Associate Professor, Dr. Debjani Roy, Assistant Professor, Dr. Manju Roy, Visiting Scientist, Dr. Smarajit Polley, Assistant Professor & DBT-Wellcome Trust Fellow, Dr. Moitri Basu, DST-Inspire Faculty.

Students/RA/Project Assistant:, Mr. Bankim Mondal, Ms. Meghamukta Mukherjee, Ms. Swapna Bera, Ms. Sudakshina Ganguly, Dr. Aparajita Pa, Mr. Bhisma Narayan Ratha, , Dr. Aditya Dev, Dr. Piya Ghosh, Dr. Madhumita Chakraborty, Dr. Gitasree Naiya, Dr. Raka Ghosh, Ms. Humaira Ilyas, Ms. Sonali Ghosh, Mr. Nilanjan Banerjee, Ms. Bhawna Pandey, Ms. Priya Mondal, Sk. Abdul Mohid, Ms. Pallabi Sengupta,, Mr. Suman Panda, Mr. Chandradeep Basu, Mr. Dwijit Guha Sarkar, Dr. Debamitra Chakraborty,Ms. Soumi Das, Ms. Monalisa Kundu, Mr. Anindya Dutta, Nilanjan Banerjee, Ms. Dipita Bhattacahrya, Ms. Nilanjana Maji, Dr. Trina Dutta, Mr. Dibakar Sarkar, Ms

Pranita Roy, Dr. Gopa Dhar, Mr. Ranit Pariary, Dr. Supriya Das, Ms.Karishma Biswas, Ms. Shruti Mukherjee, Ms. Ananya Roy, Ms. Swarnali Kar, Ms. Prateeka Borar, Ms. Mitali Manna & Ms. Nabarupa Chowdhury.

Staff Members: Basudeb Marick, Barun Majumder, Tanmoy Debnath, Baladeb Goswami, Swapan Joghsharma, Sudhir Turi, Nagnarayan Yadav.

Chemistry Department

Faculty : Prof. Joyoti Basu, Professor & Chairperson (from 01.04.2017 to 28.02.2018), Prof. Manikuntala Kundu, Professor & Chairperson (from 01.03.2018 to 31.03.2018), Prof. K. P. Das, Professor, Dr. Suman Kr. Banik, Associate Professor, Dr. Jayanta Mukhopadhyay, Associate Professor.

Students/RA/Project Assistant : Chandreyee Datta, **Arun Kr. Sharma**, Prasun Sarkar, Shreya Bagchi, Debayan Majumder, Arijita Subuddhi, Suruchi Lata, **Arkajyoti Datta**, Ayan Biswas, Sourajit Saha, Amar Ch. Mahata, Tuhin Subhra Roy, Ritu Jaiswal, Thurbu Tshering Lepcha, Madhurima Chatterjee Pankaj Jankiram Birari, Soumya Mal, Manish Kumar, Aniruddha Tewary, Soumya Mukherjee.

Staff Members: Dipak Ch. Konar, Rama Chatterjee, Sujata Roy, Gaurab Roy, Mrityunjoy Kundu, Sachchidanand Ram, Subhas Ch. Paul, Asoke Kr. Maity.

Central Instrumentation Facility

Faculty: Prof. Sujoy K. Das Gupta, Professor & In Charge (Cent. Bldg.), Prof. T. P. Sinha, Professor & In Charge (Main Campus).

Supporting Staff (Cent. Campus): Ranjan Kumar Dutta, Smriti Ranjan Maji, Mrinal Das, Swaroop Biswas, Sheolee Ghosh Chakraborty, Amarendra Nath Biswas, Pallab Chakraborty, Alpana Chattopadhyay (Bhattacharya).

Supporting Staff (Main Campus): Tanima Modak Dhar.

Division of Molecular Medicine

Faculty : Prof. Gaurisankar Sa, Professor & Head, Prof. Parames Ch. Sil, Professor, Prof. Subrata Majumdar, Professor, Prof. Tanya Das, Professor, Dr. Atin Kumar Mandal, Associate Professor, Dr. Nripendranath Mandal, Professor, Prof. Parimal C. Sen, NANSI-Platinum Jubilee Senior Scientist, Dr. Anup Kumar Misra, Professor, Dr. Mahadeb Pal, Professor, Dr. Kaushik Biswas, Associate Professor, Dr. Kuladip Jana, Senior Scientiest.

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), 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-SRF, Ishani Bhaumik, CSIR-SRF, 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), Mr. Arin Gucchait, CSIR-JRF, Ms. Tapashi Manna, UGC-JRF, Mr. Pradip Shit, CSIR-JRF

Staff Members: Shri Prabal Kr. Gupta, Shri Uttam Kumar Ghosh, Shri Arindam Basu, Shri Debasish Majumdar, Ms. Nilanjana Bhattacharya, Smt. Shanghamitra Das (Sahu), Shri Kalyan Das, Shri Amartya Sen, Shri Purnendu Manna, Shri Shankar Prasad Bari, Shri Sudhir Turi, Shri Ranjit Kumar Das and Shri Bijoy Munshi

Division of Plant Biology

Faculty: Prof. Samir Ranjan Sikdar, Professor & Head, Prof. Swati Gupta Bhattacharya, Professor, Prof. Debabrata Basu, Professor, Dr. Gaurab Gangopadhyay, Associate Professor, Dr. Shubho Chowdhuri, Associate Professor, Dr. Pallob Kundu, Associate Professor, Dr. Anupama Ghosh, Assistant Professor, Dr. A.N. Lahiri Majunder, INSA Senior Scientist, Dr. Swati Sen-Mandi, Emeritus Medical Scientist, Dr. Amita Pal, UGC Emeritus Scientist, Dr. Sampa Das, INSA Senior Scientist, Dr. D. N. Sengupta, Guest Scientist.

Project Scientist: Dr. Swagata Ghosh (DST Women Scientist), Dr. Rajeswari Mukherjee (DBT RA/BIO-CARE), Dr. Subha Das (SERB/DST Young Scientist), Dr. Akansha Jain (SERB/DST Young Scientist), Dr. Sudip Saha (DBT RA), Dr. Priyanka Das (SERB/ DST Young Scientist), Dr. Supriyo Chowdhury (DBT-RA).

Students/RA/Project Assistant : Dr. Mrinmoy Majumder, Ms. Monia Chatterjee, Mr. Joydeep Chakraborty, Ms. Papri Basak, Mr. Amit Paul, Ms. Amrita Mukherjee Ganguly, Ms. Sefa Parveen, Ms. Poulami Sarkar, Ms. Payel Ganguly, Ms. Banani Mondal, Ms. Sanghamitra Adak, Mr. Sayantan

Ghosh, Ms. Shruti Chattaraj, Ms. Aishee De, Mr. Rahul Dutta, Ms. Rwitie Mallik, Mr. Dibya Mukherjee, Ms. Pratiti Dasgupta, Ms. Shreya Chowdhury, Mr. Amartya Ghosh, Ms. Udita Acharya, Mr. Subhasish Mukherjee, Ms. Surbhi Shriti, Ms. Karishma Chanani, Ms. Jinia Chakraborty, Ms. Sonal Sachdev, Mr. Sayan Mal, Mr. Aroni Mitra, Ms. Shrabani Basak, Dr. Sambit Datta, Mr. Milan Kumar Samanta, Dr. Soumitra Maiti, Dr. Subhobrata Ghosh, Ms. Niti Yashvardini, Mrs Marufa Sultana, Ms. Sangita Roy, Ms. Nandini Ghosh, Mr. Gourab Sircar, Ms. Koyel Sengupta, Ms. Bijoya Karmakar, Ms. Moumita Bhowmik, Mr. Debabrata Datta, Mrs. Moumita Biswas Sarkar, Mr. Subham Bhakta, Mr. Sukhendu Maity, Ms. Soumili Pal, Mr. Vivek Kumar Awon, Mr. Sourab Bose.

Staff Members: Mr. Subal Basak , Mr. Ashim Kumar Nath, Mr. Binoy Krishna Modak, Mr. Jayasish Ghosh, Mr. Arup Kumar Dey, Mr. Nadiram Kayal, Mr. Birendra Kumar Bari, Mr. Chanchal Chakraborty, Mr. Jadab Kr. Ghosh, Mrs. Kaberi Ghosh, Dr. Chaitali Roy, Mr. Bipul Kumar Nag, Mr. Siddhartha Roy, Mrs. Sarama Pradhan, Mrs. Moumita Mondal, Mr. Sanjib Kumar Das, Mr. Tapas Chakraborty.

Environmental Science Section

Faculty: Prof. Sanjay Kumar Ghosh, Professor & Chairman; Dr. Abhijit Chatterjee, Assistant Professor and Dr. Sanat Kumar Das, Assistant Professor & Ramanujan Fellow.

Students/RA/Project Assistant: Dr. Debajyoti Ray, Mr. Arindam Roy, Mr. Abhinandan Ghosh, Mr. Arindam Das.

Staff members: Dr. Anandamay Adak, Mr. Saral Chandra Das

Falta Experimental Farm

Faculty: Prof. S.R. Sikdar *Professor & Coordinator* Rural Biotechnology Programme.

Staff Members: Shri Sobhan Roy Chowdhury (Senior Technical Assistant/Rural Extension Officer on contract), Shri Shuvankar Roy (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).

Integrated M.Sc.-Ph.D. Programme

Faculty: Prof. Siddhartha Roy, Professor & Dean of Studies

Staff Members : Shri Soumya Shankha Biswas, Shri Prabir Halder

Microbiology Department

Faculty: Prof. Sujoy K. Dasgupta, *Professor & Chairman*, Dr. Tapan K. Dutta, *Professor*, Dr. Wriddhiman Ghosh, *Assistant Professor*

Students: Sri. Soumik Basu, Sri. Arindam Dutta, Sri. Prasenjit Pyne, Sm. Soniya Chatterjee, Sri. Chayan Roy, Sm. Niketam Bhawinghka,Sm. Shrestha Ghosh, Sm. Satamita Deb, Mr. Rameez M.J., Sri. Sabyasachi Bhattacharya, Sm. Apurba Sarkar, Sm. Subhrangshu Mandal, Sm. Ronita Goswami, Sm. Moushumi Bhattacharyya, Sm. Poulami Ghosh, Sm Madhu Manti Patra, Sri. Saikat Deb, Sri Sourabh Samaddar, Dr. Fatem Calcuttawala, Dr. Madhumita Roy, Sm. Megha Chakraborty, Sri Rahul Shaw, Sri Anik Barman, Sri Mriganka Munshi Karmakar, Sri Nibendu Mondal.

Staff Members: SaifullahGazi,Prabir Kumar Haldar, Debashis Sarkar, Dilip Bhattacharyya (superannuated on 30.09.2017), Robin Paul, Narayan Patali.

Physics Department

Faculty: Prof. Sibaji Raha, Professor, Prof. Indrani Bose, Professor (CSIR Emeritus Scientist), Prof. Dipankar Home, Professor, Prof. Barun Kumar Chatterjee, Professor, Prof. Tripurari Prasad Sinha, Professor & Chairman, Prof. Swapan Kumar Saha, Professor, Prof. Sanjay Kumar Ghosh, 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, Dr. Prasanna Kumar Mandal, Ms. Sananda Raychaudhuri, Mr. Som Kanjilal, Mr. Pratapaditya Bej, Mr. Abhishek Banerjee, Ms. Sumana Bhattacharyya, Mr. Prasenjit Deb, Mr. Souradeep Sasmal, Ms. Pooja Bhattacharjee, Ms. Pracheta Singha, Mr. Deeptak Biswas, Mr. Debarshi Das, Ms. Trishna Bhattacharyya, Mr. Arkaprabha Ghosal, Mr. Kaushik Naskar, Mr. Saronath Halder, Ms. Rajdeep Kaur Grewal, Mr. Saptarshi Sinha, Mr. Saswata Haldar, Md. Sariful Sheikh, Mr. Tara Shankar Bhattacharyya, Mr. Ram Awdhesh Kumar, Mr. Ritwik Maity, Mr. Moumin Rudra, Mr. Tushar Kanti Bhaumik, Mr. Chayan Kumar Mitra, Mr. Sreyan Raha, Sk. Mustak Ali, Ms. Kabita Kundalia, Mr. Ranjan Sutradhar, Ms. Sumana Gop, Mr. Himadri Shekhar Tripathi, Mr. Pratik Ghosal, Ms. Shreya Roy, Mr. Susanta Ghosh, Mr. Deep Nath.

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. Rajkumar Mourya, Mr. Amarnath Hela, Mr. Ranjit Das.

INSA Senior Scientist Fellow: Prof. Prabir Roy, Prof. Sushanta Datta Gupta.

IRHPA II: Dr. Sandhya Dey (Mandal), Dr. Atanu Maulik, Mr. Soumendra Singh, Mrs. Sumana Singh.

Visiting Fellow: Dr. Subikash Choudhury. NPDL DST SERB: Dr. Abhishek Atreya.

CBM MUCH Project Asstt.: Mr. Sourav Roy.

ALICE - II: RA/SRF/JRF/Tech.Asstt.: Dr. Maitreyee Mukherjee, Mr. Rathijit Biswas, Mr. Dipanjan Nag, Mr. Sanjoy Mukherjee.

M.Sc (Physical Science) Students: Mr. Arpan Ghosh, Mr. Sudip Bhowmick, Mr. Arun Kr. Das, Mr. Sayan Chakraborty, Mr. Pratik Chowla, Mr. Tanmay Saha, Mr. Abhi Modak, Mr. Prottay Das, Mr. Sayak Chatterjee.

J. C. Bose Centre

(Publication and Museum)

Staff Members : Tarun Kumar Maji, Ishani Chatterjee, Chandra Kanta Sasmal

Library

Staff Members: Dr. Arun Kumar Chakraborty (**Librarian : on lien),** Dr. (Ms.) Banhisikha Chaudhuri (In-charge, Library), Ms. Ananya Raha, Ms. Sumita Dey, Mr. Gautam Mukherjee (superannuated on 30.06.2017), Mr. Dipak Dutta (superannuated on 31.05.2017), Ms. Tanusri Bhattacharya, Mr. Mrityunjoy Jogsharma, Mr. Dinanath Das.

Workshop

Mr. Raju Chandra Paul ,Workshop Superintendent.

Main Campus: Mr. Bholanath Saren, Mr. Abdul Rahaman Molla, 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.

Centenary Campus: Mr. Ashit Banerjee, Mr. Baidya Nath Murmu

| Distinguished Lecture |

Prof. N. Mukunda, Indian Institute of Science, Bangalore delivered distinguished lecture on “Science and the Human Predicament” on August 1, 2017.

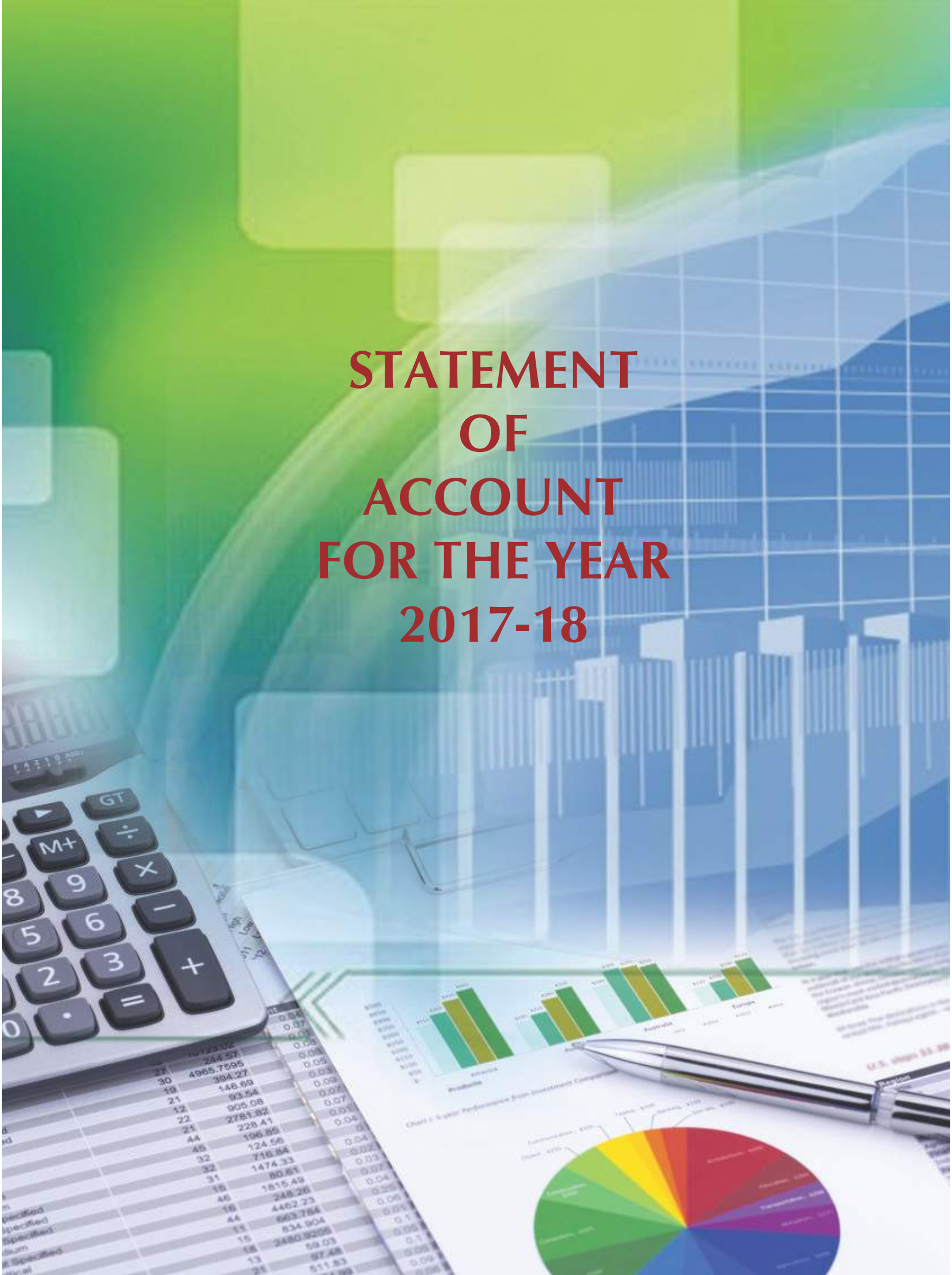
Prof. Joel Sussman, Weizmann Institute, Israel delivered distinguished lecture on “Acetylcholinesterase: 25 Years since the 3D Structure was Determined: What Have We Learned?” on October 10, 2017.

| Centenary Lecture |

Prof. Ronald G. Prinn, TEPCO professor of Atmospheric Sciences, Department of Earth, Atmospheric and Planetary Sciences and The Director of the Centre of Global Change Science of Massachusetts Institute of Technology, USA delivered 3rd Centenary Lecture on "Climate Change Risks and the Challenge of Avoiding 2°C Warming" on August 30, 2017.

Prof. Inder M. Verma, Laboratory of Genetics, The Salk Institute, La Jolla, California, USA delivered 4th Centenary Lecture on "Cancer: Lessons From the Past Forty Years" on October 17, 2017.

STATEMENT OF ACCOUNT FOR THE YEAR 2017-18



INDEPENDENT AUDITORS REPORTS

To the Members of the Council

We have audited the accompanying financial statements of BOSE INSTITUTE, which comprise the Balance Sheet as at March 31, 2018,the Income and Expenditure Account and Receipt and Payment Account for the year then ended and a summary of significant accounting policies and other explanatory information.

Management's Responsibility for the Financial Statements

Management is responsible for the preparation of these financial statements. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation of the financial statements that are free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgement, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the Institute's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Institute's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Basis of Qualified Opinion

1) The Institute has accounted for expenses on cash basis in the financial statement which is contrary to the fundamental accounting assumptions as per AS 1 notified by the Institute of Chartered Accountants of India.

2) Intangible assets in the form of books and journals are not amortised over the licence period and are being carried forward and depreciated even after expiry of their licence period which is not in accordance with the requirement of AS 26 notified by the Institute of Chartered Accountants of India. *The amount of such expired licences are presently not ascertainable.*

3) As reported by the management, fixed asset register was prepared upto 31st March 2017 and for the period upto 31st March 2018 is under process of finalisation which could not be verified by us during finalisation of annual accounts.

4) Liability towards gratuity and leave encashment are not ascertained as per actuarial valuation and the same are accounted for on cash basis contrary to the requirement of AS 15 notified by the Institute of Chartered Accountants of India.

5) The institute does not have internal audit system commensurate with the size and nature of its activity resulting in poor internal financial control.

6) The Institute could not reconcile accrued interest on fixed deposits as per books of accounts with that as per bank confirmation in few cases.

7) The Institute could not reconcile GPF and CPF fund balances with the balances in the books of the Council as on the 31st March, 2018.

8) We could not verify old brought forward current assets and liabilities amounting to Rs. 19.29 lacs and Rs. 76.60 lacs respectively. Consequential impact on the year's revenue and the net current asset position as at the end of the year is not ascertainable.

9) Asset acquired from development and modernisation fund amounting to Rs. 666.57 lacs has been held under 'Investment Under Earmarked Fund' and has not been capitalised thereby understating the fixed assets to that extent. Consequential impact on depreciation and current year's profitability is not ascertainable.

10) We could not verify old brought forward capital work in progress amounting to Rs.22.15 lacs which need immediate review and adjustments in the books of accounts. Consequential impact on the books of accounts is not ascertainable at this stage.

11) (i) There are ongoing legal cases/investigation against the Institute, the impact of which is not ascertainable at this stage.

(ii) Legal fees paid to various lawyears during the period were in excess of the limit laid down in this regard by the Central Government vide its order no.26(1)/2014/judl dated 1st October 2015.

Opinion

Subject to matters stated in the basis of qualified opinion paragraph, in our opinion and to the best of our information and according to the explanations given to us, the financial statements of BOSE

INSTITUTE for the year ended March 31, 2018, 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 2018;

b) In case of Income and Expenditure Account, of'the surplus for the year ended on that date;

c) In case of Receipts and Payment Account, of the cash transactions of the institute for the year ended on that date.

For Ray & Ray

Chartered Accountants
(Firm Registration No. 301072E)

Date : 25th September,2018

Place : Kolkata

Abhijit Neogi

Partner
Membership No : 61380

BOSE INSTITUTE
KOLKATA

BALANCE SHEET AS AT 31ST MARCH, 2018

(Amount in ₹)

	Schedules	As At 2017-18	As At 2016-17
CORPUS/CAPITAL FUND AND LIABILITIES			
Corpus /Capital fund	1	2,83,96,89,566.02	2,37,32,71,431.02
Reserves and surplus	2		
Earmarked/Endowment funds	3	57,64,07,803.51	54,53,48,915.38
Secured loans and borrowings	4		
Unsecured loans and borrowings	5		
Deferred credit liabilties	6		
Current liabilities and provisions	7	64,89,53,625.08	91,05,07,897.56
Total		**4,06,50,50,994.61**	**3,82,91,28,243.96**
ASSETS			
Fixed Assets	8	90,90,76,430.47	89,93,03,266.47
Investments-others	9	38,74,37,146.42	35,97,09,646.42
Investments -from earmarked/endowment Funds	10	12,92,89,294.00	12,62,91,112.87
Current assets, loans, advances etc.	11	2,63,92,48,123.72	2,44,38,24,218.20
Miscellaneous expenditure (to the extent not written off or adjusted)			
Total		**4,06,50,50,994.61**	**3,82,91,28,243.96**
Significant accounting policies	24		
Contingent liabilities	25		

Place : Kolkata
Date : 25/9/2018

Signed in terms of our separate Report of even date.

Sd/-
(Shaubhik Ghosh)
UDC-1

Sd/-
Vikash Kumar
Audit & Finance Office

Sd/-
Achintya Mukherjee
Accounts Officer

For Ray & Ray
Chartered Accountants
Firm Registration No 301072E

Sd/-
Mrs. Noreen Bhattacharjee
Acting Registrar

Sd/-
Prof. Sujoy Kumar Das Gupta
Director (Officiating)

Ahhijit Neogi
Partner
Membership No. 61380

BOSE INSTITUTE

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31.03.2018

(Amount in ₹)

	Schedules	For the year ended 2017-18	For the year ended 2016-17
INCOME		₹	₹
Income from Sales and Services	12	77,07,915.83	72,51,000.00
Grants/Subsidies	13	81,75,50,000.00	69,89,00,000.00
Fees/Subscriptions	15		
Income from Investments (Income on Investment, from earmarked /endowment Funds transferred to Funds)	14	2,08,91,019.62	2,54,60,213.40
Income from royalty, publication etc .	16		
Interest Earned	17		
Other Income	18	31,14,100.00	13,24,577.00
Increase/ (decrease) in stock of Finished goods and work-in-progress	19		
Total (A)		**84,92,63,035.45**	**73,29,35,790.40**
EXPENDITURE			
Establishment Expenses	20	49,66,37,165.43	43,88,81,591.00
Other Administrative Expenses	21	22,22,72,655.86	16,76,07,520.52
Expenditure on Grant, Subsidies etc.	22		
Interest	23		
Fund for capital Expenditure	23A	6,35,58,013.00	5,94,81,890.00
Depreciation (Net Total at the year end corresponding to Schedule 8)		6,35,17,020.00	5,79,44,282.00
Total (B)		**84,59,84,854.29**	**72,39,15,283.52**
Balance being excess of Income over Expenditure (A-B)		32,78,181.16	90,20,506.88
Transfer to Special Reserve (Specify each)			
Last Year Unspent Balance / Overspent Balance		-20,60,46,777.79	–21,50,67,284.67
Balance of Unspent Balance After Adjustment		-20,60,46,777.79	–21,50,67,284.67
Balance being Surplus/(deficit) carried to corpus /capital fund		-20,27,68,596.63	–20,60,46,777.79
Significant accounting policies	24		
Contingent liabilities & Notes to Accounts	25		

Place : Kolkata
Date : 25/9/2018

Signed in terms of our separate Report of even date.

Sd/-	Sd/-	Sd/-	For Ray & Ray
(Shaubhik Ghosh)	Vikash Kumar	Achintya Mukherjee	Chartered Accountants
UDC-1	Audit & Finance Office	Accounts Officer	Firm Registration No 301072E

Sd/-	Sd/-	Ahhijit Neogi
Mrs. Noreen Bhattacharjee	Prof. Sujoy Kumar Das Gupta	Partner
Acting Registrar	Director (Officiating)	Membership No. 61380

BOSE INSTITUTE

RECEIPT AND PAYMENT ACCOUNTS FOR THE YEAR ENDED 31.03.2018 (COUNCIL A/C)

(Amount in ₹)

Receipts	Schedule no	Amount (₹)	Payments	Schedule no	Amount (₹)
Opening Balance	1	39,11,45,638.62			
Establishment Expenses	2	36,91,648.00	Establishment Expenses	2	45,90,40,403.43
Laboratory Expenses	3	6,13,139.00	Laboratory Expenses	3	7,80,23,765.52
			Other Adminstrative Expenses	4	13,65,45,990.87
Other Adminstrative Expenses	4	10,48,692.00			
			Payments for the current assets	5	43,23,32,203.00
Receipt from Indirect Income	8	1,66,74,295.99	Payments for the Fixed assets	6	11,16,40,266.00
Receipt from Current Assets	5	3,56,68,001.75		-	
Receipts from Current Liabilities	7	7,36,71,930.10	Payment for Current Liabilties	7	7,64,46,936.00
Receipt from Work in progress	6	2,55,61,069.00	Payment for other income	8	4,01,496.00
Inter Unit Account			Inter Unit Account		
			FAIR		
			Scheme/Project Grant in _aid		
Scheme/Project	9	3,27,648.00	Scheme/Project	9	5,01,573.00
Scheme/Project Grant in _aid	9	85,63,51,357.00	St_Rural	9	10,000.00
St_Rural		-	Governing Body	9	43,400.00
Governing Body		-	Closing Balance	1	10,97,67,385.64
		1,40,47,53,419.46			**1,40,47,53,419.46**

Place : Kolkata
Date : 25/9/2018

Signed in terms of our separate Report of even date.

For Ray & Ray
Chartered Accountants
Firm Registration No 301072E

Sd/-
(Shaubhik Ghosh)
UDC-1

Sd/-
Accounts Officer

Sd/-
Vikash Kumar
Audit & Finance Office

Sd/-
Achintya Mukherjee
Accounts Officer

BOSE INSTITUTE
KOLKATA

Receipt and Payment accounts for the year ended 31.03.2018 (Projects)

Particulars	Sch. No.	Amount (₹)	Particulars	Sch. No.	Amount (₹)
OPENING BALANCE		70,32,14,506.88	Payment from Projects	2	16,72,51,190.20
Receipt from projects	2	26,54,98,924.00	Payment from Adhoc/ RA/PDF	3	2,39,89,022.98
Receipt from projects from Adhoc /Ra / Pdf	3	3,64,62,930.00	Payment for other than Project	4	9,35,44,214.00
Receipts from Other Than Scheme / Projects	4	9,28,24,552.00			
Receipts from IFCC	5	5,00,88,803.45	Payment OF IFCC	6	2,52,99,180.74
Fixed Deposit(IFCC)			Payment OF ST Rural	8	3,37,66,305.75
Receipts from St Rural	7	2,69,38,449.00			
Receivable From Scholors		389.00			
Branch /InterUnit			**Branch /InterUnit**		
Bose Institute		83,69,45,413.00	Bose Institute		85,86,31,256.21
IFCC		4,50,000.00	Bank Charges		6,922.00
Interest on FD		56,99,475.00			
Interest on SB 3355		37,37,418.00			
Pick Up Service		1,200.00			
Bank Charges		840.00			
			CLOSING BALANCE		81,93,74,808.45
		2,02,18,62,900.33			**2,02,18,62,900.33**

Place : Kolkata
Date : 25/9/2018

Signed in terms of our separate Report of even date.

Sd/-	Sd/-	Sd/-	For Ray & Ray
Sakantya Chakraborty	Vikash Kumar	Achintya Mukherjee	Chartered Accountants
Assistant Registrar	Audit & Finance Office	Accounts Officer	Firm Registration No 301072E

BOSE INSTITUTE
KOLKATA

Bose Institute Employees' Pension Fund
For the year ended on 31st March, 2018
Income Expenditure

For the year ended 31st March 2017 (₹)	Expenditure	For the year ended 31st March 2018 (₹)	For the year ended 31st March 2017 (₹)	Income	For the year ended 31st March 2018 (₹)
9,24,12,528.00	To Pension Account	12,67,30,442.00	12,39,30,000.00	By Contribution from Bose Institute	15,09,19,130.00
1,47,29,170.00	To Gratuity Account	1,03,95,898.00		For Pension & Gratuity	
				By Contribution from Other Organisation	
97,10,676.00	To Pension Commutation	67,19,506.00		For Pension & Gratuity By Interest	
0.00	To Bank Charges	-	95,14,345.00	Fixed Deposit with Bank	59,34,415.00
			1,92,545.00	Savings Bank Account	3,17,278.00
1,67,84,516.00	To Excess of Income over Expenditure	1,33,24,977.00			
13,36,36,890.00		**15,71,70,823.00**	**13,36,36,890.00**		**15,71,70,823.00**

Bose Institute Employees' Pension Fund
Balance Sheet as on 31st March, 2018

As at 31st March 2017 (₹)	Liabilities	As at 31st March 2018 (₹)	As at 31st March 2017 (₹)	Assets	As at 31st March 2018 (₹)
11,62,28,858.05	Balance As per last A/c	13,30,13,374.05			
1,67,84,516.00	Add: Excess of Income over Expenditure	1,33,24,977.00	10,73,29,312.00	Fixed Deposit	11,93,29,312.00
			20,46,727.00	Accrued Interest (F.D)	14,02,091.00
3,66,830.00	Payable to Pensioner	3,66,830.00	1,11,74,931.19	" Bank Balance With S.B.I Savings Bank Account "	1,48,76,784.19
			1,29,98,375.86	Receivable from Bose Institute Council	1,10,59,564.86
1,69,142.00	TDS pension	-		Receivable From Employees	21,429.00
				TDS Pension	16,000.00
0.00	Payable to Bose Institute	-			
13,35,49,346.05		**14,67,05,181.05**	**13,35,49,346.05**		**14,67,05,181.05**

Place : Kolkata
Date : 25/9/2018

Signed in terms of our separate Report of even date.

Sd/-	Sd/-	Sd/-	Sd/-
Vikash Kumar	Achintya Mukherjee	Mrs. Noreen Bhattacharya	Prof.Sujay Dasgupta
Audit & Finance Officer	Accounts Officer	(Acting Registrar)	Director (Officiating)

BOSE INSTITUTE
KOLKATA

Bose Institute Employees' Provident Fund
Kolkata
Balance Sheet as on 31st March, 2018

2016-17 Amount (₹)	Liabilities	2017-18 Amount (₹)	2016-17 Amount (₹)	Assets	2017-18 Amount (₹)
	GPF		20,86,50,000.00	Investment	22,35,10,460.00
19,62,58,162.95	Opening Balance	20,51,56,642.95	40,31,697.00	Advance outstanding from members	38,66,816.00
-	Less: Advance for previous year	-	-	Int. accrued as on 31-03-2018	
19,62,58,162.95		20,51,56,642.95	-		
2,22,62,896.00	Add: Subscription	2,13,05,754.00			
1,46,07,730.00	Add: interest Credited	1,49,76,334.13	17,91,233.00	GPF	18,04,230.00
-	Add:		-	CPF	1,22,919.00
				Receivable fromGPF	2,41,200.00
23,31,28,788.95		24,14,38,731.08	17,37,516.00	Receivable from	48,65,892.00
-	Less: Sub. For March (Current Year)	-		Bose Institute UNIVERSITY Contribution	
2,79,72,146.00	Less: Advance/withdrawl	2,85,59,629.00		NPS-II	
20,51,56,642.95		21,28,79,102.08	-	Cash In Hand	-
	Current Liabilities				
	Payable to Bose institute	24,71,251.00			
	Payable to CPF	2,41,200.00			
		27,12,451.00			
	CPF		99,43,812.00	Balance at Bank	63,14,406.70
1,22,79,521.75	Opening Balance	1,45,94,134.75			
-	Less: Sub. For March (Pr. Year)	-			
1,22,79,521.75		1,45,94,134.75			
15,28,976.00	Add: Subscription	9,04,818.00			
7,85,437.00	Add: interest Credited	11,53,837.00			
200.00	Add: payable to Bose ins.	-			
	Add: Sub. For March (Current Year)				
-	less: Advance /withdrawl	-			
1,45,94,134.75		**1,66,52,789.75**			
	Interest Reserve				
35,99,345.00	Opening Balance	64,03,481.00			
28,04,136.00	Add: Excess of Income over Exp.	20,78,099.87			
22,61,54,258.70	**Total**	**24,07,25,923.70**	**22,61,54,258.00**	**Total**	**24,07,25,923.70**

Place : Kolkata
Date : 25/9/2018

Signed in terms of our separate Report of even date.

Sd/-	Sd/-	Sd/-	Sd/-
Vikash Kumar	Achintya Mukherjee	Mrs. Noreen Bhattacharya	Prof.Sujay Dasgupta
Audit & Finance Officer	Accounts Officer	(Acting Registrar)	Director (Officiating)

AUDIT OBSERVATIONS (Forming part of Audit Report)

BOSE INSTITUTE
KOLKATA

Bose Institute Employees' Provident Fund
Income and Expenditure Account for the year ended 31/03/2018

for the financial year 2017-18

31-3-2017 Amount (₹)	Expenditure	31-3-2018 Amount (₹)	31-3-2017 Amount (₹)	Income	31-3-2018 Amount (₹)
	Interest credited to		1,70,97,257.00	Interest earned on Investment GPF	1,70,36,319.00
			11,00,046.00	Interest earned on Investment CPF	11,71,952.00
1,46,07,730.00	GPF Account	1,49,76,334.13		Add: Interest accrued but not due on 31-3-16	
7,85,437.00	CPF Account	11,53,837.00	1,81,97,303.00		1,82,08,271.00
	University Contribution			Less: Interest accrued as on March	
	NPS Tier-II Account		1,81,97,303.00		1,82,08,271.00
0.00	Bank Charges				
28,04,136.00	Excess of Income over Expenditure	20,78,099.87			
1,81,97,303.00	**Total**	**1,82,08,271.00**	**1,81,97,303.00**	**Total**	**1,82,08,271.00**

Place : Kolkata
Date : 25th September, 2018

Signed in terms of our separate Report of even date.

Sd/-	Sd/-	Sd/-	Sd/-
Vikash Kumar	Achintya Mukherjee	Mrs. Noreen Bhattacharya	Prof.Sujay Dasgupta
Audit & Finance Officer	Accounts Officer	(Acting Registrar)	Director (Officiating)

SIGNIFICANT ACCOUNTING POLICIES & NOTES ON ACCOUNTS

Schedule :

1.0 Change in Accounting Policy:

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 Sephisticated 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 2017-18, therefore the nomenclatures and order mentioned in Schedule 8 is taken into account.

2.3 Work-in-Progress

The particulars of fixed assets, under construction/installation are given in Schedule 8

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 2015-16. Further identification of the assets relating to 2017-18 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.

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%
9.	Computer	-	60%
10.	Software	-	60%

4.0 Revenue Recognition & Grant in Aid:

4.1 During financial year 2017-18, 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.

5.4 For payment of Governing Body N.R. Sarkar Prize Fund a negative balance has arise which could be restored with the approval of authority.

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 Bose Institute Employees Pension Scheme Regulations approved by the Dept. of Science and Technology, Govt. of India and Rule 3.3 of Bose Institute Contributory Provident Fund Rules, the Pension Fund, General Provident Fund and Contributory Provident Fund vest with 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.

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:

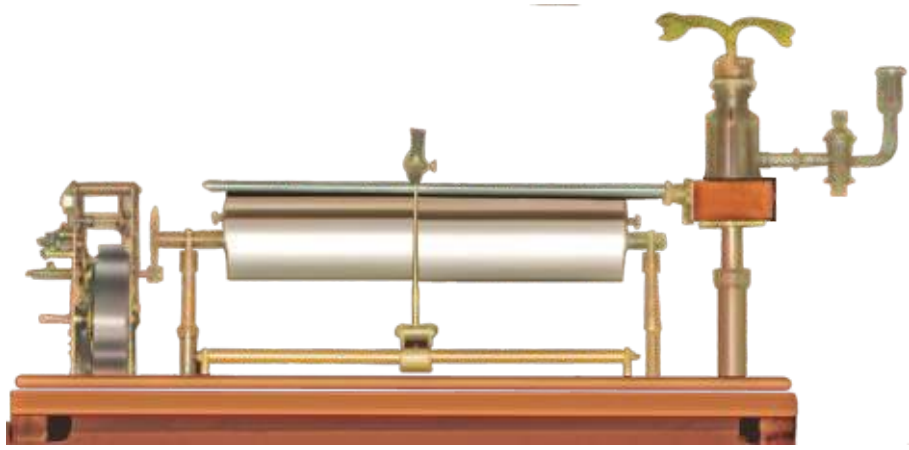
A sum of included under "Advance Council" is shown in the Balance Sheet under the head Advances (Schedule-11) which include a sum of pending recovery / adjustment prior to 24-15 is Rs. 5,48,438/-.

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.



INDEPENDENT AUDITOR'S REPORT

(TO THE MEMBERS OF THE COUNCIL)

We have audited the accompanying financial statements of **BOSE INSTITUTE, Indo-FAIR Coordination Centre** which comprise the Receipt and Payment Account for the year ended 31st March, 2018 and a summary of significant accounting policies and other explanatory information.

Management's Responsibility for the Financial Statements

Management is responsible for the preparation of these financial statements. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation of the financial statements that are free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgement, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the Institute's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Institute's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Opinion

In our opinion and to the best of our information and according to the explanations given to us, the Receipts and Payment Account of BOSE INSTITUTE, Indo-FAIR Coordination Centre for the year ended March 31, 2018, give a true and fair view in conformity with the accounting principles generally accepted in Indian, of the cash transactions of the institute for the year ended on that date.

For Ray & Ray
Chartered Accountants
(Firm Registration No. 301072E)

Date : 25th September, 2018

Place : Kolkata

Abhijit Neogi

Partner
(Membership No : 61380)

BOSE INSTITUTE (IFCC)
KOLKATA

BALANCE SHEET AS AT 31ST MARCH 2018

As on 31st March 2017 (₹)	Liabilities	As on 31st March 2018 (₹)	As on 31st March 2017 (₹)	Assets	As on 31st March 2018 (₹)
3,07,122.00	Fund for Creation of Asset	3,26,946.00	54,732.00	Shares in FAIR GmbH	54,732.00
			2,52,390.00	Office Equipment	2,72,214.00
	Unspent Grant				
21,64,61,963.34	Grant from Department of Science and Technology **(Schedule-1)**	22,14,35,585.34			
4,74,36,707.83	Grant from Department of Atomic Energy **(Schedule-2)**	6,56,71,084.54			
1,43,38,465.00	Interest Earned **(Schedule-3)**	1,58,69,199.00		**Bank Balances**	
88,500.00	Audit Fees Payable	88,500.00	43,15,548.17	S.B. A/c - Union Bank of India	2,64,33,868.88
• 22,060.00	Payable to Bose Institute	27,950.00	27,39,87,148.00	Fixed Deposits	27,66,58,450.00
•					
27,86,09,818.17		**30,34,19,264.88**	**27,86,09,818.17**		**30,34,19,264.88**

STATEMENT OF EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2018

For the year ended 31st March 2017 (₹)	Particulars	For the year ended 31st March 2018 (₹)
3,09,616.00	Advertisement Expenses	2,49,493.00
10,362.00	Ad-hoc Bonus	-6,908.00
88,500.00	Audit Fees	88,500.00
663.27	Bank Charges	684.74
1,80,000.00	Consultancy	-
9,251.00	Contingency Expenses	37,057.00
3,72,544.00	Meeting Expenses - IFCC	1,91,963.00
	Honorarium Expenses	2,000.00
	Fellowship (JRF)	2,40,054.00
11,35,175.00	Salary	12,35,430.00
-	Student Support	2,83,945.00
1,150.00	Telephone Expenses	-
3,91,490.26	Travelling Expenses	20,83,750.55
	Overhead Charges	4,50,000.00
7,81,016.00	Workshop	3,72,268.00
32,79,767.53		**52,28,237.29**

Place : Kolkata
Date : 2018

Signed in terms of our separate Report of even date.

For Ray & Ray
Chartered Accountants

Sd/-	Sd/-	Sd/-	Sd/-
Prof.Sujay Dasgupta	Mrs. Noreen Bhattacharya	Achintya Mukherjee	
Director (Officiating)	(Acting Registrar)	Accounts Officer	Accounts & Administration Officer
Incharge of Fair Projects			Fair Project

BOSE INSTITUTE (IFCC)
KOLKATA

Receipt and Payment Accounts for the year ended 31.03.2017

Particulars	(₹)	Particulars	(₹)
Opening Balance			
S.B A/c Union Bank of India	43,15,548.17		
Fixed Deposits	27,39,87,148.00		
GRANT FROM D.S.T	-		
GRANT FROM D.A.E	2,63,00,000.00		
GRANT FROM D.S.T (IFCC Exp.)	-		
Interest on SB A/c	1,11,782.00		
Interest on FD (Term Deposits)	1,57,57,417.00		
Advance	2,08,000.00	Advance	2,08,000.00
Liability for Audit Fees	88,500.00	Liability for Audit Fees	88,500.00
Profession Tax	5,890.00	Profession Tax	5,890.00
TDS (Salary: ₹ 102530.00 + Party: ₹ 82195.00)	1,84,725.00	TDS (Salary: ₹ 102530.00 + Party: ₹ 82195.00)	1,84,725.00
Sundry Creditors	63,15,000.00	Sundry Creditors	63,15,000.00
Travelling Expenses	10,14,691.45	Travelling Expenses	30,91,963.00
Workshop	90,000.00	Audit Fees	88,500.00
		Ad-hoc Bonus	-
		Advertisement Expenses	2,49,493.00
		Bank Charges	684.74
		Contingency Expenses	37,057.00
		Overhead Charges	4,50,000.00
		Honorarium Expenses	2,000.00
		Salary	12,35,430.00
		Fellowship (JRF)	2,40,054.00
		Student Support	2,83,945.00
		Workshop	4,62,268.00
		Office Equipment	19,824.00
		Power Converter (In-Kind)	26,94,472.00
		Detector (FAIR Experiment)	25,00,000.00
		Vaccum Chamber (In-Kind)	74,124.00
		Beam Stopper (In-Kind)	68,68,809.00
Inter Unit Account		**Inter Unit Account**	
Bose Institute (Council)	5,890.00	Bose Institute (Council)	-
Scheme/Project	-	Scheme/Project	-
		Closing Balance	
		S.B A/c : Union Bank of India	2,64,33,868.88
		Fixed Deposits	27,66,58,450.00
	32,83,91,499.62		**32,83,91,499.62**

Place : Kolkata
Date : 2018

Signed in terms of our separate Report of even date.

For Ray & Ray
Chartered Accountants

Sd/-	Sd/-	Sd/-	Sd/-
Prof.Sujay Dasgupta	Mrs. Noreen Bhattacharya	Achintya Mukherjee	
Director (Officiating)	(Acting Registrar)	Accounts Officer	Accounts & Administration Officer
Incharge of Fair Projects			Fair Project

INDEPENDENT AUDITORS' REPORT

TO THE MEMBERS OF THE COUNCIL

We have audited the accompanying financial statements of **BOSE INSTITUTE (Governing Body)**,which comprise the Balance Sheet as at March 31, 2018 and the Income and Expenditure Account for the year then ended and a summary of significant accounting policies and other explanatory information.

Management's Responsibility for the Financial Statements

Management is responsible for the preparation of these financial statements. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation of the financial statements that are free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgement, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the Institute's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Institute's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Basis of Qualified Opinion

1) No fixed asset register was provided for our verification. The Institute has not carried out test of impairment, if any, in accordance with the requirement of AS 28 notified by the Institute of Chartered Accountants of India.

2) No cash balance certificate as on 31st March, 2018 was provided for our verification.

3) Share certificate for investment in 7.5% preference shares of CESC was not available for our verification.

4) We could not verify old brought forward current assets and liabilities which require immediate reconciliation and adjustment. Consequential impact is not ascertainable at this stage.

Opinion

In our opinion and to the best of our information and according to the explanations given to us, the financial statements of BOSE INSTITUTE for the year ended March 31, 2018, 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 2018;

b) In case of Income and Expenditure Account, of the surplus for the year ended on that date;

For Ray & Ray
Chartered Accountants
(Firm Registration No. 301072E)

Date : 25th September, 2018

Place : Kolkata

Abhijit Neogi

Partner
(Membership No : 61380)

BOSE INSTITUTE (GOVERNING BODY)

93/1, ACHARYA PRAFULLA CHANDRA ROAD, KOLKATA - 700009

BALANCE SHEET AS AT 31ST MARCH 2018

	Schedule No.	As on 31/03/2018	As on 31/03/2017
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	29,82,629.96	29,92,629.96
DEPOSITS & OTHER LIABILITIES	2	12,15,616.66	12,22,346,66
	TOTAL	**81,15,848.38**	**81,32,578.38**
PROPERTIES & ASSETS			
FIXED ASSETS			
AS PER LAST ACCOUNT	3	23,74,712.85	23,74,712.85
INVESTMENTS			
AS PER LAST ACCOUNT	4	63,19,249.67	50,21,,566.67
RECEIVABLE & DEPOSITS			
AS PER LAST ACCOUNT	5	3,19,604.00	11,17,072.00
CASH & BANK BALANCES	6	11,88,261.34	11,75,923.34
INCOME & EXPENDITURE A/C			
EXCESS OF EXPENDITURE OVER INCOME		(20,85,979.48)	(15,56,696.48)
	TOTAL	**81,15,848.38**	**81,32,578.38**

INCOME & EXPENDITURE STATEMENT FOR THE YEAR ENDED 31ST MARCH 2018

Particulars	2017-18 (₹)	2016-17 (₹)
INCOME		
INTEREST ON TERM DEPOSIT	5,58,967.00	4,75,864.00
INTEREST ON SAVINGS BANK	4,365.00	4,364.00
TOTAL	**5,63,332.00**	**4,80,228.00**
EXPENDITURE		
SALARY & WAGES	21,600.00	21,600.00
ACCOUNTING CHARGES		
AUDIT FEES	11,800.00	11,800.00
BANK CHARGES	649.00	632.50
EXCESS OF INCOME OVER EXPENDITURE FOR THE YEAR	5,29,283.00	4,46,195.50
TOTAL	**5,63,332.00**	**4,80,228.00**
INCOME BROUGHT DOWN AND ADJUSTED WITH LAST YEAR	5,29,283.00	4,46,195.50
BALANCE BROUGHT DOWN FROM LAST A/C (DEBIT)	(15,56,696.48)	(11,10,500.98)
BALANCE TAKEN TO BALANCE SHEET (DEBIT)	(20,85,979.48)	(15,56,696.48)

Place : Kolkata
Date : 25/9/2018

Signed in terms of our separate Report of even date.

For Ray & Ray
Chartered Accountants

Sd/-	Sd/-	Sd/-	Sd/-
Vikash Kumar	Achintya Mukherjee	Mrs. Noreen Bhattacharya	Prof.Sujay Kumar DasGupta
Audit & Finance Officer	Accounts Officer	(Acting Registrar)	Director (Officiating)

AUDIT OBSERVATIONS
(Forming part of Audit Report)

COMPLIANCE REPORT

Compliance Report of Bose Institute on the Audit Observations for the Financial Year 2017-18

Sl. No	Audit Observation	Replies
1.	The Institute has accounted for expenses on cash basis in the financial statement which is contrary to the fundamental accounting assumptions as per AS 1 notified by the Institute of Chartered Accountants of India.	Since all expenses are matched with the receipt of Grant-in-aid from the Ministry of Science and Technology, Department of Science and Technology Govt. Of India 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.
2.	Intangible assets in the form of books and journals are not amortised over the licence period and are being carried forward and depreciated even after expiry of their licence period which is not in accordance with the requirement of AS 26 notified by the Institute of Chartered Accountants of India. *The amount of such expired licences are presently not ascertainable.*	From the current financial year Intangible assets in the form of books and journals will be amortised over the licence period as per the requirement of AS 26 notified by the Institute of Chartered Accountants of India.
3.	As reported by the management, fixed asset register was prepared upto 31st March 2017 and for the period upto 31st March 2018 is under process of finalisation which could not be verified by us during finalisation of annual accounts.	Up to date Fixed Asset Register will be provided to the Audit team during next Audit Session.
4.	Liability towards gratuity and leave encashment are not ascertained as per actuarial valuation and the same are accounted for on cash basis contrary to the requirement of AS 15 notified by the Institute of Chartered Accountants of India.	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.
5.	The institute does not have internal audit system commensurate with the size and nature of its activity resulting in poor internal financial control.	As per approval of Director Bose Institute a CA Farm will be appointed from the list of CAG empanelled list of auditors. Selection process will start very soon.
6.	The Institute could not reconcile accrued interest on fixed deposits as per books of accounts with that as per bank confirmation in few cases.	Reconciliation process of accrued interest on fixed deposits as per books of accounts with that as per bank confirmation has been initiated and as soon as it will be done, the same will be placed to the Statutory Auditor for verification.
7.	The Institute could not reconcile GPF and CPF fund balances with the balances in the books of the Council as on the 31st March, 2018.	Reconciliation process of the GPF and CPF fund balances with the balances in the books of the Council is on the way and will be placed to the Statutory Auditor for verification.
8.	We could not verify old brought forward current assets and liabilities amounting to Rs.19.29 lacs and Rs.76.60 lacs respectively. Consequential impact on the year's revenue and the net current asset position as at the end of the year is not ascertainable.	Reconciliation process of the Old outstanding balances of Current Assets / Liabilities are initiated and will be produced to the statutory auditor for verification when fully reconciled.
9.	Asset acquired from development and modernisation fund amounting to Rs. 666.57 lacs has been held under 'Investment Under Earmarked Fund' and has not been capitalised thereby understating the fixed assets to that extent. Consequential impact on depreciation and current year's profitability is not ascertainable.	Preparation of Fixed Asset register of Bose Institute up to 2017-18 is in process. With the finalization of Fixed Asset register, asset acquired under "Institute Development and Modernization Fund" will be capitalized.
10.	We could not verify old brought forward capital work in progress amounting to Rs. 22.15 lacs which need immediate review and adjustments in the books of	Reconciliation of the capital work in progress is in process and the amount is reduced from the

accounts. Consequential impact on the books of accounts is not ascertainable at this stage.

previous year's balance. Very soon the total reconciliation will be done and will be reported to the Statutory Auditor.

11. (i) There are ongoing legal cases/investigation against the Institute, the impact of which is not ascertainable at this stage.

(ii) Legal fees paid to various lawyers during the period were in excess of the limit laid down in this regard by the Central Government vide its order no.26(1)/2014/judl dated 1st October 2015.

In continuation and persuasion of Agenda Item No. 5 of the Finance Committee meeting held on 03.06.1994 and subsequent 179th meeting 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.
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 made between lawyer and the Institute may be drawn up.
3. Director, BI was delegated full powers to appoint senior advocates/barrister along with payment of their fees as applicable /charged by this 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 procedure, initially for legal affairs vide order No. R/135/16/1969 dated 16/09/2016,which is being placed before the next council meeting scheduled to be held on 16/10/2017

On going project during 2017-18

Sl. No.	Name of the Project	Duration	Guide		Opening Balance as on 01.04.17	Grant Received during 2017-18	Other Receipts during 2017-18	Expenditure during the year 2017-18	Debit / Credit Balance as on 31.03.18
	DBT - "Setting up of National Facility on Interactive Graphics Computer System for Biometecular Modeting molecular dynamics & structures"	extended upto 31.03.2020	Prof Pinakpani Chakrabarti, B.I.C	381	788,350.53	316,184.00	23,255.00	200,200.00	927,589.53
2	DBT - "Centre of Excellence (COE) at Bose Institute"	extended upto 31.03.2020	Pror Pinakpani Chakrabarti, B.I.C	775(A)(B)	916,221.04	1,231,543.00	33,181.00	416,215.00	1,764,730.04
3	DST - "Award of J.C.Bose Fellowship to Prof. Pinakpani Chakraborti"	03.05.2007 to 02.05.2012 extended upto 02.05.2022	Pror Pinakpani Chakrabarti, B.I.C	795	126,829.03	1,063,804.00	-	635,300.00	555,333.00
4	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 Extended upto 08.01.2018	Prof. Joyoti Basu, Chemistry	1033	106,329.43	3,344,977.00	24,986.00	3,363,754.00	112,538.43
5	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 Extended upto 25.06.2018	Prof. Sibaji Raha, Phsics	1042	4,422,779.84	35,000,000.00	-	8,741,472.00	30,681,307.84
6	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 Extended upto 28.06.2017	Prof. Swati Gupta Bhattacharya, Department of Plant Biology	1125	23,003.00	-	-	23,003.00	-
7	DBT - "Studies on the efficacy of flavonoid and non-flavonoid polyphenols against chronic inflammation induced disease pathogenesis"	03.03.2014 to 02.03.2017 Extended upto 02.09.2017	Dr. Kaushik Biswas, DMM	1127	475,063.72	-	7,885.00	400,285.00	82,663.72

8	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	586.00	800,000.00	-	798,674.00	1,912.00
9	DBT-" Binning stochastic phenotypic states of cancer cell population in different color box"	02.06.2014 to 01.06.2017 Extended upto 01.12.2017	Prof. Tanya Das, Division of Molecular Medicine	1150	(612,495.18)	986,000.00	-	329,150.00	44,354.82
10	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	20,325,679.00	96,350,000.00	1,235,673.00	2,154,849.00	115,756,503.00
11	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	233,039.00	298,333.00	-	297,080.00	234,292.00
12	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	308,869.00	199,403.00	-	199,404.00	308,868.00
13	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	210,062.75	-	-	210,063.00	(0.25)
14	CSIR - "Exploring membrane-associated NAC-transcription factors (NAC MTFs) in tomato to apprehend membrane mediated signaling during pathogenesis"	01.10.2014 30.09.2017 Extended upto 30.09.2018	Dr. Pallob Kundu, Division of Plant Biology	1171	77,867.29	422,133.00	-	451,314.00	48,686.29
15	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	76,410.43	1,122,619.00	20,973.00	969,233.00	250,769.43
16	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	11,863.23	809,047.00	6,770.00	820,076.00	7,604.23

17	CSIR - "Investigation of the archaeal diversity and activity in Sundarbans mangrove sediment, India"	01.01.2015 to 31.12.2017 Extended upto 31.12.2018	Dr. Abhrajyoti Ghosh, Department of Biochemistry	1177	157,174.19	342,826.00	-	678,956.00	(178,955.81)
18	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 Extemded upto 31.08.2018	Prof. Swati Gupta Bhattacharya, Department of Plant Biology	1184	99,676.26	2,162,003.00	-	1,299,438.71	962,240.55
19	DBT- "TLR2-dependent engagement of the host cell kinases and phosphatases that dictate disease progression or resolution	30.1.2015 to 29.01.2017 Extended upto 29.11.2018	Prof. Subrata Majumdar, Division of Molecular Medicine	1192	(53,135.85)	1,388,000.00	-	737,515.00	597,349.15
20	Regulation of the mycobacterial stress response by the two-omponent system SenX3-RegX3 in *Mycobacterium tuberculosis*	03-06-2015 to 02-06-2018	Prof. Manikuntala Kundu, Dept. of Chmistry	1191	(971.78)	1,300,000.00	-	815,132.00	483,896.22
21	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	1,611,955.30	2,307,283.00	30,542.00	1,487,836.00	2,461,944.30
22	Astrophysical S-factor from nuclear reactions with a rare isotope beam ^{7}Be	06-08-2015 to 05-08-2018 Dept. of Physics	Dr. Dhruba Gupta,	1200	(98,744.04)	1,420,000.00	-	577,130.00	744,125.96
23	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	46,388.00	660,000.00	12,943.00	636,802.00	82,529.00
24	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	(63,864.00)	1,050,000.00	-	981,306.00	4,830.00
25	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	11,440.45	1,000,000.00	-	809,005.00	202,435.45

ON GOING PROJECT

26	Development of Nanoparticle-based Directed Delivery Systems for Peptide Therapeutics	03-12-2015 to 02-12-2018	Prof. Siddhartha Roy, Dept. of Biophysics	1223	1,527,557.08	-	-	1,519,370.00	8,187.08
27	Vertical profiling of the sedimentary microbiome of the Arabian sea OMZ with special reference to carbon and sulfur cycles	02-01.2016 to 01-01-2018	Dr. Wriddhiman Ghosh, Dept. of Microbiology	1224	95.00	-	-	-	95.00
28	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	(143,996.36)	800,000.00	-	5,900.00	650,103.64
29	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	-	300,000.00	-	300,000.00	-
30	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	459.29	1,900,000.00	-	1,501,313.00	399,146.29
31	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	2.00	400,000.00	-	400,002.00	-
32	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	4,236.00	36,000.00	-	31,068.00	9,168.00
33	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	1231	10,860,377.06	3,081,947.00	268,616.00	11,018,674.87	3,192,265.19
34	INSA - Senior Scientist	01.03.2016 to 28.02.2019	Prof. A. N. Lahiri Majumder, Division of Plant Biology	1236	-	460,000.00	-	459,993.00	7.00
35	Assessment of the anti-cancer effect of Methylglyoxal in combination with conventional anticancer drugs at Metronomic doses with special reference to cancer stem cells	01.06.2016 to 31.05.2019	Prof. Manju Ray, Dept of Biophysics	1249	23,843.00	796,058.00	-	691,505.00	128,396.00

36	Studies on quantum entanglement as a resource for quantum information processing	18.07.2016 to 17.07.2019	Dr. Somshubhra Bandyopadhyay, CAPSS	1269	600,000.00	-	-	254,586.00	345,414.00
37	Development of Molecular Diganostics and Immunotherapeutic Vaccines for Prawn and Brinjal Allergy	23.08.2016 to 22.08.2019	Prof. Swati Gupta Bhattcharya, Division of Plant Biology	1273	1,214,278.00	-	14,757.00	1,215,382.77	75,619.23
38	NASI-Senior Scientist Platinum Jubilee Fellowship	01-09-2016 to 31.08.2019	Prof. P. C. Sen Division of Molecular Medicine	1275	542,576.00	1,004,440.00	-	1,006,491.14	540,524.86
39	Genome wide transcriptome analysis to develop strategies for quality improvement of blackgram	31.08.2016 to 30.08.2019	Prof. Amita Pal, Division of Plant Biology	1277	756,928.00	366,392.00	15,681.00	708,596.00	430,405.00
40	Mechanistic insight into the ligand induced perturbation on the intrinsic dynamics and conformational sampling of the ±, ² dimer of Tubulin: Applications to combat cancer	12.09.2016 to 11.09.2019	Dr. Shubhra Ghosh Dastidar Division of Molecular Medicine	1278	2,503,799.00	200,000.00	-	2,143,708.00	560,091.00
41	Targeting the mrRNA axis with a synthetic small molecule, Nifetepimine to restrict migration of triple negative breast cancer cells	25.10.2016 to 24.10.2019	Prof. P. C. Sen Division of Molecular Medicine	1281	950,752.00	1,300,000.00	-	1,428,196.00	822,556.00
42	Understanding the role of G-quadruplex structures in BC1-2, KRAS and c-MYC promoters in the development of cancer	30.08.2016 to 29.08.2019	Dr. Subhrangsu Chatterjee Dept. of Biophysics	1282	601,463.58	-	-	1,057,500.00	(456,036.42)
43	Development of High yielding, Non lodging and Biotic resistant Varieties of Black Scented Rice of Manipur and Joha Rice of Assam through Biotechnological Intervention	19.10.2016 to 18.10.2019	Prof. Debabrata Basu, Division of Plant Biology	1285	680,060.00	-	-	573,923.00	106,137.00
44	DST - Ramanujan Fellowship	10-09-2012 to 09-09-2017	Dr. Saikat Biswas, Capps	1288	428,829.00	-	-	764,674.98	(335,845.98)
45	Study of Helium potential in soil gases at Tantloi-Bakreswar of Jharkhand - West Bengal Region	08.11.2016 to 07.11.2017	Prof. Sibaji Raha, Phsics	1289	314,674.00	-	-	1,485,436.00	(1,170,762.00)
46	CBM MUCH	01.08.2016 to 31.07.2022	Prof. Sanjay K. Ghosh	1293	14,872,160.00	-	-	2,685,358.87	12,186,801.13

ON GOING PROJECT

47	Study to understand the pollination ecology as well as applicability of placing apiary boxes in the forested area of Sundarbans	01.12.2016 to 31.07.2019	Prof. Swati Gupta Bhattcharya, Division of Plant Biology	1301	495,000.00	250,000.00	-	689,834.00	55,166.00
48	Elucidating the GWAS-Associated Genetic Variants within IncRNA candidate loci: Role in Cancer	10.03.2017 to 09.03.2020	Dr. Zhumur Ghosh	1303	499,625.00	1,400,000.00	-	1,801,825.00	97,800.00
49	Hydrogenogenic carbon monoxide conversion under mesophilic condition using anaerobic granular sludge biomass for biodesulphurization	19.07.2017 to 18.01.2020	Prof. Tapan K. Dutta	1305	1,136,000.00	-	28,094.00	932,804.68	231,289.32
50	Role of co-chaperones in triage decision of Hsp70	21.03.2017 to 20.03.2020	Dr. Atin Kumar Mandal	1306	600,080.00	1,114,000.00	-	1,711,192.00	2,888.00
51	Systematic identification of regulatory networks in pluripotent cells integrating coding and noncoding word	01.03.2017 to 29.02.2020	Dr. Sudipto Saha	1307	1,290,000.00	-	-	1,119,706.00	170,294.00
52	Epigenetic Alterations Inducing Oncogenicity in Stem Cell Derivatives	01.03.2017 to 29.02.2020	Dr. Zhumur Ghosh	1311	1,500,000.00	-	-	1,395,043.44	104,956.56
53	Multi-dimensional Reserch to Enable Systems Medicine: Acceleration using a Cluster Approach' at Kalyani, West Bengal	09.01.2017 to 08.01.2021	Director, Bose Institute	1312	52,300,345.00	1,881,600.00	1,222,671.00	47,530,488.29	7,874,127.71
54	A novel role of ganglioside GM2 in the regulation of the Hippo signaling pathway in tumorigenesis	21.03.2017 to 20.03.2020	Dr. Kaushik Biswas, Division of Molecular Mediciine)	1314	799,564.00	1,100,083.00	-	1,910,304.01	(10,657.01
55	Quest for the biophysical basis of habitability of dydrothermal vent ecosystems	23.03.2017 to 22.03.2020	Dr. Wriddhiman Ghosh, Dept. of Microbiology	1327	784,212.00	933,000.00	-	853,494.00	863,718.00
56	CSIR - Structural insight and Dynamical properties of Alpha synuclein fibrillation in the context of Mitochondrial membrane or Biological membrances : Pathological role in synaptic transmission Aggregation property and cellular toxicity	01.07.2017 to 30.06.2020	Dr. Anirban Bhunia	1329	-	187,500.00	-	194,771.38	(7,271.38)

57	CSIR - Crucial role of transcription factor-EB(TFEB) in regulating differential antigen presentation and cross presentation during Leishmania donovani infection	10.07.2017 to 09.07.2020	Prof. Subrata Majumdar,	1336	-	671,000.00	-	600,061.00	70,939.00
58	CSIR - Proteome analysis during Lipaphis erysimi - Rorippa indica incompatible interaction to identify putative proteins responsible for aphid tolerance and their interacting partners	01.08.2017 to 31.07.2020	Prof. S. R. Sikdar	1338	-	458,333.00	-	431,979.00	26,354.00
59	Indo-Swedish - Antimicrobial peptides against crop disease	20.06.2017 19.06.2019	Dr. Anirban Bhunia	1340	-	1,794,500.00	-	1,480,085.29	314,414.71
60	DBT - Transcriptional regulator RegX3-dependent modulation of the macrophage immune response by Mycobacterium tuberculosis	13.07.2017 to 12.07.2020	Prof. Manikuntala Kundu	1348	-	2,708,400.00	57,451.00	933,664.00	1,832,187.00
61	CSIR - Deciphering the in-planta secretome of Rhizoctonia solani AG1-1A during infection of rice	25.07.2017 to 31.07.2020	Prof. Swati Gupta Bhattacharjee	1358	-	762,667.00	-	356,456.00	406,211.00
62	MOEFCC - National Carbonaceous Aerosols Programme WGIII: Carbonaceous Aerosols Emmissions, Source appointment and Climate effects	29.03.2017 to 28.06.2022	Dr. Abhijit Chatterjee	1362	4,000,000.00	2,787,880.00	136,569.00	387,664.00	6,536,785.00
63	SERB(DST) - Award of J.C. Bose Fellowship to Prof. Joyoti Basu	24.03.2017 to 31.01.2018	Prof. Joyoti Basu	1375	100,000.00	1,400,000.00	-	1,170,202.00	329,798.00
64	DST -The development and implementation of sensors and treatment technologies for freshwater systems in India	26.02.2018 to 25.02.2021	Prof. Tapan K. Dutta	1386	-	12,520,600.00	-	27,001.00	12,493,599.00
65	DBT - Understand molecular mechanism of action of a protein chaperone inducer azadiradione and its therapeutic development for Parkinson's disease treatment	30.01.2018 to 29.01.2021	Prof. Mahadeb Pal	1387	-	1,594,000.00	-	-	1,594,000.00

ON GOING PROJECT

66	SERB(DST) - Role of Cancer Stem Cells in Tumor Neo-Angiogenesis : A mechanistic study	05.03.2018 to 04.03.2021	Prof. Tanya Das	1390	-	970,000.00	-	-	970,000.00
67	SERB - Phage inspired antibiotics for mycobacteria	21.03.2018 to 20.03.2021	Prof. Sujoy K. Das Gupta	1396	-	990,000.00	-	-	990,000.00
68	DST(SPLICE) - Understanding the Role of Local and Transported Biogenic and Anthropogenic Aerosols on Microphysical and Chemical Properites Low-Clouds Over Eastern Himalaya, India	22.03.2018 to 21.03.2021	Dr. Abhijit Chatterjee	1399	-	6,182,000.00	-	-	6,182,000.00
69	SERB - Nanoparticle-mediated co-delivery of chemotherapeutic drugs and genes for synergistic cancer treatment	15.03.2018 to 14.03.2021	Prof. P. C. Sil	1401	-	955,000.00	-	70,000.00	885,000.00
70	SERB - Evaluation of secreted proteases of Ustilago maydis as potential effector proteins	16.03.2018 to 15.03.2021	Dr. Anupama Ghosh	1407	-	1,460,633.00	-	65,000.00	1,395,633.00

Centenary Lecture

Centenary Lecture delivered by
Bharat Ratna Prof. C. N. R. Rao
Title
"Can India become a global leader in science?" during March 28, 2018 at 11:30 AM in the Lecture Hall of the Main Campus of the Institute on the occasion of Centenary Celebration of the Bose Institute.